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New Advances
in Information Systems
and Technologies

Volume 2

Springer

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Preface

This book contains a selection of papers accepted for presentation and discussion at The 2016 World Conference on Information Systems and Technologies (WorldCIST'16). This Conference had the support of the Federal Rural University of Pernambuco, IEEE Systems, Man, and Cybernetics Society, AISTI (Iberian Association for Information Systems and Technologies/Associação Ibérica de Sistemas e Tecnologias de Informação), and GIIM (Global Institute for IT Management). It took place at Recife, Pernambuco, Brazil, March 22–24, 2016.

The World Conference on Information Systems and Technologies (WorldCIST) is a global forum for researchers and practitioners to present and discuss recent results and innovations, current trends, professional experiences, and challenges of modern Information Systems and Technologies research, technological development and applications. One of its main aims is to strengthen the drive toward a holistic symbiosis between academy, society, and industry. WorldCIST'16 built on the successes of WorldCIST'13, held at Olhão, Algarve, Portugal, WorldCIST'14 held at Funchal, Madeira, Portugal, and WorldCIST'15 which took place at São Miguel, Azores, Portugal.

The Program Committee of WorldCIST'16 was composed of a multidisciplinary group of experts and those who are intimately concerned with Information Systems and Technologies. They have had the responsibility for evaluating, in a 'blind review' process, the papers received for each of the main themes proposed for the Conference: (A) Information and Knowledge Management; (B) Organizational Models and Information Systems; (C) Software and Systems Modeling; (D) Software Systems, Architectures, Applications and Tools; (E) Multimedia Systems and Applications; (F) Computer Networks, Mobility and Pervasive Systems; (G) Intelligent and Decision Support Systems; (H) Big Data Analytics and Applications; (I) Human–Computer Interaction; (J) Health Informatics; (K) Information Technologies in Education; (L) Information Technologies in Radiocommunications.

WorldCIST'16 also included workshop sessions taking place in parallel with the conference ones. Workshop sessions covered themes such as (i) Communication

and Journalism in Online Social Networks, (ii) Computer Supported Qualitative Analysis, (iii) Emerging Trends and Challenges in Business Process Management, (iv) Healthcare Information Systems Interoperability, Security and Efficiency, (v) Human–Machine Interfaces in Automation, Robotics and Mechanics, (vi) Innovation in Information Management, (vii) Intelligent Systems, (viii) Internet, Business and Social Networks, Pervasive Information Systems, (ix) Semantics for Humanities Resources.

WorldCIST'16 received contributions from 41 countries around the world. The papers accepted for presentation and discussion at the Conference are published by Springer (this book) and by AISTI (another e-book) and will be submitted for indexing by ISI, EI-Compendex, SCOPUS, DBLP and/or Scholar Google, among others. Extended versions of selected best papers will be published in relevant journals, including SCI/SSCI and Scopus indexed journals.

We acknowledge all those who contributed to the staging of WorldCIST16 (authors, committees, and sponsors); their involvement and support is very much appreciated.

Pernambuco   Álvaro Rocha
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Health Informatics

Using Mobile Technology to improve Nutritional Information of Diabetic Patient's

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Abstract. In recent years the use of mobile technology has become very common and popular. It is important to provide correct and useful nutritional information to diabetic patients, which can be easily accessed by mobile technology. However, providing such information to patients using mobile application is limited. One method is to use mobile technology, which is a very effective method in the expansion of information process visually, especially in health-related areas by using mobile devices. Therefore, the integration of mobile application with Diabetes management can provide useful nutritional and health information in order to improve the lifestyle of diabetic patients. This paper presents a comprehensive review of the state of the art in mobile application for Diabetes management.

Keywords: *Diabetics, Health information, Android Technology, Nutritional Information, Mobile health, Type 1(T1DM) and Type 2 (T2DM).*

1   Introduction

The growing population of diabetic patients will continue to increase pressure on healthcare systems. Multidisciplinary research fields that integrate both Information and Communication Technologies (ICT) and healthcare disciplines are thus looking at advances to transform our personalized healthcare. Significant advances in the field of mobile technology deliver cost-effective solutions to patient health management, anyone, anywhere, and anytime [1].

With rapid growth in mobile technology, interaction with mobile device is gaining momentum. This is to support users and increase application usability, thus mobile Augmented Reality (AR) is state-of-the-art technology that has modernized the mode

of accessing and interacting with information. This invokes new experiences for users globally [2]. The precision of AR shifts the focus of research from technical to user interaction that generates a likelihood to implement mobile AR in more innovative ways [3]. For AR technology, a concept of visual environment integrated with real environment [4], is defined as the integration of computer-generated images with the real world including 3D and 2D form or video overlapped with real time; a scene which is very popular at present.

Software developments have made this technology accessible using webcam, mobile phone camera, computer and/or sensor, so the program users can view and ultimately experience the 360 degree or 4D images and places in real time. Recently, the use of AR technology has become very popular and is currently used in many other fields especially in medicine. In the last few years, food has appeared in Human Computer Interaction (HCI) research in everyday activities. In its own right, HCI research on food, or 'Human-Food Interaction' (HFI), has emerged as an area of significant interest in the HCI community. HFI is a new field where technology helps in growing, cooking and eating food in a sustainable environment.

In this paper, we review the literature on current Mobile Application, AR technology and discuss about the use of Augment Reality in nutritional information.

2   Literature Review

Diabetes Mellitus is a complex condition caused by either lack of production of Insulin in the beta cells of the Islets of Langerhans in the pancreas or the body cells fail to respond to the Insulin so that there is excess glucose in the blood. Glucose, is a 'simple' sugar, obtained from the enzymatic breakdown of starch and carbohydrates. It is an essential energy source required by the body cells to function. Since there is a lack of Insulin or insulin resistance, the cells begin to starve due to lack of glucose. Diabetes is often called 'starvation in plenty'. There is excess glucose in the blood circulation but not available to the cells to facilitate optimal function. Since the cells are not functioning at optimal capacity, critical tissue and organs are adversely affected. In the case of the eye, due to poor retinal blood vessel intercellular adhesion integrity there is a tendency in poorly controlled Diabetes Mellitus, for retinal bleeding to occur. If left untreated this can lead to blindness. Similar haemorrhage in the brain and heart can lead to stroke (Cerebrovascular accident) and Myocardial Infarcts (Heart Attacks), respectively. In the case of the lower limb peripheries, this can lead to gangrene and foot amputations. It must be noted that there is no cell in the body that is immune to the adverse effects of Diabetes mellitus.

Diabetes mellitus has become quite prevalent at a global level. In Australia, 1.1 million people have been diagnosed with diabetes [8] and is prevalent in the Aboriginal and Torres Island population. There are two types of Diabetes Mellitus, Type 1(T1DM) and Type 2 (T2DM). Australian statistics have revealed that 120,000 people have suffered from Type 1 diabetes and 956,000 have Type 2 diabetes [9].

T1DM occurs when the body produces no insulin and is occasionally referred to as Juvenile Diabetes or Early-Onset Diabetes. It mostly occurs during teenage years or before the age of forty. Patients with T1DM need to take insulin injections for life and

must ensure that their blood glucose levels stay balanced by eating a healthy diet, an effective exercise programme and carrying out regular monitoring of their blood glucose with blood tests. Whereas in T2DM, there is inadequate insulin and thus the cell does not work effectively.

In order to manage the blood glucose level, Diabetes patients need to maintain a balance between the quantity of food they eat, their physical activity and insulin medication. People with diabetes were placed on rigid diets and were given a list of dos and don'ts about eating. Some of the food restrictions were advised friends or family, which works sometimes but some of their advices may be out of date and inaccurate. It is difficult for Diabetes patients to find a food in the market which ensures that it not harmful for their health. As mentioned [5], poor diet and physical inactivity are the key factors in developing chronic diseases in humans.

For diabetes patients it is important to assess the consumption of sugar by establishing a link between the diet and disease. However, it is currently challenging as people have moved away from traditional homemade food to more Take-Away food and eating out. Consumption of such food makes it difficult for people to accurately assess their food intake and food composition. Advancement in ICT has brought essential health related information for Diabetes patients. Parallel to this growth, mobile devices provide different applications in the field of health that improves communication between health practitioners and patients [6]. It provides feedback on individual eating habits, which may enable people with diabetes to better manage their condition [7]. Previous research has developed tools that can support dietary management for Type 1 and Type 2 diabetes patients. Findings suggest that greater growth is required for mobile dietary and nutritional support in Diabetes patients. Mobile applications that support healthy eating habits should be integrated with applications for managing blood glucose and physical activity data, as well as medication data [5] [6]. However, mobile applications-based self-management is not a quick solution for the problem and it is critical to understand that its effect is based on strong behavioural change by the patient. Some patients encounter difficulties managing technical problems and others cannot afford the cost. Therefore, the adoption and use of user-centred and socio-technical design principles is highly needed to improve usability, perceived usefulness, and, ultimately, adoption of the technology [8].

There are numerous diabetes management applications available [9], however, the dominant ones offer comparable functionalities and have one to two functionalities in one application. Patients and doctors alike should be included in the application improvement and clinical application procedures to ensure ongoing review as well as research and development. The usability of these diabetes apps for patients aged 50 or older was moderate to good. Besides this outcome applied mainly to apps offering a small range of functions. Multifunctional applications performed significantly more terrible in terms of usability. In addition, the presence of documentation or examination function brought about fundamentally lower usability scores. The operability of accessibility features for diabetes apps was quite limited, except for the feature "screen reader" [10]. As specified in [11] that interest in mobile health applications for self-management of diabetes is growing rapidly. Research on both the design, usability and the use of diabetes mobile health applications is rare. Furthermore, the potential impact of social media on diabetes mobile health

applications is largely unexplored. Choosing healthy foods and being active will help manage blood glucose levels and body weight. Adhering to a good diet for people with diabetes is similar to recommendations for everyone. Therefore, there is no need to prepare separate meals or buy special foods. The entire family can enjoy healthy eating. Managing blood glucose levels for a person with T1DM requires matching the amount of insulin to the carbohydrate foods they consume.

In [12] proposes a methodology for automatic food recognition, based on the bag-of-features (BoF) model and this is a first step toward the development of a portable application and providing dietary advice to diabetic patients through automatic carbohydrate counting. For the design and evaluation of this application, a visual dataset with nearly 5000 food images was created and organized into 11 classes. In these mobile applications designed for diabetes, usability is a persistent issue and can cause severe health problems if not managed properly. Diabetes is very common in ages 60 and above therefore they may have memory limitations, poor vision, or declining motor and cognitive skills, which may impair usability [13].

According to [14] predictions of information technology research and advisory firms, such as Gartner, hybrid HTML5 applications will be the future in mobile application development. Furthermore, exploring the feasibility of using HTML5 and related web application standards in the development of mobile e-health applications by using a diabetes monitoring application, as a practical use case. In this paper [14] practical experiences with using HTML5 and related web technologies to deliver context-aware personal health assistance applications, and the challenges with targeting such smart e-health applications to mobile devices was reviewed. Mobile technologies have matured to the point where healthcare services for chronic disease could be provided beyond hospital borders [15]. The usage of mobile-health technologies has the potential to enhance a patient's self-care ability, thereby modify their lifestyles and improve metabolic conditions. Despite the fact that the benefits of mobile health interventions for diabetic patients are well established, the impacts on diabetes self-care practices have not been extensively validated. Most mobile health studies have emphasized on assessing clinical metabolic outcome, such as decreased level of Glycosylated Haemoglobin (HbA1C), rather than validating self-care processes from the patient's perspectives. Little is known about the effect of m-health on self-care processes [16]. Outcomes of self-care ability enhancement can be categorized as immediate (knowledge and skills acquisition), intermediate (behavioural change) and long term manifestation (improved health status). Studies have suggested adding focus on identifying immediate and intermediate outcomes.

From the research review it is clear that mobile phones are becoming a popular and powerful platform, and many healthcare-related applications have been explored, such as remote health monitoring, SMS medical tips, fitness coaches, and diabetes guides outcomes [17]. Obesity, where mobile phone aided healthcare can assist, is becoming an epidemic in most developed countries. In the past three decades, obesity rates for both adults and children in the developed countries have increased significantly [18]. The continuing rise in overweight and obesity patients has attracted increasing research interest to explore practical new technology to prevent these conditions [19]. However, the usual case is that individuals with potential obesity problems are more likely to ignore their food intakes and regular exercise. Efforts have been made to record calorie contents without user awareness or knowledge by processing chewing

sounds of the user with on-body sensors [20]. Novel obesity management applications arise as mobile phones are becoming more powerful for people-centric computing. The fact that mobile phones are necessary and used by people almost everywhere makes them perfect devices for information gathering and delivering.

Some commercial applications have appeared in recent years, such as MyFoodPhone by Sprint, Diet Fitness Diary by Verizon, and Sensei. These existing academic and commercial systems rely heavily on manual data analysis and labor intensive user interaction. Automatic dietary monitoring has been developed by analysing chewing sounds detected by on-body sensors. However, it is not possible for people to wear sensors all the time and it is not accurate enough to estimate the food intake only with chewing sounds [18]. Researchers have used mobile phones as tools for encouraging physical activity and healthy diets, for symptom monitoring in asthma and heart disease, for sending patients reminders about upcoming appointments, for supporting smoking cessation, and for a range of other health problems [21]. In [22] presented a mobile application that aims at supporting sustainable weight loss by leveraging established behaviour change theories. Three interfaces were designed and implemented: A messaging system, a personal goal achievement system and a group goal achievement system. The application was validated through a usability testing experiment. Seven young female adults, native Arabic speakers, tested the Android application in the smart phones and were asked to perform tasks relevant to each interface. Understanding that Augmented Reality offers information visualization, which creates a system that serves as an interactive e-Ordering system for ice dessert. The prototype was created and was evaluated as a good alternative to the traditional ice dessert purchasing. In addition, this mobile AR system is expected to improve the user interfaces and system usability [23].

In [24], authors successfully demonstrated how mobile Augmented Reality can be helpful in capturing and translating one language to another for language learning. This application has to be tested with more users to know efficiencies of mobile augmented reality for language learning. Also, there is a need to modify and enhance the application.

There are many features that are discussed above but we only select those features which have importance and are still under research. Following are the features that are extracted from the literature 2008 till now which includes: Real time, User Centred Sociotech Design, Functionalities, Augmented Reality, Usability, User, Estimate CHO, Measure meal composition, Independent Life Style and Clinically Accurate. We plotted all these features in the graph where X-axis is the time and Y-axis is the importance of these features. The plus sign indicates the importance and still under research.
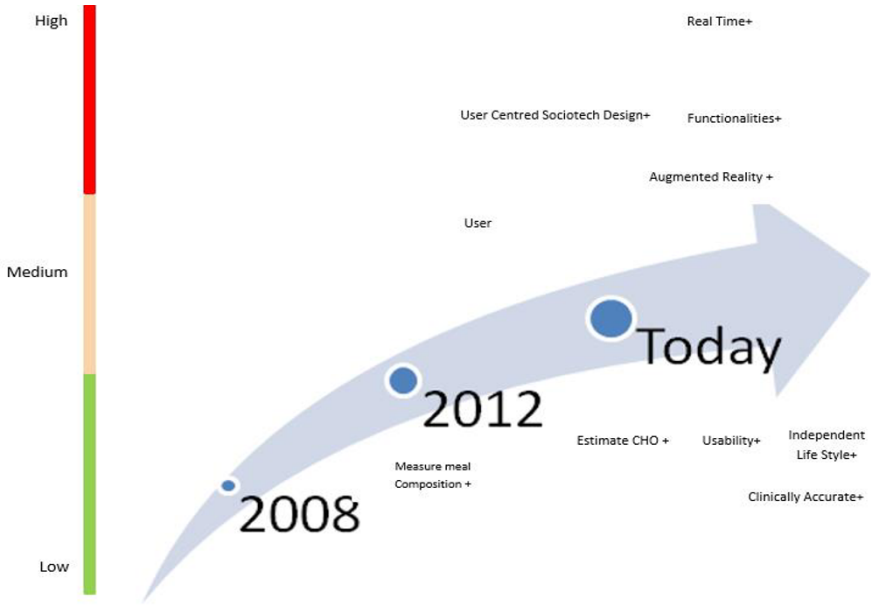
Fig. 1. Time graph of most useful features

3   Future Work

In this paper we discussed about Diabetes, food nutrition and mobile technology. Some mobile application are discussed in the literature review section to understand how mobile application is playing their role in the field of Diabetes management to reducing hospitalization and supporting an independent lifestyle in Adult Type 1 Diabetics. Nevertheless, all of these applications are lacking usability, user involvement and less consideration of real time features. At present, mobile applications are widely used in Medicine to handle health issues. However, as per discussion, the majority offer similar functionalities and combine only one to two functions in one app. Patients and physicians alike should be involved in the application development process to a greater extent. Despite the growth, research on both the design and the use of health applications is scarce. Furthermore, the potential influence of social media on health applications is largely unexplored. There are no studies evaluating social media concepts in diabetes self-management on mobile devices, and it's potential; remains largely unexplored.

4 Proposed Idea

Based on the important factors as mentioned in section 2, we proposed an idea called BIG-GLUCON-HERO. The proposed idea is to develop a diabetic's application to reduce hospitalization and support independent lifestyle in Adult Diabetics. This application is based on user-centred and sociotechnical design principles that can monitor patient food intake to control obesity, provide real time feedback from doctors and parents, support in decision making and interaction with outside world using social media and provide help in case of emergency.

Fig. 2. BIG-GLUCON-HERO

5 Conclusion

The paper discussed the role of using mobile technology in nutritional information. Although the use of mobile technology is getting more advanced and its use seems common in many fields especially medicine. In this paper, we reviewed the literature relating to using mobile applications to help diabetes patient in selecting nutritious food and avoid obesity. From the literature it seems that some applications are available for diabetes management whereas some application use mobile AR in food making. Despite the fact there is rapid growth in mobile technology, usability, real time support, clinically accuracy and interface design are still major concerns in mobile health applications. Finally Big-Gulcon-Hero is a proposed idea to reduce hospitalization and support independent lifestyle in Adult Diabetics.

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Monitoring Indoor Air Quality to Improve Occupational Health

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Abstract. Indoor environments are characterized by several pollutant sources. As people typically spend more than 90% of their time in indoor environments. Thus, indoor air quality (iAQ) is recognized as an important factor to be controlled for the occupants' health and comfort. The majority of the monitoring systems presently available is very expensive and only allow to collect random samples. This work describes the system (iAQ), a low-cost indoor air quality monitoring wireless sensor network system, developed using Arduino, XBee modules and micro sensors, for storage and availability of monitoring data on a web portal in real time. Five micro sensors of environmental parameters (air temperature, humidity, carbon monoxide, carbon dioxide and luminosity) were used. Other sensors can be added for monitoring specific pollutants. The results reveal that the system can provide an effective indoor air quality assessment to prevent exposure risk. In fact, the indoor air quality may be extremely different compared to what is expected for a quality living environment.

Keywords: Indoor air quality, indoor environment, air quality monitoring, wireless sensor network, ZigBee, gas sensors, smart cities.

1 Introduction

Indoor environments are characterized by several pollutant sources. Thus, indoor air quality (iAQ) is recognized as an important factor to be controlled for the occupants' health and comfort. This issue is more important if we take into consideration that today most people spend more than 90% of their time in artificial environments [1]. But is also important that health problems and diseases caused by poor indoor air quality can negatively affect the productivity. According to the United States Environmental Protection Agency [2], human exposure to indoor air pollutants may be 2 to 5 times— occasionally more than 100 times higher than outdoor pollutant levels, because a home's interior accumulates and concentrates pollutants given off by finishes, furnishings and the daily activities of the occupants [3]. In fact, indoor air pollutants have been ranked among the top five environmental risks to public health. Ventilation is used in buildings to create thermally comfortable environments with acceptable IAQ by regulating indoor air parameters, such as air temperature, relative humidity, air

speed, and chemical species concentrations in the air [4]. In this study the authors present some numerical predictions of pollutants dispersion in a ventilated room.

An indoor air quality assessment system helps in the detection and improvement of indoor air quality. Local and distributed assessment of chemicals concentrations is significant for safety (gas spills detection, pollution monitoring) and security applications as well as for to effectively control heating, ventilation and air conditioning (HVAC) system for energy efficiency [5]. In fact, the indoor air quality measured in the built environment provides a continuous stream of information for seamless controlling of building automation systems, and provides a platform for informed decision making [6]. However, the monitoring systems presently available are normally very expensive and only allow to collect random samples.

Recently, several new systems have been developed for monitoring environmental parameters, always with the aim of improving the indoor air quality efficiency [7]. Actually, the availability of cheap, low power, and miniature embedded processors, radios, sensors, and actuators, often integrated on a single chip, is leading to the use of wireless communications and computing for interacting with the physical world in applications such as air quality control [8]. A wireless indoor air quality monitoring in order to provide real time information for assisted living is proposed by [9]. The proposed system has carbon dioxide, carbon monoxide, propane and methane sensors. Another study involving wireless sensor networks for indoor air quality monitoring was proposed by [10].

This study describes the iAQ system, developed by the authors, which aims to ensure, autonomously, accurately and simultaneously, the indoor air quality monitoring of different building rooms. The system consists of a low cost indoor air quality monitoring wireless sensor network system, developed using Arduino, XBee modules and micro sensors, for storage and availability of monitoring data on a web portal in real time. This system collects five environmental parameters (air temperature, humidity, carbon monoxide, carbon dioxide and luminosity) from different places simultaneously. Other sensors can be added for monitoring specific pollutants. Currently, in the preliminary laboratory tests, only two remote modules were used.

2   Technical Solution

2.1   Implementation

The **iAQ** system is an automatic indoor air quality monitoring system that allows the user, such as the building manager, to know, in real time, a variety of environmental parameters as air temperature, relative humidity, carbon monoxide (CO), carbon dioxide (CO2) and luminosity. Other sensors for specific pollutants can be added.

The parameters are monitored using the **iAQ Sensor** system that collects data and sends it to the **iAQ Gateway** system that records the data in a MySQL database using web services developed in PHP.

The end user can access the data from the web portal **iAQ Web** built in PHP. After login, the end user can access the **iAQ Web** and can get all the information about environmental parameters. The monitoring data are shown as numeric values or in a chart form. This portal also allows the user to keep the parameters history. Providing a history of changes, the system helps the user to analyze precisely and detailed the air quality behaviour. This is very important to decide on possible interventions to improve the air quality in the building. The **iAQ Web** is also equipped with a powerful alerts manager that advises the user when a specific parameter exceeds the maximum value.

2.2   Wireless Sensor Network Architecture

The wireless communication is implemented using the XBee module what implements the IEEE 802.15.4 radio and ZigBee networking protocol [11]. The IEEE 802.15.4 standard specifies the physical and medium access control layers for low data-rate wireless personal area networks. ZigBee is a low-cost, low-power, wireless mesh networking standard built upon 802.15.4 [12,13].

Communication signals are transmitted from the **iAQ Sensor** to the base station **iAQ Gateway** use XBee. The modules operate within the 2.4 GHz frequency band and outdoor RF line-of-sight range up to 4000 ft. (1200 m) and RF data rate 250,000 bps. These modules use the IEEE 802.15.4 networking protocol for fast point-to-multipoint or peer-to-peer networking. They are designed for high-throughput applications requiring low latency and predictable communication timing. XBee modules are ideal for low-power, low-cost applications. XBee-PRO modules are power-amplified versions of XBee modules for extended-range applications [14].

2.3   Hardware and System Architecture

The **iAQ** system is composed of one or several **iAQ Sensor's.** They are used to collect and transfer environmental factors from the different rooms where they are installed. The **iAQ Sensor's** send the data to the **iAQ Gateway** (Fig.1), which is connected to the Internet with an Arduino Ethernet Shield, for recording data in the database.
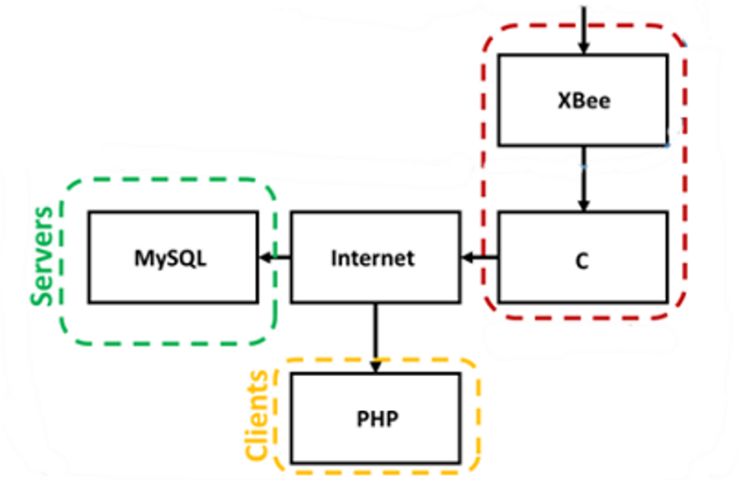
Fig. 1. iAQ GATEWAY Architecture.

Therefore, it is made possible to construct a modular system that can monitor one or more spaces simultaneously. Figure 2 schematically illustrates the system architecture used in the **iAQ**.
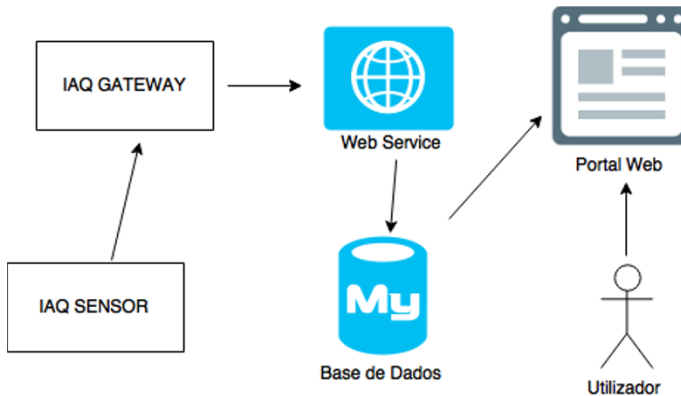
Fig. 2. iAQ System Architecture.

The **iAQ Sensor** is built using the embedded Arduino Mega system, an open source platform that incorporates an Atmel AVR microcontroller [15,16]. In order to allow communication between the iAQ Sensor's and iAQ Gateway, the ZigBee technology was applied with the use of Xbee modules.

The **iAQ Sensor** is equipped with multiple sensors, a processing unit (Arduino MEGA), and a wireless communication and mesh networking module as schematically shown in Fig. 3 (see also [17]). Currently, the **iAQ Sensor** is equipped with five sensors (Fig. 4): air temperature, relative humidity (RH), carbon monoxide (CO), carbon dioxide (CO_2) and luminosity.
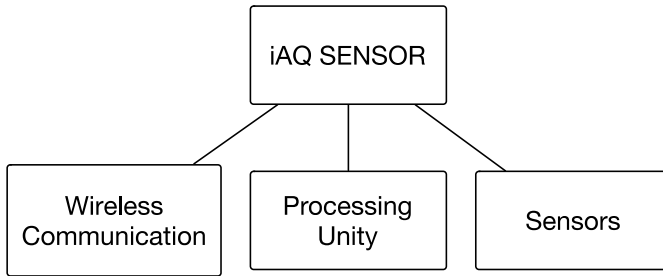
Fig. 3. iAQ Sensor
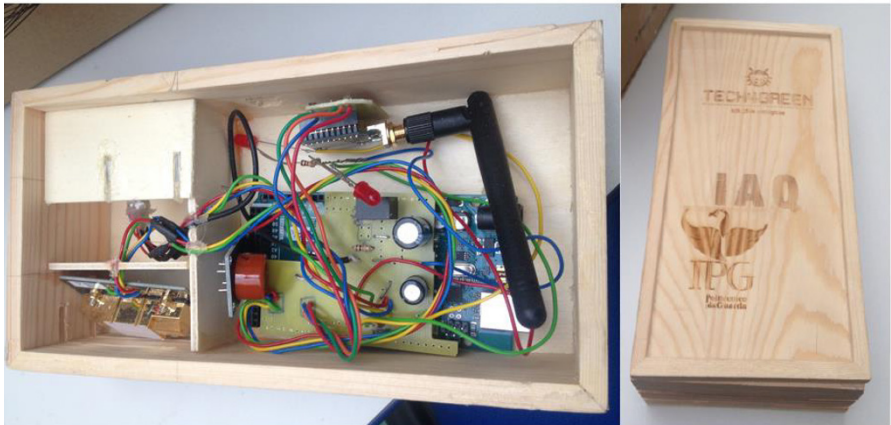
Fig. 4. iAQ Sensor Hardware

A brief description of the used sensors is presented below.

- Sensor SHT10 – it is a low power, stable and fully calibrated Relative humidity and Temperature sensor [18]; Measurement range: 0-100% (humidity), -40ºC ~ 120ºC (temperature); Accuracy: ±4,5% (humidity), ± 0.5 ºC (temperature); Response time < 30 seg.

- MQ7 Sensor – it is a high sensitivity CO (carbon monoxide) sensor with several many features [19]: high sensitivity, fast response, wide detection range (20 to 2000 ppm), stable performance and long life, simple drive circuit; Requires manual calibration.

- T6615 CO2 Sensor – it is a low power, good performance CO2 (carbon dioxide) sensor (designed for HVAC purposes), with the following main specifications [20] - Measurement range: 0-5,000ppm; Accuracy: ±50 ppm ± 3% of Reading; Response time: 2 minutes; Automatic calibration (every 24h).

- LDR 5 mm Sensor – it is a sensor that allow to detect light; it is basically a resistor that changes its resistive value (in ohms) depending on how much light is shining onto the squiggly face [21]; Since it is low cost but inaccurate, they shouldn't be used to try to determine precise light levels in lux; instead, we can expect to only be able to determine basic light changes. Resistance range: 200K ohm (dark) to 10K ohm (10 lux brightness); Sensitivity range: CdS cells respond to light between 400nm (violet) and 600nm (orange) wavelengths, peaking at about 520nm (green).

2.4 Software

The firmware of the **iAQ Sensor** and **iAQ Gateway** was implemented using the Arduino platform language in the IDE ARDUINO. It belongs to the C-family programming languages.

The **iAQ Web** was developed in PHP and MySQL database. Web services that allow data collection are also built in PHP [22].

3   Results and discussion

The **iAQ Web** allows viewing the data as numeric values or in a chart form. A sample of experiment data for a selected room is shown in Figures 5 to 7. As examples, the graphs of relative humidity (Fig. 5), air temperature (Fig. 6) and CO_2 (Fig. 7) were chosen.
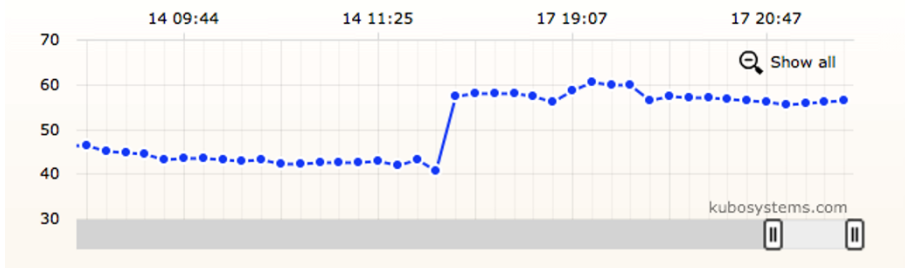
Fig. 5. Data visualization: Relative Humidity (%)
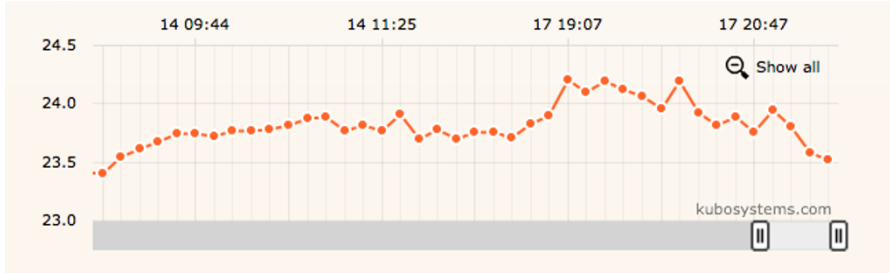
Fig. 6. Data visualization: Temperature (ºC)
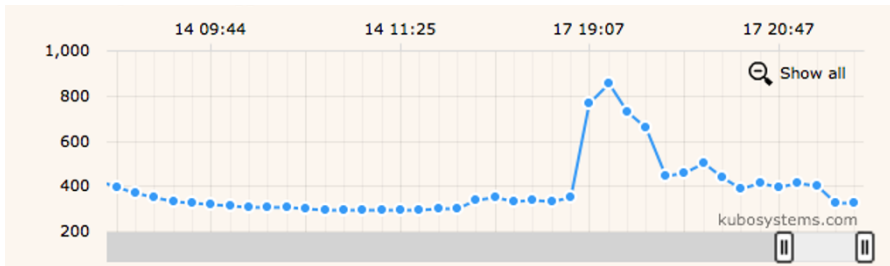
Fig. 7. Data visualization: carbon dioxide (CO2) concentration (ppm)

The graphic display of the environmental factors allows a greater perception of the behaviour of the monitored parameter than the numerical display format. On the other hand, the Internet portal also allows the user to access the historical data, which enables a more precise analysis of the detailed temporal evolution of environmental parameters. Thus, the system is a powerful tool for the detection of problems and decision making on possible interventions to improve air quality in the building.

The iAQ system is in the testing phase. At this stage the main goal is to make technical improvements, including their calibration. Among other advantages of the iAQ system, it stands out for its modularity, small size, low cost of construction and ease installation. Improvements to the system hardware and software are planned to make it much more appropriate for specific purposes such as hospitals, commercial buildings or factories.

4   Conclusion

This work aimed to present an effective indoor air quality monitoring system to prevent exposure risk. The system is developed using low-cost micro gas sensors and an open source microcontroller development platform Arduino. Five micro sensors of environmental parameters were used in each module, but other sensors can be added as needed. The system was tested by monitoring two classrooms. The results obtained are very promising, representing a significant contribution to indoor environmental studies. Nevertheless, the system needs further experimental validation in real environments, in particular with the assembly of more than two remote modules as used in laboratory

tests, in order to verify and calibrate the system more accurately. In addition to this validation study, physical system and web portal improvements have been planned with a view to adapt the system to specific cases or problems, such as schools, kindergartens or shops.

Compared to existing systems, it has great importance due to the use of low cost and open-source technologies. Note that the system has advantages both in ease of installation and configuration due to the use of wireless technology for communication between the IAQ sensor and IAQ Gateway, but also due to its small size, about 20x10 cm2, compared to other systems.

This system is extremely useful in monitoring air quality conditions inside buildings to better understand the current status of air quality as well as to study the behavior of environmental parameters. Thus, the system can be used to help the building manager for proper operation and maintenance to provide not only a safe and healthy workplace, but also a comfortable and productive one.

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Towards Paperless Hospitals: Lessons Learned From 15 Health Facilities In Uganda

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Abstract. This paper presents action research results on critical features that impact the implementation and acceptance of Electronic Patient Records Management Systems (EPRMS) by health facilities. The paper also discusses automation approaches as well as initial benefits reported by health facilities. The EPRMS is in use by over 15 health facilities in Uganda. The goal is to create a paperless environment for a group of health facilities in a resource constrained environment. The EPRMS incorporates features for Electronic Patient Records (EPR), Electronic Medical Records (EMR) and Hospital Management. A phased-roll out approach was used as a way to ease challenges of insufficient resources such as computers, unstable local area network, frequent power outages and skills-gap among others. The first phase covered Outpatient Departments (OPD) for production deployment while Inpatients, Maternal and Child Health(MCH), HIV/AIDS care centres are setup in training mode awaiting the next phase of roll out. After a year of use, we administered a questionnaire to understand the impact and challenges of EPRMS. The respondents were hospital administrators and managers. In addition to the questionnaire, the Uganda Catholic Medical Bureau (UCMB) has its internal annual reporting process. The results reported are from the questionnaire, UCMB internal reporting, our observations and interactions with key stakeholders during implementation. Our finding indicate EMR and EPR functionality are not highly rated by hospital managers while Hospital Management features are considered important.

1 Introduction

Manual hospital management, manual patient and electronic records are time consuming especially during collating and coding of data for local government and national reporting requirements. Automation of hospital processes has seen increased attempts in the recent years[14, 5, 18, 16]. EPR and automation of hospital processes relate to the management of hospital transactions including patients through capture and use of electronic data as the patient consumes services. There is consensus that automation of hospital facilities can breed efficiency and improve patient satisfaction [3]. ndeed Governments and Non-government Organisations are willing to invest in ICT-enabled Health are [10]. Despite evidence that EPR is crucial in provision of quality medical services [9], most hospitals in Uganda are still manual. Barriers that hinder implementation of EPRMS include the

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time involved for a practice to convert to EPRs from paper records, the training of health professionals on the new systems, and computer literacy [10]. Other challenges also include financial cost associated with purchasing the new EPR system and availability of technical sup

The Uganda Catholic Medical Bureau (UCMB) [19] is one of the key players in the Ugan heath sector. UCMB coordinates Catholic health units in Uganda, assists in personnel training the evaluation of facilities, and represents and advocates for Roman Catholic health care ser nationally and internationally. At the moment UCMB counts 32 hospitals (2 of them are specia service providers) with 12 training schools, 2 laboratory training school and 252 Lower Lever U (LLU), with over 8,225 health workers. The UCMB health service infrastructure constitut sizeable component (about 40%) of the public health system in Uganda.

UCMB envisages that the benefits of automation are much more than the cost and effort ne to address the challenges. With automation, UCMB aimed to help facilities to benefit from effe delivery of health services through fast access to information that supports planning, monito and evaluation of healthcare programmes. The information includes patient bio-data, insur records, as well as critical medical information. To facilitate the operation of these heath ce UCMB considered a robust management information system that can operate under the var environments across different parts of the country. The Hospital Information System that deployed is a heavily customised version of Care2X [2] renamed HeleCare2x [4].

The health facilities under the UCMB network differ in size, capabilities, resources, loca and are autonomous. Each facility is managed independently to best suit local needs and f innovation by facility managers. For instance rural based facilities use different billing struct and offer community based medical services. Consequently, the facilities share common core EPR features but need a number of unique features and customisation. The rollout process also ne to appreciate local technical and human resources to operate and manage the EPRMS.

The rest of the paper is organised as follows: In section 2, we review related work, Sec 3 describes the methodology used and Section 4 describe the key features prioritised by he facilities. Section ?? describes the challenges and initial benefits and a conclusion is given in Sec 6.

2   Related Work

In Uganda, many systems have been proposed by the Ministry of Health. Currently the min health operates a comprehensive manual Health Medical Information System (HMIS) [12, 7]. hospital facility is required to fill a given set of reports on a daily basis, monthly, quarter annual. Some of the information is sent to the local government authorities while the other is to the Ministry of Health Headquarters. Some of the nation wide automated systems focusin specific aspects include DHIS2 [1], IQCare [8]. At the moment, there is no official EMR or system recommended for use at the facility level.

DHIS2 was adopted at the Uganda National national level in January 2011. The system initially piloted in 4 districts, before it was rolled out to all the 112 districts by July 2012. As of the roll-out process, 35 training workshops targeting 972 users were conducted throughout country [11]

IQCare is a robust Electronic Medical Records (EMR) package designed by the Futures G International[3] specifically for HIV/AIDS care facilities. IQCare was adopted by PEPFAR fu

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[3] www.futuresgroup.com

project under the AIDS relief. It has been deployed in over 100 locations in Kenya, Uganda, Nigeria and Zimbabwe. IQCare is flexible and scalable with features to create multiple departments and orms; set up facility and patient home page reports and queries.

Through the Uganda National eHealth Technology framework [13] over 50 e-health related nitiatives were reported by the Ugandan Ministry of Health. The initiatives include mobile enabled ools such as Mtrack[15], web-based, decision support systems and surveillance tools. However, most nitiatives especially those related to EPR have not seen wide-adoptability or sustained usage for by health facilities.

3   Methodology

Our approach is based on action research process [17] in which we are monitoring and spearheading he implementation, deployment and use of EPRMS at 15 health facilities in Uganda. The implementation started in January 2013 and initially targeted five facilities for piloting and a phased oll-out to another 10 facilities before a future full-scale deployment to over 200 facilities under the UCMB network. However, our efforts at 2 of the pilot facilities and 3 of the 15 roll-out facilities were met with administrative and skill-gap challenges. New facilities within the UCMB network were selected.

The implementation started with an open source EPRMS that was customised and extended o fit the needs of health facilities in Uganda. To speed up implementation, requirement elicitaion and initial training were combined. The training started with the open source EPRMS as the first version. Care2x was chosen as the starting platform because is a Integrated Hospital Informaion System including Surgery, Nursing, Outpatient, Wards, Labs, Pharmacy, Security, Admission, Schedulers, Repair and Communication among others. It is Multilanguage, with WYSIWYG forms, Modular & scalable among others. Care2x is a mature product and has been implemented in other ountries including Kenya [6]. In addition there is a large number of programmers in Uganda familiar with key technologies such as Php and MySQL used in the development of care2x.

The customisation followed a detailed requirements gathering process from a representative set of hospitals. The hospitals were selected based on the location, nature of services provided and type of patients catchment. The catchment targeted is a combination of rural, peri-urban and urban health acilities. A comprehensive requirement analysis was undertaken to understand the current practices within the hospital facilities. The training and requirements elicitation were group based and in ome cases one-on-one. The training was in two parts: - one on the use of EPRMS and the other for ystems administrators. The systems administrators were considered as key stakeholders and their raining including Linux systems administration. The first round of training lasted between 3 to 4 days per facility. The initial training allowed intimate interaction with key stakeholders such as nurses, clinicians, doctors, pharmacists, managers and systems administrators in oder to understand heir needs. Before launch another round of 1 week training was conducted at UCMB headquarters or systems administrators. After the initial training, two setups we made, one for production and another for training.

A phased-roll out approach was used both on the number of the health facilities to be automated and the number of departments to automated at each facility. The pilot started with five facilities, and later scaled to10 health facilities. Within each facility, the EPRMS was first installed at the OPD which accounts for a larger percentage of the patients. The OPD deployment covers EPR, EMR, and related services such as laboratories, billing, pharmacy and reception/triage.

After a year of use, we administered a questionnaire to understand the impact and challe of EPRMS. The respondents were hospital administrators and managers. In addition to the q tionnaire, UCMB has its internal annual reporting process. The results reported are from questionnaire, UCMB internal reporting, our observations and interactions with key stakeho during implementation.

4   Core Features and Services

Health facility administrators are among the key stakeholders required for successful impleme tion and sustainability of EPRMS. In all facilities, hospital managers ranked patient and reso management features above EPR and EMR features. Key issues of concern included minim revenue loses and increasing patient satisfaction through faster service delivery.

4.1   Existing Process and Patient Flow

Figure 4.1 is a high level view of the common flow of patients as they move from one service p to another. It is expected that all patients flow from the registration desk to cashiers, clinic and so on. In the majority of the OPD cases the flow will include: Entry $A \rightarrow$ Registration, pay consultation, $C \rightarrow$ go for examination by Clinicians/Doctors, $D \rightarrow$ Pay for Investigation, go for investigation, $F \rightarrow$ interpretation of results, Diagnosis, prescription by Clinicians/Do $D \rightarrow$ pay for Medicine, $G \rightarrow$ Receive Drugs from Pharmacy, $H \rightarrow$. However in a number of c a patient may skip the registration desk and proceed to the doctors. This is common for emerg cases where no time must be wasted at the registration. In other scenarios, patients may just in for lab tests recommended by clinicians from other facilities. In all these scenarios, the sy must be able to take critical data at the first point where it interfaces with the patient.

Other categories of patients such as Pregnant Mothers, HIV patients and Maternity case usually managed separately from the rest of patients and the data needs to be captured at the point of contact with the hospital staff for subsequent use in the rest of the patients visit.

To enforce data capture, no billing is possible unless a patient has a minimal set of data rec In normal usage, the bill is generated as the patient moves from service points such as lab t consultations at physicians desk, prescriptions and so on. We have discovered that staff man some of the service points may not enter the data immediately either due to electricity/p challenges or inefficiency by the staff thereby making it hard for other tasks to proceed. The bi points and server room are installed with power backups and this ensures billing functionalit continue even when other points have no power. Because of this challenge, the system is desi to capture varying levels of data at each of the possible service points. For instance, the bi point allows capture basic information such as bio-data and service consumed in case they are already in the system. Hospital managers required that the system supported all existing pa flows. However some facilities have been able to find optimal path that speed up service deliv

4.2   Drug Distribution Framework

Drugs and other consumables are a critical resource in hospitals. Their acquisition, management tracking must be monitored and audited for hospital managers to realize the benefits of autom hospital management information.
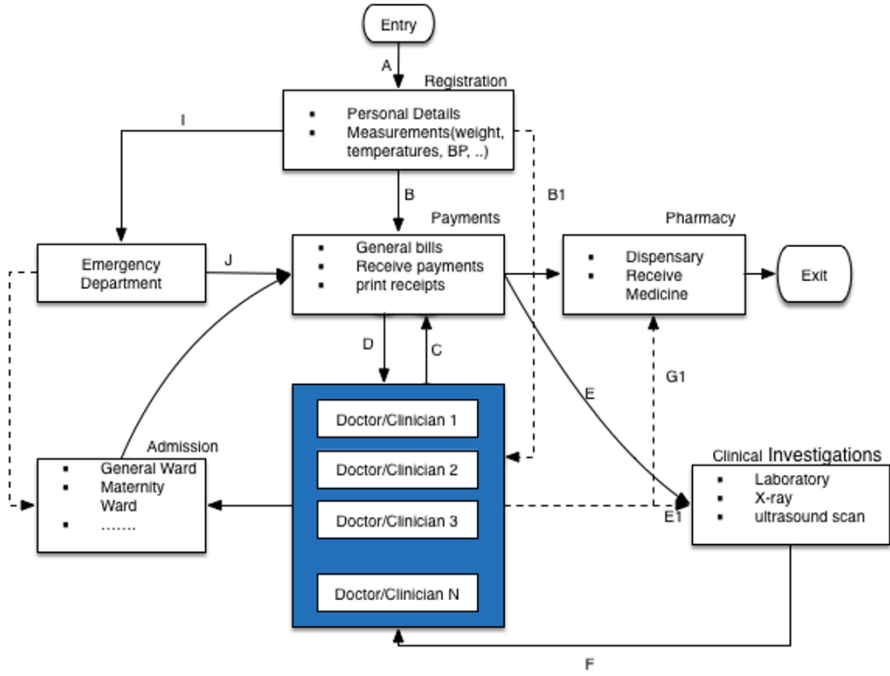
Fig. 4.1: Standard Flow of patients in health facility. .

In most hospitals, when drugs are purchased, they are first stored and recorded in the main pharmacy or medical deport. From the main pharmacy, drugs are then distributed to the dispens- ng departments. A dispensing department may serve one or more medical units. However, some dispensing units can also distribute drugs to other dispensing units. At the same time, drugs can be lost through damages and as such there is a need for a reconciliation between stocks in the dispensaries and those in the main pharmacy.

Tracking of batches is one important aspect. It would be nice to have code readers at the dispensing units to track batches up-to the patient. However due to cost implications, a provision or manual capture of such information is provided. A key design decisions was taken to enable or disable strong coupling between pharmacy inventory, ability to prescribe or dispense drugs on the ystem in case of low inventory levels in pharmacy/dispensaries. This design decision was based on need to capture medical data without strong emphasis on drug auditing logs. Drug management was needed as key feature to allow sustainable of the system by hospital administrators and managers.

4.3   Knowledge Management

During pilot deployments, the use keyboard as the main data capture device proved to be consuming for physicians and draw attention away from the patients during consultations. Also typing speed of most users was still low. A design decision was taken to minimise typing by u Information such as drugs and their dosages, symptoms, diagnosis, lab tests and interpretatio findings, test result ranges among others are part of the system initialisation with provision the systems administrator to add, remove and edit the details. Whereas there was a tempta to allow clinicians or doctors to edit these lists, a decision to allow centralized control of the through the systems admin was considered. The advantages allows consistence in data analysi symptoms, diagnosis, allergies and other medical information. Also a centralized list improved speed of data capture since users just pick without typing as indicated in Figure 4.2 that shows of the interface for prescription of drugs. The knowledge on drugs is already captured and man within the system. To speed up data entry, a browser based search was implemented.
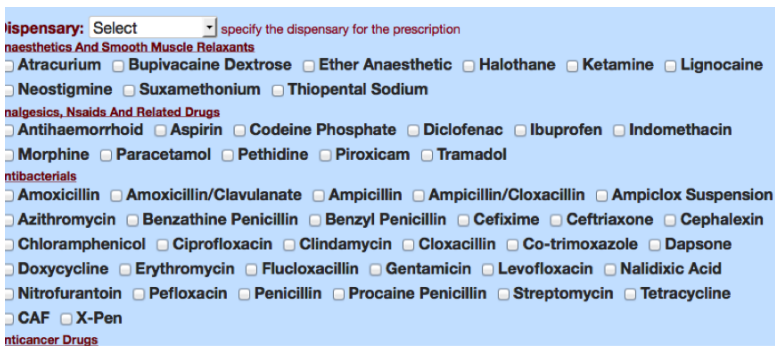
Fig. 4.2: Screen short of the drug prescription interface. The interface allows medical offers to select o more drugs and proceed to provide additional prescription details. Typing of drugs by medical offic eliminated to avoid mistakes and allow more precise analysis and reporting. Drugs missing on the lis be added by through a back end interface

One of the key concerns by clinicians was was that excessive typing districted them from tending to patients. Therefore any reduction on the time spent on the computer by adding feat such as searching, drop-down options, and so grately increase acceptance.

4.4   Familiar and Faster Interfaces

Through practice, medical personnel are accustomed to specific documents such as Form 5 to cap treatment details for a given patients' visit. Data capture cards for outpatients, inpatients, anten and many other documents are well understood by most medical personnel. Paper-like inter such as in Figure 4.3 were developed to ensure smoother transition from paper to electronic. De similarity between paper-based forms and the electronic versions, users mainly from rural faci still required more time and patience to train them to use computer and appreciate the interf

The Ugandan Ministry of Health in its HMIS manual [12, 7] specifies over 200 paper-based templates or data capture and reporting.

Fig. 4.3: Paper like look and feel for patient registration with links to standard forms such as Form 5

Routine inspection by Ministry of Health Officials still require specific layouts of certain reports and registers. So for acceptance, all efforts were made to make electronic versions of reports and orms similar to paper versions

4.5   Billing and Payments Automation

Most hospitals provide all or some services at a fee. The modes of billing vary from facility to facility. General billing systems charge according to what has been consumed. However, some hospital acilities provide for flat rate services. A flat rate is where a set of drugs and services require a ingle fixed fee regardless of the actual overall cost of the items consumed. 3 of the 15 facilities apply flat rate services.

Management of insurance schemes together with flat rate schemes poses another automation hallenge. An account for each insurance scheme must be kept and patients must be properly dentified to belong to the right insurance scheme. Some insurance schemes also cover dependants who must be identified and billed accordingly. Similar to flat rate schemes some insurance schemes have a limit on the amount to be consumed within a given period. The time periods for the ceiling ange from a single visit, to daily, monthly or annual. The limit may be applied on specific services uch dental or plastic surgery. This makes it important for the system to establish which medicines or services have to be paid for by the patient.

5   Benefits and Challenges

This section contains preliminary findings on the benefits and challenges of using EPRMS.

5.1   Challenges Encountered

The main challenges encountered are lack of resources such as computers, unstable Local Network (LAN), and frequent power outages. All facilities are connected to national power however the power grid is on and off. Alternative power sources such as generators or solar p are not yet affordable by most facilities.

The EPRMS runs on Local Area Network (LAN) and the perceived speed and availabili the EPRMS is much dependent on the quality of the LAN. One challenge that was noticed is most LAN setups at the healthy facilities were very unstable mainly due to poor networking low technical skills by IT staff. Some facilities try to cut cost and use indoor Cat 6 cables as out cables to connect distant departments and wards.

Another challenge is that technical skills in computer use and maintenance, internet use low in the health facilities. Despite the training it was noticed that it takes time for the trai to translate into good level of skills. Related to computer skills, the new Windows 8 and o 2010 user interface was confusing for users trained using older versions. Fear of technology by s health workers also affected utilisation and adoption for routine activities.

Introduction of new costs to the facilities implementing EPRMS such as timely replacem of spoilt parts of equipment was another challenge. For instance, lightening affected/destr equipment in five of the fifteen facilities. Lightening arresters were installed at all facilities to a reoccurrence.

Last but not least, implementation of EPRMS was also face with a challenge of poor inte connectivity in many rural areas where the majority of the facilities are located. This affected ability to download new updates, provision of online technical support and need to download definitions.

5.2   Initial Benefits Reported

During the June 2014 UCMB reporting, of the 14 hospitals that were asked to provide info tion on changes brought about by EPRMS, 60% noted that Patients receiving services from t facilities trust receipts produced by the system more and complained when issued with summ receipts from receipt books whenever there was an interruption to the system. Such interrup are common due to power load shedding. Printed receipts have information for the patient to v and this contributes to patients satisfaction because of the detailed breakdown of the charges as consultation charges, lab tests requested, drugs prescribed. This improves patient to hos relationship and eventually increases service utilization because of recommendations by sati patients to friends and relatives.

There is a reported increase in revenue collection by some facilities. St Johns Paul Aber St Josephs Kitgum hospitals have reported at least 3% increase in user fees. The increme attributed to the ability to capture and bill all patients that visit the facilities.

A reduction and reuse of stationary has been observed at some facilities. Receipts and o outputs such as treatment forms for patients are printed using ordinary ink and in some cas the back of already used paper with minor prints.

6   Conclusion and Future Work

We have been able to deploy and monitor the EPRMS for at least 15 facilities. Initial benefits include ncreased revenue, minimal stationary usage, improved decision making at the hospital level, and more trust by patients due to detailed information provided to them on the receipts. Our unique etup required a system with multiple configuration to allow flexibility especially during billing. As more options were provided to accommodate the variations, the system inevitably grew bigger and more complex requiring more training on the side of system administrators. We hope to extend usage of EPRMS other 200 health facilities in the country under the UCMB network. In addition, we plan to active EPRMS usage beyond the OPD to cover Inpatient department, Maternal and Child Health Units and HIV/AIDS care centres among others.

Observations and interactions at facilities indicated that preparation of reports for local authorities and national reporting is time consuming. Therefore integration of helecare2x with existing national reporting systems such as Dhis2 [1] is one of the future tasks to be carried out. More tudies and support for decision making at hospital level will be carried out in order to increase the benefits of EPRMS for hospital managers who are the key drivers for sustainability of EPRMS.

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Performance Improvements to a Large Scale Public Health Data and Analytics Platform: A Technical Perspective

A Case Study of a Large Public Health Data and Analytics Program for a State Government in India

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Abstract. Public Health planning and administration comprises 3 broad functions viz., health needs assessments, policy development, and administration of services. Health Informatics plays a significant role for effectiveness of each of these functions. This paper presents practical technical learnings from implementation of performance improvement measures for a large Open Source based Data Analytics platform for Public Health. This paper is unique in its attempt to categorize the problem on the above lines. The authors present a study of a real-life large data warehouse and public health data mining implementation that has faced significant challenges and discuss solutions to address those challenges. With rapidly changing technology landscape, specifically in data and analytics space, dynamic changes to population composition and the resultant expectations from public health, research focused on public health data integration and data mining needs higher attention. The paper concludes with summary of best practices discussed and future directions.

Keywords: *health informatics . public health metrics . KPI . data mining . insights . challenges . solutions . implementation . data quality . public health data research . Decision support systems . Open source stack .*

1 Introduction

Public Health is the collective action taken by Society to protect and promote the health of the entire population. Public Health is broad and inclusive, although it is often considered from only a narrow medical perspective [1].

Public health accrues innumerable measurable indicators. Key performance indicators represent a set of measures focusing on organizational performance and outcomes that are most critical for the current and future success of the organization. KPIs are highly relevant in management of public health. They act as flags drawing attention where required, bring in accountability, enhance scrutiny, and help channel public resources to areas of need [2].

This paper is organized in 4 Chapters. Chapter 1 discusses literature on the topic of health analytics, public health data collection and analysis. Chapter 2 introduces

the context of the project discussed in detail in this paper as a case study i.e. State Health Data Resource Centre (SHDRC). Chapter 3 lists out the technical challenges faced & solutions implemented in this large scale public health data warehouse. Chapter 4 concludes the discussions with summary of learnings from the case study.

Public health informatics necessitates collection of data from primary health care organization to tertiary organization inclusive of different federal and private bodies. The very fact attributes to multiple data sources and standards thereby adding to the complexity of data collection. OSS is rapidly becoming part of more public health applications [3]. The reasons are multifold viz., policy, lower total cost of ownership, version upgrades, auditability, flexibility and freedom.

Published literature explains how Public Health Surveillance moved from mere counting of death to more advanced data collection and comprehensive information management as Health Informatics [4]. Another published report lists that the key challenges to be addressed in future will be lack of skilled workforce for analytics, database management, and inadequate computing resources [5]. It is in this backdrop that this paper presents as case study of a large scale data collection and analytics program in public health in India that aligns with published literature on the need for such works and addresses the growing domestic health intelligence expectations while aligning to the global recommendations described above.

2   Overview of State Health Repository

2.1 Program Background

Healthcare delivery in India follows a very unique and balanced model. It follows a hybrid concept where it is neither completely market driven as in the US nor is it entirely public funded as in UK or Canada. Healthcare in India is a State subject. Each State gets to set up and run its healthcare delivery infrastructure independently. This is supported by National level programs that focus on a specific disease or a section of the population. The system follows a hub and spoke model for primary, secondary, and tertiary care. This is supplemented by various other networks like those of Medical Education, Revised National Tuberculosis Control Program (RNTCP), Indian Medicine (AYUSH), National AIDS control organization (NACO), ESI (Employees State Insurance), etc.

With each of the arms providing a whole range of services, it is difficult to get a comprehensive view of population health statistics; however, each function is necessary for the valuable services they provide and to cater to the high population numbers in the country. Universal access and affordable health are the key drivers currently directing the health set up in the country [6]. While the country is focusing on providing its citizens access to basic healthcare, the need for data and analytics is all the more pertinent. It needs to focus on optimization of resources in the most appropriate manner to get the best program outcomes. As more and more people gain access, it is now encountering a situation called Double Burden of Disease [7] where

it has to handle communicable diseases as well as a   growing   number   of   non-communicable diseases and injuries.

The State of Tamil Nadu, the sixth most populous state in India with a population of 72 million [8], has always been proactive in improving its health situation. Today it is one of the healthier states in the country [9]. It has an Infant mortality rate of 21 against the country average of 40, similarly the maternal mortality rate stands at 90 against India's 178 [10].

The State Government of Tamil Nadu has taken various steps to make its public sector health services more accessible and equitable to the general public and the poor alike through "Tamil Nadu Health Systems Project" (TNHSP).   In order to promote research, improve health outcomes, initiate evidence based actions at State, District, Directorate & other Institutions and to enable research insights based policy formulation, TNHSP embarked on a progressive move to establish a comprehensive state-wide health data repository named State Health Data Resource Center (SHDRC).   This progressive initiative is funded by The World Bank, State Government of Tamil Nadu, National Rural Health Mission, and Indian Council for Medical Research.

Accenture is the System Integration partner responsible for infrastructure planning, design / build and implementation of this large Data Warehouse. Functional and technical Experts from Accenture Health Analytics Solution Factory architected the Solution and were steering end-to-end implementation. Open Source BI was the chosen platform for all layers of the Technical Solution (PostGRE SQL for RDBMS, Pentaho for ETL, Pentaho for Dashboards / Reporting / Visualization and Weka as the data mining and predictive Analytics engine).   This project is successfully implemented and currently extensive organization wide adoption is taken up with training and enhancements.

2.2 Program Objectives

The primary objectives of establishing SHDRC are listed below:

- Health data consolidation at the state-level from various health data sources.
- Implement, maintain and support the technical infrastructure required for the state data resource center.
- Devise and implement strategies for data quality improvement and data validation
- Develop and maintain health information management related policies and standards.
- Develop, implement/recommend training/capacity building strategies related to data monitoring and evaluation.
- Liaise and provide support to various Directorates in ensuring that the mandated data reporting requirements (such as the notifiable diseases reporting) from public and private institutions.

- Strengthen health system research through independent research as well by providing mentorship to directorates and other stakeholders at various levels.

2.3 Conceptual view

Fig. 1 provides a view of the Data Warehouse System (DWH) built with the various layers from source systems to staging to DWH and end user consumption layer.
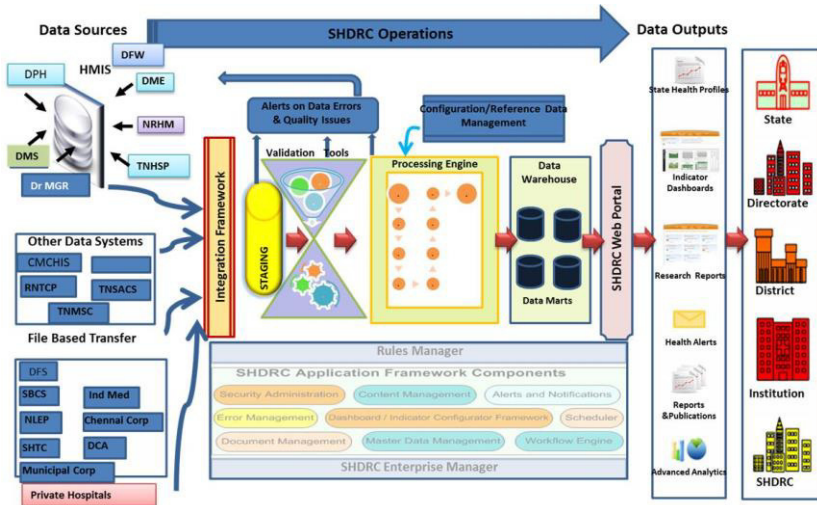
Fig. 1. Conceptual view of the DWH System SHDRC

3 Challenges and Solutions

This section covers the challenges faced & solutions implemented in the process of consolidation, cleansing, integration and reporting of data in a large scale public health initiative, based on the implementation experiences of the project being presented as a case study i.e. SHDRC introduced in Section 2. The challenges are categorized as given in Table 1

Table 1. Category of Challenges

S. No	Category	Description
1	Definition	Challenges related to defining the data sets or defining the Key Performance Indicators required to meet the program objectives etc.
2	Data governance	Challenges related to collection of large scale public health data or their consolidation and integration.
3	Design & Performance	Challenges related to application design, solution & information architecture, development and consistency across health directorates; application, database, user interface, network, OLAP cube performance and tuning the former.

3.1 Definition Challenges

Requirements. Being a pioneer project in the country, lack of precedence resulted in a huge challenge in arriving at requirements of the project. The health directorates were traditionally used to paper work. The skill and comfort level of the directorate to adapt to information technologies has been an additional effort to them, leaving them to expend very little time for requirement discussions.

Data diversity. Data was sourced from 9 different sources and from ~300 web forms in different formats. ~900 Extraction/Transformation and loading routines are used for cleaning and integrating data.

Data Volume. 5000+ indicators were rolled up into 300 KPIs. 3+ TB of data was sourced from 2200 hospitals and other institutions serving ~5 million beneficiaries.

Dataset Definition. The challenge was to decide how to group the incoming data to facilitate storage as well as keep them malleable to various analyses.

Fig. 2. Logical groupings of KPI's

Solution. The KPIs were organized logically into 5 categories as in Fig. 2 viz., input, process, output, outcome, and impact metrics. More than 10,000 indicators were analyzed along with more than 300 key reports to identify the few indicators which

would provide the exact picture of inputs, process, output and outcomes of any program/directorate.

The problem of plenty was solved through an approach of "Divide and focus". SHDRC was designed to streamline the analytics offerings organized into 6 layers explained in Table 2

Table 2. Presentation Layer by Zones

S. No	Layer	Description
1	Dashboard Zone	Summary view of KPI performance against targets / thresholds with color schemes to highlight under or over performance. This layer was targeted at very senior level policy decision makers.
2	Reports Zone	Detailed reports with drill down at granular level data available for middle level management.
3	Indicator Zone	Micro level indicators (several thousands) available for reference including history for comparison targeted at operational level personnel
4	Analysis Zone	Pre-defined analytical templates that present insights for medical officers and research professionals
5	Freehand Zone	Key data elements grouped as data sets and provided as palette for users to define their own templates and analysis views.
6	Predictive Zone	Scientific analysis, data mining and predictive analytics leveraging Weka predictive engine, targeted at Policy research and medical outcome research.

3.2 Data Governance Challenges

Data Availability. The first challenge faced here was to ascertain data availability. Data is collected reaching out to grass-roots level and setting up appropriate processes.

Data Integrity. At most locations, data capture was being done by public health practitioners who face practical challenges of huge patient turnaround, hence poor attention is given to capture of complete and in many occasions correct data. This resulted high levels of data quality issues at the source systems itself. Due to the vastness of the system and speed of response and treatment being the primary objective at the field level, it was also a challenge to implement incremental checks and balances at the data capture stage to ascertain the integrity of the data.

Data Duplicity. India is still in the process of setting up a universal identification number. This meant that the chances of data duplicity were high as there were very limited means of defining unique patient identifiers. The likelihood of one patient

visiting multiple times for the same or different illness getting clocked as different patients was very high. This meant potential anomalies in analyses and research insights.

Solution. While Data integrity was maintained by training and education programs, we can manage to maintain the integrity for advanced analytics needs by applying imputation techniques like hot deck imputation etc. Data de-duplication by identifying a patient across visits using contact number, address, name helped reduce duplicates by 75%.

3.3 Design and Performance Challenges

Portable design. The application had to cater 21 health directorates collecting data from compound sources. Design has to be maintained consistent, seamless and portable across directorates where system of records vary greatly. Schema objects and design components has to be mutually exclusive and finally integrated. Open source software was the preferred tool stack. Tool selections have to be made consciously to ensure security, features, interact with legacy systems and external/Third party application for data exchange needs.

Simplified user interface. Design simplicity has been an admirable challenge. Data entry points should be at the comfort level of users. Designing complex UI will lead users to skip entries and thereby data capture loss. Presentation Layer consistency across directorates is very much appreciated since training across directorates is much easier and transfer of employees between directorates do not require big learning curve.

The Design and performance challenges and solutions are given in Fig. 3 and Table 3.
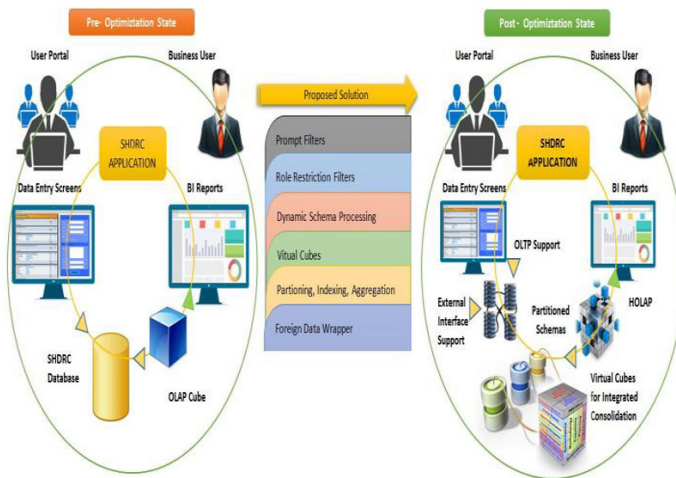
Fig. 3. Performance Optimization

Table 3. Performance challenges and solutions

Pre-Optimization	Proposed Solution	Post-optimization
BI reports refresh took ~4-5 minutes	Prompt Filters	BI reports refresh in ~30-40 sec
OLAP cube failure on data volume	Dynamic schema processing top parameterize OLAP cubes	Parameterized OLAP cube was able to handle large volume of data
Slow DB response	Partitioning, indexing, Aggregate tables	Data retrieval within a minute
External data load took more time	Foreign data wrapper	FDW made external data access local to the system
Unrestricted access	Role restriction filters	Improved data security
Data retrieval across directorates took ~6 minutes to load	Virtual cubes	Consolidation of common data across directorates reduced load time ~1 minute

4   Conclusion

This Paper presented a summary view of experiences from a real-life, large scale public health data consolidation and integration project, presented as a case study. Besides data collection, integration and consolidation, this project also involved data summarization and consumption of data i.e. insights generation and their adoption through structured analysis of key performance indicators.

This Section provides a conclusion summarizing the key learnings presented in this paper as below:

- The approach to rank and prioritize the focus key performance indicators from a long list of indicators that public health administrators require for administration of public health service.
- Approach to categorize information requirements in the structure of Input-Process-Output-Outcome-Impact metrics and how they are mapped to the data elements.
- Approach to handle key design and performance challenges in the capacity of database, user interface, OLAP cube and presentation layer.

- From a technology perspective, it is interesting to note that Open Source BI Technologies can be effectively used for large scale data integration and analysis in public domain.
- In future, tremendous scope exists for exploring data quality assessment and measurement methods integrated as part of large data and analytics initiatives for public health.
- Predictive analytics, even though still in nascent form in public health, is essentially the future of public health and the same needs to be developed systematically.

Acknowledgment

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An mHealth remote monitor system approach applied to MCC using ECG signal in an android application

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Abstract. Nowadays some mHealth paradigms are being subject to changes with the emergence and advances in Mobile Cloud Computing (MCC) using low power data exchange systems like Bluetooth for sensors. This paper shows a different approach of MCC applied to mHealth by introducing a new architecture developed to an application for mobile devices, treating ECG signals using Cloud Data storage and a specially developed frame architecture between the sensor and the mobile device to detect and correct as many errors as possible. The proposed approach not only shows the convergence of MCC, but also focuses on the mHealth scenario to show some benefits of its use in the modern world. A secure link algorithm was also developed between mobile devices and the ECG sensor transmitter.

Keywords: IoT; Mobile Cloud Computing; Bluetooth; ECG monitoring; Error Control.

1   Introduction

In many ways smartphones have turned out to play a major role in our modern world, breaking paradigms not only for mobile health (mHealth) systems, but also in many other circumstances of our daily lives. Almost every day, new applications for mobile devices come up to solve problems in different areas. This way, smartphones have become part of an increasing revolution when using several different services since calling a taxi, booking hotels, up to more specific tasks such as remotely monitoring elderly people's health conditions as it is the proposal of this paper.

The contribution of this work is to provide means of using the available hardware present in most of mobile devices to have a safe link to an ECG node, combined with

new services recently available on the Internet that allows remote users to access any data stored on a remote server with the format defined by the system's designer.

2   Related work

Many recent studies have proposed solutions considering IoT and cloud computing for different scenarios. Some of them are related to the smart city concept [1-4], others to mobile health (mHealth) as the one in [5] that discusses about the Virtual Cloud Carer Project which has health and social proposals as objectives and presents an overview of the architecture that they developed using intelligent mobile devices able to integrate with many biosensors and the data processor cloud. Another example is a detailed platform by Pereira et al. in [6] based on the Mobile Cloud Computing where sensors interact with a mobile device by Bluetooth and access the cloud via Internet. What differs from this work is that another specific goal is aimed, which is the supervision of an ECG signal with specific requirements concerning sampled data rate and error control.

3   Internet of Things and Cloud Computing

New web services are influencing all aspects of new businesses model on today's life [7]. Nevertheless, only in 2005 the first article about this theme [8] was published by the ITU about this theme. By that time, ITU explained IoT as "a new dimension has been added to the world of information and communication technologies (ICT): at anytime, any place connectivity for anyone, we'll now have connectivity for anything." Since then, many new definitions for IoT has appeared like the one in 2009 from the Cluster of European Research projects on the Internet of things (CERP-IoT) that states: "a dynamic global network infrastructure with self capabilities based on standard and interoperable communication protocols where physical and virtual things have identities, physical attributes, virtual personalities, use intelligent interfaces and are seamlessly integrated into the information network" [9].

In this world of information with different network objects, according to [10] new definitions come up like Machine-to-Machine (M2M) communications related to the connection between two entities that don't need any human intervention, Mobile Cloud Computing (MCC) that is a combination of Cloud Computing and mobile networks as well as Smart Objects that are related to the objects like sensors, mobile devices or any other object on the network.

4   Application scenario and implementation

In this paper a solution is proposed to find a way for establishing a link between an ECG sensor and a local mobile device with flow and error control, as well as

connecting the so called local mobile device with an extra remote device using cloud data storage, like showed in figure 1.
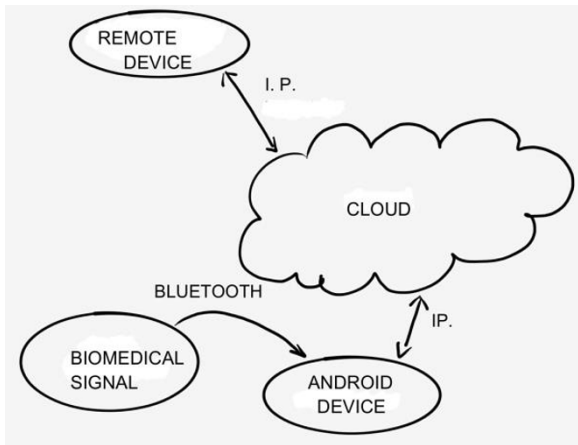
Fig. 1 Main idea of Cloud Computing

Among mobile devices on the market, most of them are equipped with android operation system. That is the main reason why this operational system was chosen. However most devices still have a simple Bluetooth hardware, they do not implement an appropriate Bluetooth protocol with flow control in asynchronous mode communications. Although Bluetooth has been developed to be implemented in many different scenarios, when a kind of oriented connection is necessary, its data flow control is handled only by the operational system, but not by the application itself. That's why one of the prior tasks to be implemented in this work was a data flow control algorithm, not only running on the sensor side but also implemented in the android device.

4.1 The ECG sensor

The first challenge faced by this work concerned an electrocardiographic (ECG) signal to be sent from a sensor physically connected to a microprocessor, more precisely an Arduino Nano board, that sends the ECG signal to a local mobile device like a mobile phone or tablet by Bluetooth, either with no errors or warning signals telling that the sensor is either far from the device or having problems sending the data. Signal loss must be prevented at all costs, because the project takes into account that the ECG must be appropriately sent, frame by frame, and in order to avoid the android screen from stopping responding or eventually even freezing.

The ECG waveform is first treated and conditioned to a 1 Vpp signal that is applied to an input pin of the Arduino board. Afterwards, the microprocessor's analog to digital converter (ADC) circuitry sample the input samples at a rate of 500 samples per second, storing the data internally before sending.
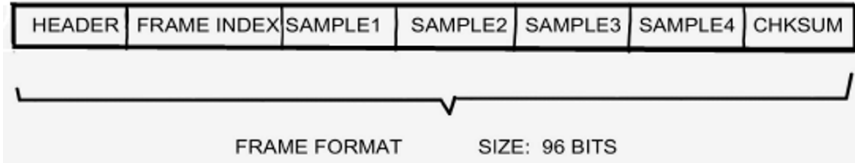
Fig 2. Frame Format

Within each four samples, a frame is generated as shown in figure 2 for further transmission. This frame contains a preamble, an index corresponding to the frame number, the four sampled data and a checksum code generated for the 4 samples. Within the time while the other three samples are only being stored for further transmission, the algorithm verify if there is any other frame that has not been correctly received yet by the android device, still then to be transmitted. This is shown in figure 3. In this case an error code is generated by the comparison between the checksum received with the one calculated from the received four samples. This code corresponds to the frame index number itself and it is sent back to the Arduino board that puts it into a buffer waiting for retransmission. This buffer is organized by an internal routine in ascending order, so that the oldest frame always has the priority to be retransmitted.
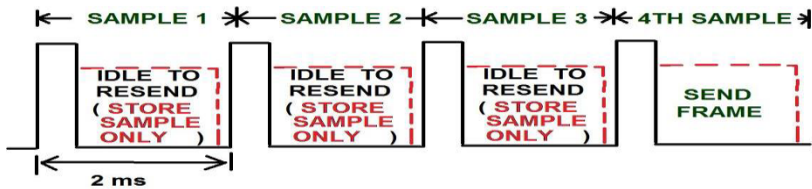
Fig 3.Sequence of four frames

This scheme of transmission was developed as a sort of oriented connection communication between the two parts involved as a simple solution for correcting few transmission errors that may happen by chance in low noise environments. The amount of errors handled by the Arduino board is limited to five frames as a fixed parameter. This means that no more than five frame indexes retransmitted back from the android device can be stored in the error vector in the Arduino side. The equivalent of a maximal 20 samples can be retransmitted. After that, a signal loss is shown in the screen and the transmission starts from the beginning.

The microcontroller keeps sending data frames to the android device and at the same time the interrupt service routine (ISR) receives data from the mobile device also by Bluetooth. Whenever an error code is detected by the local application, it is sent back to the Arduino board. The following figure 4 shows the timeline description of this procedure between the two parts.
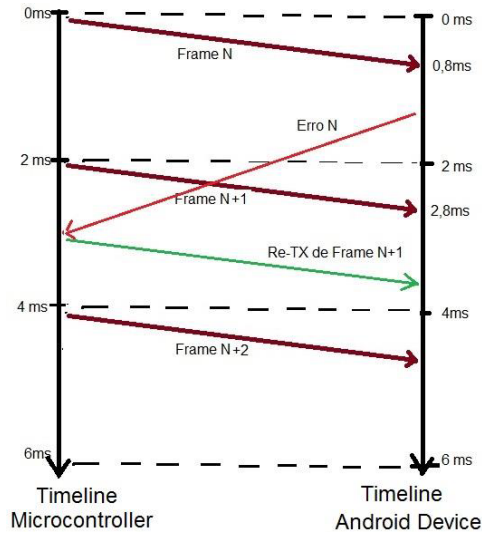
Fig 4. Timeline between the microprocessor and the Arduino

4.2 The Android application side

In the Android application side, a specially designed thread exists to process the data received from the Bluetooth internal hardware, not mentioning the main activity responsible for showing it on the screen display. The thread treats each received frame, taking the four samples from it apart, for further checksum calculation. The calculated checksum is then compared with the one sent within the frame and if they differ from each other, the just received frame number is sent back to the Arduino asking for further retransmission by Bluetooth. In such case, this index frame number is stored by the local application in a local vector of errors still to be received correctly. Only when that same frame number is received correctly, the vector of errors storage is then reset.

The android screen is renewed every second corresponding to 500 samples that are contained in 125 frames. The 500 samples are sent at once to the main activity together with the number of errors count by the thread.

The user interface also lets the user decide whether or not to store the data in the cloud. For this purpose, parse cloud was selected because of its easy usage. In order to do so, the user simply has to click on the respective button at the main window user application. Parse.com deals with many sorts of data types, like strings, bytes, vectors of bytes, integers, etc, but unfortunately not with word vectors. As each sample corresponds to a 16-bit word, existing in this case a vector of 500 words to be sent to the remote cloud server, this vector must be split into two parts: the most significant byte vector and the least significant byte vector, both of size 500. The storage process works by storing these 2 byte vectors. The parse cloud focuses on making easier for the application developer to store data on its remote server, working as a backend for android applications.

Another thread in the local application works in android devices as a timer in order to prevent the application from stops responding. It counts until 1 second in 100ms steps. If for any reason the transmission fails or stops responding for more than 900ms, the system starts all over again, as the previous screen was lost. Figure 5 shows the flowchart of it.
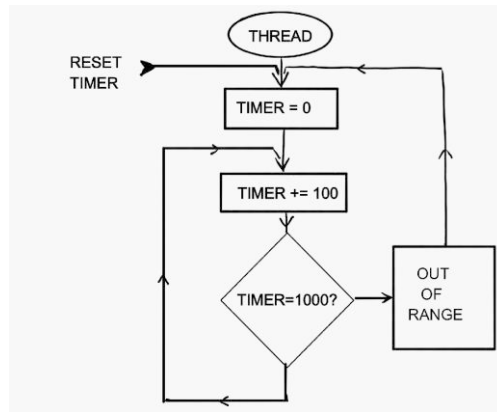
Fig 5. Timer routine

4.3. The remote android application

The remote android application was simply designed to read the appropriate formatted data from the cloud server whenever it exists. When started, it waits for 10 seconds until some data arrives, otherwise an error message appears on the display. If there is data in the cloud, it starts reading and displaying 500 samples per second. There is also a rewind button that allows to start the reading from the beginning and another button to freeze the reading, working like a time-shift. In this last case, by pressing the resume button, it continues displaying from the point where it had stopped.

5.   Final Comments

This article showed a new proposal for a more controlled communication between an ECG sensor node and a local android application concerning flow and error control, as well as proposes a way of easily sending data to a remote IP address linked to another specially designed android application, highlighting the convergence of mobile cloud computing and mobile health systems. In our approach, a secure connection algorithm was developed to establish the appropriate link to the local android application that displayed the ECG signal on the device screen, as well as let the data available at a remote cloud server, either for an online reading by a specially developed remote application or for a future reevaluation of the prestored signal whenever needed.

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The impact of the Security Competency on "Self-efficacy in Information Security" for Effective Health Information Security in Iran

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Abstract. The security effectiveness based on users' behaviors is becoming a top priority of Health Information System (HIS). In the first step of this study, through the review of previous studies 'Self-efficacy in Information Security' (SEIS) and 'Security Competency' (SCMP) were identified as the important factors to transforming HIS users to the first line of defense in the security. Subsequently, a conceptual model was proposed taking into mentioned factors for HIS security effectiveness. Then, this quantitative study used the structural equation modeling to examine the proposed model based on survey data collected from a sample of 263 HIS users from eight hospitals in Iran. The result shows that SEIS is one of the important factors to cultivate of good end users' behaviors toward HIS security effectiveness. However SCMP appears a feasible alternative to providing SEIS. This study also confirms the mediation effects of SEIS on the relationship between SCMP and HIS security effectiveness. The results of this research paper can be used by HIS and IT managers to implement their information security process more effectively.

Keywords: Health Information System; Security Effectiveness; Security Competency; Self-efficacy in Information Security.

1   Introduction

Health information system (HIS) is defined by the World Bank [1] as "system for the collection/processing of data from various sources, and using the information for policy making and management of health services"; in fact, HIS is the "key component of any health system".

However, the use of HIS is caused to reduce clinical errors and improve the quality of patient care; the importance of securing HIS increases progressively.

Healthcare organizations spend more on security technologies, both software and hardware and focus mostly on external attacks. However, the use of new security technologies does not minimize the number of security incidents. Literature on HIS

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security and data security has shown that cautious and unintentional users' behaviors may cause a threat to IS [2].

Some researchers identify and organize the significant threats related to HIS and found that the majority of HIS security incidents occur as a result of human factors and HIS users' behaviors [3-6], whereas some of the studies have identified users are a key threat to overall IS security [7-10].

Although the information security literature contains an abundance of studies, which have identified factors that mitigate information security risks [11, 12], very limited research has focused on studying HIS security and risks in the healthcare sector [4, 13] and less data exists on the nature and extent of security incidents in HIS; and most of the existing methods were based on technical viewpoint [14-16]. Therefore, it is important to focus on the HIS security effectiveness related behaviors of existing and possible HIS users [13, 17].

This study uses the definition of IS Security effectiveness that provided by Straub [18] based on people behaviors and introduces HIS security effectiveness as the ability of HIS security measures to protect the HIS assets against different threats by users' behaviors.

While some researches address the deterring bad end user behavior , there is a little study on promoting good end user behavior in security of information, particularly in healthcare domain [19, 20]. For example, Appari and Johnson [7] conducted a critical survey on importance the information security and privacy in healthcare organizations. They found that Accidental Disclosure, Insider Curiosity, Data Breach by Insider, Data Breach by Outsider with physical intrusion, and Unauthorized Intrusion of Network System that related or refer to user behavior s are the organizational threats to HIS.

Some researchers also focused on the human factor and proposed framework based on the criminological theory of General Deterrence (GDT) which provides theoretical justification for the use of security countermeasures as mechanisms to reduce IS misuse [18]. The most important thing about this theory is that the theory assumes that potential violators have malicious intentions. They also become aware of efforts to control anti-social behavior s such as punishment [19].

Since, users with low ability to protect IS' assets through negligence are one of the weakest security loopholes HIS [21] so, it is important for HIS user to exercise control over the information security events as a defense against threats to IS. Moreover, the IT managers need to understand the factors influencing end users' control-enhancing behavior [22]. To address this need, this study suggests that the self-efficacy of HIS users in information security can promote good end user behavior to reach HIS security effectiveness by affecting on users' motivation and action.

'Self-efficacy in Information Security' (SEIS) was defined by Rhee and et al. [8]. They suggested that users with SEIS can transform from the weakest link of IS to the first line of defense. In addition, because of the importance of end-user behavior on overall security, understanding factors influencing self-efficacy of HIS users in information security could provide helpful benefits for IT and HIS managers and information security professionals to assess the effectiveness of an information security program. This paper also covers the current understanding of self-efficacy in a new domain, health information security.

2 Self-efficacy in Information Security

Self-efficacy is defined as "the belief of people in their abilities to organize the motivation, understanding of resources, and courses of action needed to exercise control over occurred events" [23]. This belief allows people to exert difficult tasks as challenges to be solved and not as a threat that should be avoided [23].

Davis et al. [24] first discussed Computer Self-efficacy (CSE). Computer self-efficacy is an individual judgment of one's capability to utilize a computer [25]. Moreover, as CSE is the key factor in the adoption of technology in the every environment [26] therefore, some researchers have investigated the security self-efficacy in terms of computer self-efficacy [6], data security self-efficacy [27], self-efficacy on security behavior [28], and security professional effectiveness.

The study by Lending and Dillon [27] found that self-efficacy is used to facilitate the identification of the user's grasp of the privacy of confidential information and its effect on the implementation of HIS. They used a survey questionnaire from 600 hospital nursing staff. The results indicated that perceived confidentiality of health records and self-efficacy are concerned. Therefore, hospitals should consider steps to improve self-efficacy by enhancing confidentiality training.

Another study [8] provided a specific definition of 'Self-efficacy in information Security' (SEIS) as belief in people's ability to protect IS' assets from different internal or external threats such as unauthorized disclosure, modification, loss, destruction, and lack of availability. They also assessed the SEIS of 415 graduated students in the field of business in the U.S., and discovered that SEIS is widely different among the users. People with high self-efficacy use more security software for protection of their information. They strongly intend to apply more attempts to gain more powerful their information security not simply in terms of technology use but also in security aware care behavior.

The function of the human's psychological aspects such as self-efficacy for the security of the human technological environment was emphasized in another study [29]. Through evaluation of the SEIS of end users, the study demonstrated that self-efficacy in security varies extensively among the users. People with high self-efficacy use more security protection software and have stronger decisions to strengthen their data security. Furthermore, the study demonstrated that the past general computer and Internet experience have good influence, and previous security incidents have a negative effect on users' belief in self-efficacy in the security.

As discussed above, SEIS can be a significant factor to improve of the HIS users' behaviors in the information security issues. Therefore, it is introduced as an effective variable on the 'Security Effectiveness' construct in the research model. As such, the following hypothesis is suggested:

Hypothesis 1: 'Self-efficacy in Information Security' positively affects security effectiveness in health information systems.

3   Security Competency

Competency was defined by Rodriguez et al., [30] as "a measurable pattern of knowledge, skill, abilities, behaviors, and other characteristics that an individual needs to perform work roles or occupational functions successfully." Based on this definition, Mussa [31] defined 'Security Competency' (SCMP) as a model to measure the knowledge and other individual characteristics such as skills, abilities, and behaviors, which are needed to protect information against different threats. He developed a model with integration of the Theory of Planned Behavior (TPB) and the Health Belief Model (HBM) to measure and examines the health care professionals' prudent access control behavior.

Additionally, Yeratziotis et al. [32] evaluated the effectiveness and usability of security in two online health social networks and discovered that merging Human Computer Interaction, and Information Security can influence positively on their adoption by the patients.

Recent studies show that previous experiences about computer, and the Internet have a positive effect on users' self-efficacy and also previous security incidents could have negative influence on users' SEIS [8, 29]. Users, who have experienced using computers, are more knowledgeable about the threats to HIS; and when a threat had been received by users, experience causes the users to have a better understanding of this threat, and it would help decrease the effects of threats to IS.

It is important to note that there is a difference between SEIS and SCMP. SEIS reflects the belief in the person's capability to protect the information assets [8] whereas Security Competency is related to the actual knowledge and skills about protecting information assets [33].

Therefore, improving users' competence in security can improve the confidence of employees when a user places in adverse condition of using the IS assets [13]. It also makes the users feel that their behavior will not have any bad consequences [22].

The study predicts the effect of security competency on the users' SEIS base on Mussa' study and develops and adopts this relation for security of HIS and offers the following hypothesis:

Hypothesis 2: 'Security Competency' is related to the perceived 'Self-efficacy in Information Security' of HIS users towards HIS security effectiveness.

4   Research Methodology

Through the review of previous studies and based on secondary data this study identified SEIS as the significant factor that improve the HIS users' behavior in security issues. In addition, the study predicts the effect of SCMP on the users' SEIS. Therefore, a conceptual model is proposed taking into the mentioned constructs for HIS security effectiveness.

A quantitative research design was established for this study. The data were gathered using a survey instrument from HIS users of eight hospitals in Iran, in 2015. The Analysis of Moment Structures (AMOS) software was employed in testing the research hypothesis (Fig 1).
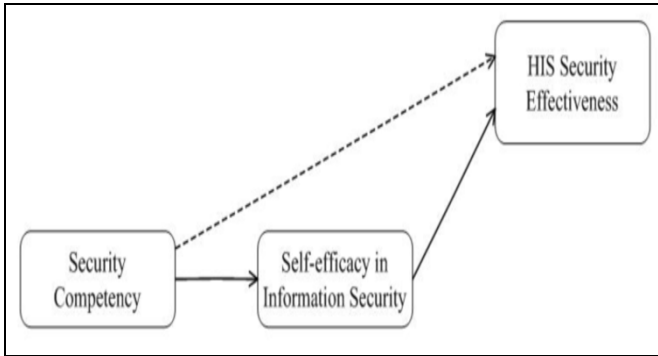
Fig. 1. The Concept Model of the HIS Security Effectiveness based on Self-efficacy of user in Information Security

4.1 Instrument

The study constructed a survey instrument by adopting measures from previous research [31, 33-36] and modified for health information systems.

The survey validation review process was done by experts from the field of information technology as well as the health industry. Ahead of the data analyzing process, the survey instrument was validated through pilot study. The pilot test was done by random distributing of 34 questionnaires among HIS users in a hospital.

4.2 Data Collection

This research was done in eight hospitals in the province of Sistan and Baluchetan in southeast of Iran. The survey instrument was distributed among 500 HIS users and 367 questionnaires (approximately 75%) were delivered to the researcher. After pre-analysis data screening and outlier detection process, 263 usable questionnaires (76%) were available for final analysis.

5 Data Analysis

The structural modeling approach is implemented to test the relationships among the constructs.

The model fit indicators that were used for model fit in this study are normal chi-square (CMIN/df), goodness-of-fit index (GFI), adjusted goodness-of-fit (AGFI), comparative fit index (CFI), Tucker Lewis Index (TLI), and the root mean square error of approximation (RMSEA). Briefly, the fit is acceptable if TLI, CFI, and GFI are 0.90 or greater and RMSEA is 0.10 or less [37].

The overall qualities of model fit indicators for modified constructs are presented in Table 1.

Table 1. Summary of Final Model Fit Values

CMIN/DF	CFI	RMSEA	GFI	AGFI	TLI
1.790	0.974	0.055	0.945	0.912	0.965

The test of the hypothesis is the second step in model estimation. The significance of two offered hypotheses was measured by a multiple regression analysis test.

The model also confirms significant associations between Information HIS Security Effectiveness (SEFF) and Self-efficacy in Information Security. The relationship between Information Security Competency (ISCM) and Self-efficacy in Information Security is also significant at p < 0.001.

6.1   Relationship between 'Self-efficacy in Information Security' and 'Security Effectiveness'

The first hypothesis is:

H1: 'Self-efficacy in Information Security' positively affects HIS security effectiveness.

The findings in Table 3**Error! Reference source not found.** indicated that SEIS significantly and positively predicted 'HIS Security Effectiveness' with a standardized regression coefficient of 0.191. HIS users who possess an experience in the use of more security software for protection of their information are more knowledgeable about the threats to HIS. It would help diminish the effects of threats to HIS [8].

6.2   Relationship between 'Security Competency' and 'Self-efficacy in Information Security'

The second hypothesis analyses the relationship between SCMP and SEIS. The Hypothesis is:

H2: There is a strong relationship between 'Security Competency' and 'Self-efficacy in Information Security'.

As illustrated in Table 2 the standardized regression coefficient between SCMP and SEIS was statistically significant (0.304, p<0.001) and had a positive relationship. Therefore H2 was supported, i.e., SEIS will be increased by improving the security competency of HIS users. The outcome is consistent with prior empirical study [31]. The results demonstrate that both hypotheses were supported.

Table 2. Hypothesis Tests

Hypothesis	Variable			Estimate	Sig.	Supported
H1	SEFF	<---	SEIS	0.191	<.001	Yes
H2	SEIS	<---	SCMP	0.304	<.001	Yes

6.3   Analysis of Mediation Effect of SEIS on the Relationship between SCMP and 'HIS Security Effectiveness'

However, the best-fitting model test yielded support for the mediating role of the SEIS, to address the extent of the relations between SCMP (independent variables) and 'HIS Security Effectiveness' (dependent variable), additional tests were necessary. According to the SEM analysis that is shown in Table 3, there is a significant direct and indirect effect of 'Security Competency' on 'HIS Security Effectiveness'. Thus, the unmediated relationship is significant as well as SCMP to SEIS as the mediator and the mediator to 'HIS Security Effectiveness' relationships. In fact, three direct effects are individually significant. The results therefore support the partially mediating of SEIS in the relationship between SCMP, and 'HIS Security Effectiveness'. The outcomes also confirm the hypothesis 2.

Table 3. Mediating Effect in the Relationship between SCMP and 'HIS Security Effectiveness

Relationship	Direct effect		Direct with Mediator	Type of Mediator
SCMP-SEIS-SEFF	SCMP-SEFF	0.42 (0.001)	0.25 (0.001)	Partial Mediation
	SCMP-SEIS	0.45 (0.001)		
	SEIS-SEFF	0.56 (0.001)		

Fig 2 presents an illustration of the final model fit tests with path diagram of the final model. The model has one dependent variable ('HIS Security Effectiveness') and two independent variables (SEIS and SCMP) with direct impact on the dependent variable. The result indicates that all values are shown fit model indicators are very good (Fig 2).
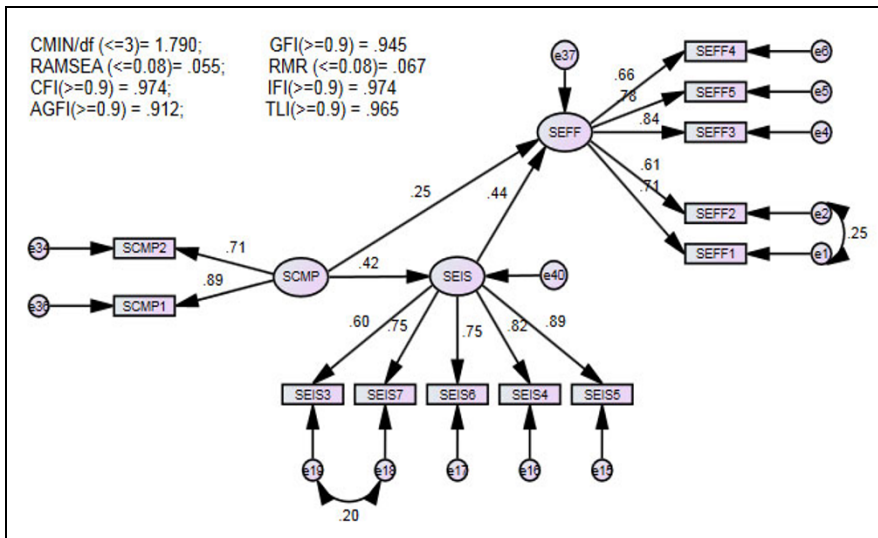
Fig. 2. The Final Model for HIS Security Effectiveness

7   Discussion

The purpose of this section is to provide the findings of all analyses performed and the results of the two research hypothesis. The paper presented the results of an empirical examination designed to assess the contribution of SEIS and 'SCMP to 'HIS security effectiveness' in Iran.

SEM using AMOS was used to analyze the research hypotheses. The research results showed that SEIS significantly and positively predicted HIS Security effectiveness, while 'Security Competency' significantly predicted 'SEIS'.

Therefore, it becomes a critical contributor to achieving the security effectiveness of HIS. Moreover, by the use of two different mediator tests for SEIS, it found that SEIS has a mediating effect between SCMP construct and 'HIS Security Effectiveness'. This shows that users with high 'SEIS' have more conscious of safety and security, and have strength intentions to exert more effort to make stronger their information security.

8   Implication

The findings of this study validate previous studies on all positive antecedents toward HIS security effectiveness. It provides evidence to support the promotion of HIS security effectiveness based on user behaviors besides technological solutions. There is a paucity of study on users' behavior especially in the healthcare domain. In spite of that, this study concentrates on user behaviors of Iranian HIS users from eight hospitals. Hence, this study is timely and adds empirical evidence to HIS security research.

From practical perception, this study has the potential to contribute hospital administrator particularly the HIS administrators in Iran. Results from this study will facilitate a better understanding of the causes of some HIS security incidents, thus HIS administrators can examine the HIS security effectiveness from the perspective of users' behavior. Moreover, HIS administrators may be able to assess the strengths and weaknesses of their HIS security. The research outcomes may also assists HIS administrators in addressing IT strategies, to design the policies and regulations to establish effective security in HIS taking into consideration HIS users' behaviors. This implies that insights on HIS users' behavior play a role in enhancing HIS security effectiveness, which will ultimately assist health organizations in providing secured patient data.

9 Conclusion

The users have been identified as the weakest link in the chain of security of HIS. In order to transform HIS users to the first line of defense in the security of HIS, this research proposed a model for HIS security effectiveness. It examined the impact of SEIS and SCMP on HIS security effectiveness in Iran.

However, SEIS has never applied in HIS security effectiveness; and past studies have investigated the security self-efficacy in terms of computer self-efficacy [6], data security self-efficacy [27], self-efficacy on security behavior [38]. Brady [39] used 'Computer Self-efficacy' construct in the proposed model for HIPAA security compliance, but he could not find a strong relationship between it and predicting HIPAA security compliance. Therefore, following a comprehensive literature review, this study identified 'Self efficacy in Information Security' that suggest by Rhee and et al. [8] and 'Security Competency' suggested by Mussa [31] as possible contributing factors to HIS security effectiveness.

In an effort to better understand how these variables interact and impact each other, a predictive study was designed to investigate the incorporation of SCMP and SEIS, and their effect on HIS security effectiveness in Iran. SEIS was also examined as a mediator variable.

This study made significant contributions to the body of literature in terms of variables and the population under investigation. The proposed model in this study has not been tested before in the real health information system with actual HIS users. The result shows that SEIS is one of the important factors to cultivate of users' behavior s toward HIS security effectiveness. However SCMP appears a feasible alternative to providing SEIS.

The paper shows that, SCMP influence SEIS of HIS users, and further impact HIS security effectiveness. This study also confirms the mediating effects of SEIS on the relationship between SCMP and 'HIS security effectiveness'.

The results of this research paper will provide some guidance and insights to both researchers and professionals of information security in the health care domain. It can also be used by HIS and IT managers to implement their information security process more effectively.

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Evaluating the Use of Gamification in *m-Health* Lifestyle-related Applications

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Abstract. The concept of applications (apps) as medical devices emerges as an important one in the field of mobile health (m-health). Within this field, apps have been used as tools that can drastically change the quality of healthcare on a global scale, as well as radically alter the reach of medical investigation. The use of gamification techniques to inspire the experience of app users has also stimulated the field of m-health, using the mechanics of games to improve the thought processes of app users. The article evaluates four m-health apps from the standpoint of the gamification of their functionalities. To this end, we have adopted the analytical framework of Werback and Hunter and used a six-step system. Our results empirically confirm some of the evidence found in the current literature; that is, the majority of apps that use gamification elements aim to achieve publicity as a secondary objective.

Keywords: m-health; gamification; wellness applications.

1 Introduction

The rising use of smartphones – given the improvements in their connectivity and usability, as well as reduction in their cost – has made it so that mobile connectivity surpasses the time that people spend watching TV [1]. Through their smartphones, individuals can manage their finances, travel plans, entertainment, health, and education [2, 3], particularly by using increasingly interactive applications (apps). As of 2012, there were over 40.000 health-related apps in operation.

The alignment between mobility, mobile devices, and health led to the emergence of the field of mobile health (m-health) [4]. The Global Observatory for eHealth (GOe) defines m-health as the practice of medicine and public health supported by mobile devices, which have portable sensors that can turn these mobile devices into diagnostic tools capable of processing medical information - such as glucometers or heart rate / blood pressure sensors. These devices collect real time data and are backed by automated clinical tools that support decision-making [5].

In this context, the concept of "apps as medical devices" emerges as an important one in the field of m-health. Within this field, apps have been used as tools that can

drastically change the quality of healthcare on a global scale, as well as radically alter the reach of medical investigation [1, 2].

On the other hand, gamification techniques can improve the experience of app users in m-health because gaming mechanics engage and stimulate the users' desire to solve problems (including health ones) [6], as long as these mechanics are carefully and correctly implemented [7].

First introduced in early 2000, the term gamification describes the use of the structural elements of games for some purpose beyond pure entertainment, using these elements to stimulate desired behaviors and practical results. By 2020, it is estimated that up to 85% of individuals' routines will be based on common gamification elements [8]. Common examples are business fidelity programs, which use the mechanisms of rewards, return, and challenge to keep costumers motivated [9].

As Deterding et al. [10] explains, for a process or a product to be gamified, it must display at least four basic game characteristics: objectives, defined rules, feedback systems, and voluntary participation. In this manner, it is possible to transform user experience in a fun, involving practice.

In the field of m-health, the techniques of gamification emerged as a way to add value to apps, allowing users to realize that improving their health is not only their responsibility, but is also as a way for them to achieve wellness [9], which is more motivating and personalized [11].

However, certain aspects of usability, the idea of being monitored, or using an app that does not create a compromise are still challenges for m-health [12]. Considering the growing need for mobile apps that are user-friendly and inter-operable in the field of health, wellness, and lifestyle [1, 13], we posited the following research question: which techniques of gamification are currently being used in lifestyle-related m-health applications to maximize user engagement and experience?

The present study aims to evaluate m-health apps from the standpoint of the gamification of their functionality, identifying the elements of gamification used in them. This study focuses on mobile apps related to user's physical activity, wellness, and lifestyle. To this end, we adopted the analytical framework of Werbach and Hunter [14]. This article is structured in the following manner: the following section describes the current literature in the field, section 3 describes the methodology adopted in this study, section 4 describes the study results, and section 5 discusses final considerations.

2 Literature Review

This section discusses concepts related to mobile technologies and gamification, with a focus on its health applications, which underlies theoretically this study.

2.1 Mobile technologies and health

The use of mobile technologies is increasingly a part of global culture because "the contemporary practices linked to technology and cyber-culture have configured contemporary culture as a culture of mobility" [15, p. 10].

Focusing on health information, McCallum [11, p. 2] ponders that this demands the "registering of all actions taken by other professionals that are involved in this field, beyond those that directly or indirectly contribute to the quality of patient care", even when this involves technological aspects, such as e-health and m-health.

E-health involves the use of information and communication technologies (ICTs), especially the internet, to improve health and healthcare. This is an emerging field at the intersection between medical informatics, public health, and businesses, and refers to health services and health information delivered or reinforced through ICTs [16]. Besides that, it supports several groups of people, as particularly communities in need, due to its easy scalability [5].

As a subfield of e-health, m-health is defined as the practice of medicine and public health through mobile devices that collect community data and deliver health information to healthcare professionals, researchers, and beneficiaries, monitoring in real time the vital signs of users and the delivery of direct services [17].

There is a wide range of uses for apps in the field of health, from simple text message reminders that remind an user to apply sunscreen to more sophisticated apps that help an user manage diabetes. The most popular categories of apps are related to drug use, to the support for clinical decision-making and communication, and to electronic registries of medical materials and health education [2, 3].

Even though there is currently no evidence of its efficacy, there are factors that call for studying the use of m-health in terms of increasing quality of care, access to care, health outcomes data, particularly in places where those were previously scarce or inexistent [4], such as the African continent – where the mobile devices have reached 433 million users [18].

2.2 Gamification and health

Gamification techniques that motivate, engage, and develop loyalty are very common in the fields of business, education, and health [8, 11]. However, games and gamification are not the same thing. Games are "related to ways of playing in a free and spontaneous manner, controlled by their own rules (which are different from the real world), and exist in a fictitious reality, voluntarily created for the purposes of playing" [19, p. 9]. Therefore, the mission that a gamer must accomplish in a game does not fulfill any significant purpose, and also has a defined beginning and a defined end to be reached.

In this manner, gamification is usually different because its objectives are presented in a non-ambiguous manner as the interaction happens. That is, as the design is developed, it aims to achieve goals, experiment new strategies, and address new challenges [9, 11]

Despite the polysemy, Deterding and colleagues [19, p. 2] describe gamification as "the use of the design elements of games in non-game contexts" to the end of

addressing human motivation. On one hand, motivation can be thought of as extrinsic to the person or the task, such as external rewards and status; on another hand, it can be though of as intrinsic, emerging from the inside in search of novelty, entertainment, or new abilities [11].

In sum, the seven main elements of games are [11, 14, 20]: points, levels, leaderboards, badges, challenges, onboarding loops, and engagement loops.

Several scholars [9, 11] have presented gamification models; this study, however, adopted the framework proposed by Werbach and Hunter [14]. They provide a schematic of gamification techniques in the shape of a three-level pyramid: dynamics (theme and storyline told to promote user interaction), mechanics (details of the interaction, gears, paths, and rewards), and components (elements such as unlocking levels or visual representations through avatars).

At the level of dynamics, there are the emotions (happiness, achievement, or sadness, all of which can encourage users' continuing engagement), the narrative (structure of ideas and consistency of the path), progression (measures the efforts and the results obtained by the user), and relationships (interaction with other users).

At the level of the mechanics, there are challenges (objectives that users aim to achieve), luck (random results that can cause surprise or uncertainty), winner status (indicative of whether a user has or has not won), feedback (progress), resource acquisition (items that can be collected to aid in achieving the user's objective), rewards (received for enacting a certain action), and turns (actions and moments).

Finally, at the level of the components, there are attainments (objects received when the user completes a task), avatars (visual representations of the users), medals (visual representations of the user's status), challenges (complex challenges between the last remaining users), collections (pieces that must be grouped to achieve a goal or transaction), combat (duel), unblocking (possibility of accessing a certain space within the game), leaderboard (of users and their point counts), levels (progress aimed at engaging), and teams (teamwork in achieving an objective).

In this manner, Werbach and Hunter [14] have defined a six-step framework for implementing gamification in a system:

1. Define objectives: to have performance objectives with measurable goals, ranked by importance in order to prioritize ends;
2. Define desired behaviors: identify what actions are expected from the users and relate them to the actions users must do while interacting with the system;
3. Describe users: collect fundamental information, including how users understand the gamified system, as well as their behaviors within the game – such as: what kind of person will use the system? How can we motivate them? What is the difficulty involved in completing these tasks without gamification?
4. Define engagement loops: the objective is that the users, as they learn from their own mistakes, will be motivated to try again. When defining levels to finish a challenge, there can be a feedback that inspires the user to get additional points or discover new sceneries;
5. Entertainment: propose rules and elements while at the same time allowing for fun, making it so that the user voluntarily chooses to engage with the system, and making the system attractive whether the user gets something in exchange for participating or not;

6. Correct use of tools: verify which are the best elements to use in the system, given that there are a wide range of elements that can be applied depending on which is the target public and the issue that the system desires to address.

In the health field, the topic of interest for the present study, there are internal barriers that individuals try to overcome such as confidence, anxiety, frustration, etc. This makes it so that individuals feel stuck and fail to improve or achieve their intended objectives. However, by using components of gamification, health apps can engage their users in ludic, interactive situations that seek to improve their clinical status [2].

In m-health apps, we add the idea of turning the smartphone into an auxiliary device (that can, as an example, collect blood measurements to identify blood sugar levels), and therefore obtain several benefits to the patients and to healthcare (as an example, through the reduction in potential hospital visits and stays).

The merge between the fields of gamification and m-health is starting to present relevant results. One example is a pilot study done with adolescents with diabetes type 1, which demonstrates that using gamified elements leads to an increase in daily blood sugar measurements that are needed to control the condition [21].

3 Methodology

This study aimed to explore which gamification techniques are used in m-health wellness apps, and how these techniques are used. To that end, this study employed a qualitative, exploratory design; we assume that there is a dynamic relationship between the real world and its subjects, that is, an unbreakable bond between the objective world and the subjectivity of individuals that cannot be translated into numbers [15]. That is, the evaluation of m-health apps can be charged with the beliefs and values of the researcher, even if these are mitigated by a scientifically rigorous and internally valid study design.

Initially, we conducted a literature review on the topic of gamification which allowed us to identify the framework by Werbach and Hunter [14] as the analytical strategy to be adopted for the evaluation of gamified m-health apps, because it defines a schematic model of gamification techniques.

Then, the selection of apps to be evaluated in this study also followed specific steps. First, we defined the operational system and the app store to be used in the search; we selected the Android system because is available in 70% of all mobile devices [1]. We conducted a search in the virtual store of Google© Play Store using the search strings "gamified health apps", "best gamified apps", "gamified wellness apps", "health apps using gamification", and "m-health apps with gamification"; this search resulted in a list with 200 apps. A second filter was applied to this list, focusing on lifestyle and wellness apps, and adopting a research instrument for data collection which contained the following inclusion criteria: Google© screens apps submitted for distribution through the store for objectionable content and categorizes them based on functionality and developers' descriptions. We analyzed apps in the "Health & Fitness" Google© Play Store category, which are further grouped on the basis of popularity and other attributes. This new list contained 15 apps: Atari, Couch-

to-5k, Dieta e saúde, Fitocracy, FitBit, GymPact, Nike+ Training Club, MapMyFitness, Meu Orientador de Dietas, MyFitnessPal, Runtastic butt trainer, RunKeeper, Strava, TecnoNutri e Zumbies. Finally, we elected 4 (four) apps for the final analysis considering the number of cumulative downloads and positive reviews from users; two of these supported physical activity and two other focused on eating habits: FitBit (in English and free), RunKeeper, Meu Orientador de Dietas (from hereon, My Diet Guide), and MyFitnessPal (these three were available in Portuguese and were also free).

4 Results and Discussion

Figure 1 illustrates four main screens of the FitBit, My Diet Guide, MyFitnessPal, and RunKeeper, in this order. It is noteworthy that the researchers themselves installed and tested each of the selected apps, according the research design. Moreover, in the discussions that follow, gamified elements identified were grouped into categories: dynamics, mechanics and components.
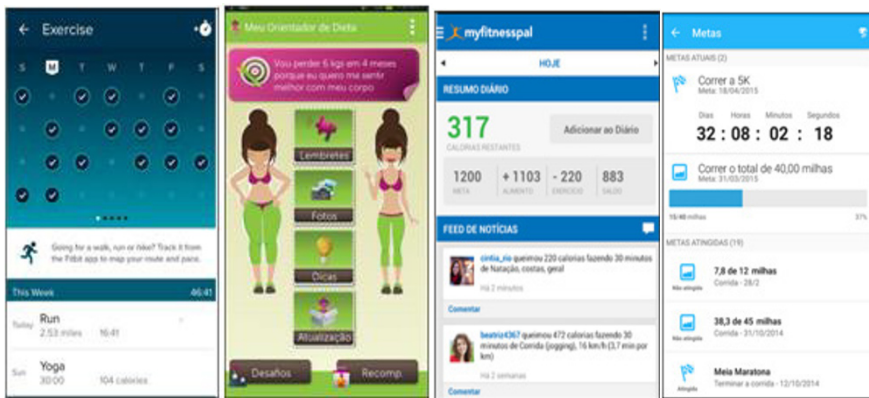
Fig. 1. Main screens of the four evaluated apps in this study.

The **FitBit** app has the objective of evaluating user performance through measurable goals, which are represented in graphs and icons throughout the app. Regarding the definition of desired behaviors, the app shows the user which exercises can be practiced, associating them to eating habits and heart rate. This app connects with "wearables". When using the smartphone, the option of measuring heart rate was not shown, but it did allow for entering how much liquid was ingested during the day.

As far as describing its users, we could not locate any kind of definition of which users should engage with this application; it was assumed that any individual without physical limitations (i.e.: inability to walk or run) can use the app.

Regarding the engagement loops, motivation was provided through badges, which can be shared with friends through social networks. Entertainment was inferred from the elaborated structure of icons and user interaction through the use of vibrant colors.

In regards to the correct use of tools, the app shows user progress. In addition, connecting with other tools makes the exercise less exhausting, allowing the user to develop his or her own achievable goal. Table 1 summarizes the elements identified in this app, according to the framework by Werbach and Hunter [14].

Table 1. Gamified elements identified in FitBit.

Dynamics	Mechanics	Components
Progression, Relationship	Challenge, Competition and Cooperation, Feedback, Acquisition of Resources and Rewards	Achieving Goals, Avatar, Medals, Collections, Leaderboard, Levels, Points, Social Graph

The app **My Diet Guide**, in its objectives, demonstrates the users' performances and goals through images of the users themselves; in addition, it also uses avatars and pre-defined incentive messages through multiple systems from which users can select the one that better fits their profile.

Regarding the definition of desired behaviors, the app presents – in an interactive manner – how and when the user should eat healthy foods, ingest a specific amount of liquids, engage in physical activity, etc. Icons and alert messages can be programmed by the users themselves.

When describing its users, the app focuses on women of all ages that want to follow a diet. To define engagement loops, it tries to motivate users through the use of incentive messages, throught pictures of the users themselves (before and after), through avatars that implement wardrobe changes (each completed goal earns the user a new clothing item or accessory), and through incentives to eat fresh fruits/vegetables and practice physical activities.

As far as entertainment goes, the app shows icons and tips, in addition to the user's progress – the latter is shown using the avatar, which can lose or gain weight. Regarding the correct use of tools, the system uses knowledge of its target audience to develop the app and to motivate users. Table 2 summarizes these elements.

Table 2. Gamified elements identified in My Diet Guide.

Dynamics	Mechanics	Components
Restrictions, Progress	Challenges, Feedback Resource Acquisition, Turns	Achievements, Avatar, Rewards, Points

The **MyFitnessPal** app presents its objectives, in a summarized manner, as achieving the goals set by the users themselves, along with information on eating habits and friends in common.

As far as defining desired behaviors, the app demonstrates what is expected from the users; however, the first time around, the app can seem confusing because it offers limited guidance and information. The main screen contains a couple news/tips about eating habits and trackers that start at zero. This makes the app somewhat simplistic and intimidating, given that it does not offer help to users as they take their first steps; as an example, when a user wants to add a food item to their food diary, the plus (+) item is not immediately shown on the screen, and only appears after the user touches

the screen. Another issue regards the list of food items, which has only one explanation – located at the bottom of the screen, where it can be hard to see.

Regarding the description of the users, the app does not offer any indication as to who constitutes its target audience, indicating that any individual who might need a food diary can use the app for that purpose. Motivation happens through different notifications either at meal times or inform users about how many days have passed since they last filled their food diary.

While evaluating this app, it was not possible to identify engagement loops or entertainment. The app also lacked the characteristic of correct use of tools. The element of gamification most employed in this app was motivation generated through social media connection and user evolution. Table 3 summarizes these elements.

Table 3. Gamified elements identified in MyFitnessPal.

Dynamics	Mechanics	Components
Progression, Relationships	Challenges, Competition, Cooperation, Feedback	Avatar, Leaderboard, Social Graph

The **Runkeeper** app, in its definition, exhibits goals achieved over time, graphs, and a map of the user's running trajectories. Regarding the definition of desired behaviors, the app displays the logo in the main screen, what it expects the users to do, and the options of exercise users can choose from.

It was not possible to identify any description of who should use the app, therefore indicating that the app may be used by anyone that wishes to keep track of physical activity. Motivation in this app comes from the self-imposed goals that users set for themselves, can evaluate through statistics and share through social media – including their trajectory, the music they listened to, and the pictures taken during their run.

This app does not include a definition of the engagement loop, given that the users themselves set goals and sceneries – such as the places where they will exercise, a congratulatory message for feedback – and the app offers feedback through messages that praise users for achieving their goals.

Entertainment in this system happens through the use of colorful graphs and the trajectory maps created by users as they run, as well as the functionality of listening to music and taking pictures while exercising. Regarding the correct use of tools, there is not a clear definition of the intended target audience. Elements of gamification most commonly used were sharing running routes and maps with friends on social media. Table 4 summarizes the elements identified in this app.

Table 4. Gamified elements identified in Runkeeper.

Dynamics	Mechanics	Components
Progress, Relationships	Challenges, Competition, Cooperation, Feedback	Attainment, Avatar, Leaderboard, Points, Social Graph, Teams

In summary, Table 5 illustrates the general evaluation of the four apps included in this study. My Diet Guide app was the one that most fulfilled the gamification elements adopted and MyFitnessPal was the weaker one.

Table 5. Summary of the evaluation of four m-health lifestyle-related apps.

	FitBit	My Diet Guide	MyFitnessPal	Runkeeper
Objective	🏆	🏆	🏆	🏆
Definition of desired behaviors	🏆	🏆	🏆	🏆
Description of the users		🏆		
Engagement loops	🏆	🏆		
Entertainment	🏆	🏆		🏆
Correct use of tools	🏆	🏆		

Furthermore, we found that there is a trend in the mechanics of gaming apps; however, we identified an emphasis on a single element, namely, the sharing of user data in social networks as a way to raise interest among other users and as a means of free publicity for the app. Results have also empirically confirmed the evidence found on the literature indicating that the majority of apps use gamification elements as a way to get publicity, to the exclusion of other elements from the literature model [14].

5   Final considerations

The present study was motivated by the need for further studies on the theme of mobile health, especially as it concerns its use of gamification. Despite the fact that there are models for the use of gamification in the literature, we found that there are still deviations in the ways used to engage users through gamified techniques. Most apps emphasize social interaction; this happens when users share data with each other; while it creates a competition of sorts, it also works as advertising – because it encourages others to use the same app.

We indicate that there is no regulating office that promote app health policies, despite the existence of a wealth of apps focused on health and wellness. We also must note that we lack methods to measure the utilization and the quality of these apps. However, we observed a great demand for m-health apps, which indicates a concern among users with their well-being and quality of life.

Our analysis and results indicate that dissemination of apps aimed at supporting healthcare is, in large part, related to physical activity conditioning. In addition, even without public policies, the apps that display the most gamified techniques have reached broader acceptance and utilization levels and are well rated among users – as indicated by comments posted on the virtual app stores. Suggestions for future studies include validating the Werbach and Hunter model in the field of m-health alongside other health professionals in experimental research or survey.

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Serious Games for Balance Improvement: A Systematic Literature Mapping

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Abstract. Rehabilitation using video games is more motivating than standard rehabilitation. There are several games developed for balance rehabilitation however, they focus on different aspects, apply a variety of assessment and were developed using a myriad of approaches. In order to provide an overview about specially purposed games for balance rehabilitation, a systematic literature mapping was conducted to assess how they were developed, what software evaluation and clinical assessment were applied and the devices they used. A total of 514 studies were analyzed, but only 44 of them satisfied the inclusion and exclusion criteria. As a result, we verified that most studies used attachment based commercial devices; usability is the most used criteria to evaluate the game and questionnaires are used for it. There is no consensus on clinical assessment metrics and a remarkable lack of design methodology used. From the plethora of serious games found in the literature it is clear that much research need to be done but games can already be considered an acceptable approach for balance promotion.

Keywords: serious games, balance, rehabilitation, literature mapping.

1 Introduction

The increase in the elderly population in the world requires attention on the aspects that affect this age group and one of the most prevalent aspect is balance deficit. In fact, fall injuries have collaborated to increase health care costs [1]. Beyond age, there are other pathologies that require special balance attentions, such as [2]: chronic ankle sprains, chronic degenerative low back pain, scoliosis, paroxysmal positional vertigo, head injury, stroke, cerebellar disease, Parkinson's disease, vestibular deficits, peripheral neuropathies, amputation, and cerebral palsy. The common treatment for balance is rehabilitation in a specialized clinic with a physiotherapist. However, it is common for patients to loose motivation by repetitive and not very engaging exercises [3].

Therefore, the adoption of balance training with video game becomes an interesting choice for promoting health. There are two approaches that can be used for

this end: to use existing commercial video games to see if and how they affect balance, and to develop a brand new video game targeted specifically to balance training. Serious Games (SG) are games developed with a purpose from the very beginning and that go beyond entertainment [4]. The aim of this literature mapping is to identify games that have been targeting balance and not games that "somehow" can be used for such. Also, it is of concern how these games have been developed and how they have been evaluated.

2 Related Work

In recent years, many Systematic Literature Mappings (SLM) and Systematic Literature Reviews (SLR) have been done about health games. A high-level overview on the current state of health games research conducted by [5] shows positive progress towards adapting new gaming technology in specialized health contexts and important recommendations in promoting health games research were done. [6] presents a survey of SG for rehabilitation and proposed a classification to properly distinguish and compare SG for rehabilitation in fundamental characteristics, such as application area, interaction technology, game interface, number of players, game genre, adaptability, performance feedback, progress monitoring and game portability.

It was reported by [7], that many researches don't have health professionals involved in the development of video games and that the evaluation of the results has been carried out informally without methodologies and without the use of statistically meaningful samples, compromising the results. The SLR presented in [8] discussed applications that used Kinect in elderly care and stroke rehabilitation and concluded that the Kinect already shows notable potential in making therapy and alert systems financially accessible and medically beneficial; however, some significant technological limitations are still present. In another study about the Kinect, [9] verified that most of the studies have investigated physical rehabilitation of upper limbs and the most investigated system type was SG. [10] reviews the use of novel methods of rehabilitation using Virtual Reality (VR) interventions for people living with post-traumatic brain injuries and observed that the use of VR has the potential to provide alternative, possibly more available and affordable rehabilitation therapy and highlighted the importance of specific games for this audience.

Finally, [11] made a SLR comparing VR and standard rehabilitation. Although the benefits are small, they described that VR-based rehabilitation brings greater benefits in walking speed, balance and mobility in people after stroke than standard rehabilitation. None of the above mentioned reviews focused on SG designs and assessments which is the focus of the present SLM.

3 Search Method

The primary research question of this SLM is "how SG for balance have been designed?". To this end, devices, design methodologies, target population and, software and effectiveness evaluations will be analyzed. This SLM follows the guidelines described by [12] because it is from technology background, as the focus

of this research ACM Digital Library, ScienceDirect, IEEE Xplore, Engineering Village, Web of Science, Scopus, PUBMED and Lilacs databases were searched using the following search terms:

(("virtual reality" OR game OR games OR videogame OR "video game") AND (balance OR equilibrium OR "risk of fall" OR falling) AND (therapy OR rehabilitation OR diagnostic OR treatment))

A initial search (try out phase) was performed on paper's titles only on July 27, 2015. To be included, studies had (1) to present a SG; (2) to involve balance functions; (3) be in English;(4) to have been published between 2005 and 2015; (5) to be a full paper; (6) to be a primary study; (7) to be a research paper; (8) to be available. Papers were excluded if: (1) they do not describe a game, (2) present a commercial video game; (3) were a duplicate. Table 1 shows the data from the try out search.

Table 1. Number paper hits returned in try out research in the titles.

Database	Papers	After Inclusion Criteria	After Exclusion Criteria	After Review Duplicates
PUBMED	19	16	6	6
IEEE	7	3	2	1
ScienceDirect	14	6	4	0
Web Of Science	30	21	15	0
ACM	2	0	0	0
Scopus	36	24	9	0
Engineering Village	14	10	8	0
Lilacs	2	2	0	0
Total	**124**	**82**	**44**	**7**

Because of the few results in try out search, it was decided to apply the same search in paper's abstract but only in the following databases that had good performance in try out phase: PUBMED, IEEE, ScienceDirect and ACM. This search was performed on September 30, 2015 and the results are shown in Table 2.

Table 2. Number of paper hits while searching in the "abstract".

Database	Papers	After Inclusion Criteria	After Exclusion Criteria	After Review Duplicates
PUBMED	181	131	23	12
IEEE	75	66	18	12
ScienceDirect	113	95	12	3
ACM	21	19	4	3
Total	**390**	**311**	**57**	**30**

4 Results

Adding title and abstract searches, 37 different papers remained, and 7 already known papers from an ad-hoc search were added. A total of 44 full text papers were downloaded. Table 3 shows authors, paper's titles and year publication.

Table 3. Authors and publishing journal/event.

	Author	Journal/Event	Year
R1	CHEN, Po-Yin et al.	Archives of gerontology and geriatrics	2012
R2	BETKER, Aimee L. et al.	Archives of physical medicine and rehabilitation	2006
R3	LLORENS, R. et al.	Neurología (English Edition)	2013
R4	DA, Daniel Q. Freitas Alana EF et al.	Engineering in Medicine and Biology Society, EMBC	2012
R5	BARANYI, Rene et al.	Serious Games and Applications for Health (SeGAH)	2013
R6	LANGE, Belinda et al.	Topics in stroke rehabilitation	2010
R7	BETKER, Aimee L. et al.	Physical therapy	2007
R8	DOWLING, Glenna A. et al.	Telemedicine and e-Health	2013
R9	GERLING, Kathrin Maria et al.	Proceedings of the 7th International Conference on Advances in Computer Entertainment Technology	2010
R10	ALBIOL-PÉREZ, Sergio et al.	Pervasive Computing Technologies for Healthcare (PervasiveHealth)	2013
R11	ROSSITO, Gabriel Mesquita et al.	Proceedings of SBGames 2014	2014
R12	BOSSE, Rafaela. et al.	Proceedings of SBGames 2015	2015
R13	DE MORAIS, Wagner O. et al.	Serious Games and Applications for Health (SeGAH)	2011
R14	MCCONVILLE, Kristiina M. Valter et al.	Virtual Reality	2012
R15	UZOR, Stephen et al.	Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.	2012
R16	ALBIOL-PÉREZ, Sergio et al.	Proceedings of the 13th International Conference on Interacción Persona-Ordenador	2012
R17	LIU, Lin; XIE, Le; CAI, Ping.	Proceedings of the 4th International Convention on Rehabilitation Engineering & Assistive Technology.	2010
R18	FARJADIAN, Amir B. et al.	Robotics and Automation (ICRA)	2015
R19	O'HUIGINN, Brendan et al.	Wearable and Implantable Body Sensor Networks	2009
R20	BORGHESE, Nunzio Alberto et al.	Virtual Systems and Multimedia (VSMM)	2012
R21	NAKAI, Akihito et al.	Cognitive Infocommunications (CogInfoCom)	2013
R22	ZHANG, Sen et al.	6th IEEE Conference on Industrial Electronics and Applications	2011
R23	CANTU, Miguel et al.	3D User Interfaces (3DUI)	2014

R24	SEN, Sim Lee et al.	Control Conference (ASCC)	2015
R25	IMAIZUMI, Daichi et al.	Biomedical Engineering and Informatics (BMEI)	2010
R26	UZOR, Stephen et al.	Pervasive Computing Technologies for Healthcare (PervasiveHealth)	2011
R27	JAUME-I-CAPO, Antoni et al.	Neural Systems and Rehabilitation Engineering	2014
R28	MADEIRA, Rui Neves et al.	Electrical and Power Engineering (EPE)	2014
R29	DING, Ye et al.	Haptics Symposium	2010
R30	IM, Dal Jae et al.	Annals of rehabilitation medicine	2015
R31	LOZANO-QUILIS, Jose-Antonio et al.	JMIR serious games	2014
R32	SONG, Yoon Bum et al.	Annals of rehabilitation medicine	2014
R33	RADTKA, Sandra et al.	GAMES FOR HEALTH: Research, Development, and Clinical Applications	2013
R34	BORGHESE, Nunzio Alberto et al.	Games for Health: Research, Development, and Clinical Applications	2013
R35	GALNA, Brook et al.	Journal of neuroengineering and rehabilitation	2014
R36	CHEN, Po-Yin et al.	Journal of neuroengineering and rehabilitation	2012
R37	USTINOVA, Ksenia I. et al.	Journal of neuroengineering and rehabilitation	2011
R38	SZTURM, Tony et al.	Physical Therapy	2011
R39	GIL-GÓMEZ, José-Antonio et al.	Journal of neuroengineering and rehabilitation	2011
R40	SAYENKO, Dimitry G. et al.	Spinal cord	2010
R41	FITZGERALD, Diarmaid et al.	Engineering in Medicine and Biology Society	2008
R42	SZTURM, Tony et al.	Gait & posture	2014
R43	YEH, Shih-Ching et al.	Computer methods and programs in biomedicine	2014
R44	CAMPOS, Carlos et al.	Psychology of Sport and Exercise	2015

4.1 Characteristics of the devices being used

In this section the devices used with the video games for therapy, rehabilitation or training balance are analyzed. Some devices are commercially available but were presented in a paper with a new game. In total 59 devices were found, ones (some paper used more than one device) and 25 devices were noncommercial.

Devices can be divided into image-based (23) or attachment-based (36) according to the sensor technology used. Most papers used attached devices and the majority were produced or devised specifically for the video game being presented. Figure 1 and 2 details the type and number of devices found.
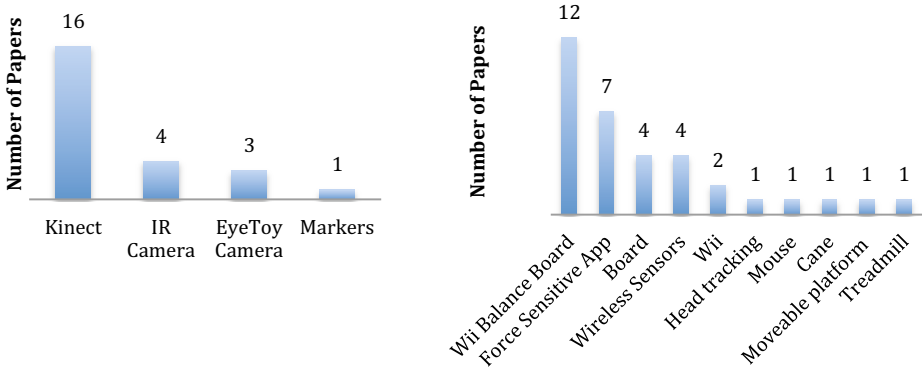
Fig. 1. Image-based devices used in games for balance. **Fig. 2.** Attachment-based devices used in games for balance.

4.2 Game Design Methodology

Only 11 publications reported applying some game design methodology. Methodologies used were divided: in categories: software engineering-oriented, 3 papers applied User-Centered game design (UCD) [R5,R6,R35] and one Model-View-Controller [R22] software design pattern; 4 papers applied Human-Computer Interaction Based-Design [R8,R9,R15]; 2 used a Game-Oriented Design Methodology (MOLDE) [R11,R12] and; one Health-Oriented Design [R27]. The remaining 75% didn't mention what design methodology have been applied, if any. Figure 3 shows the amount of game design methodologies used.
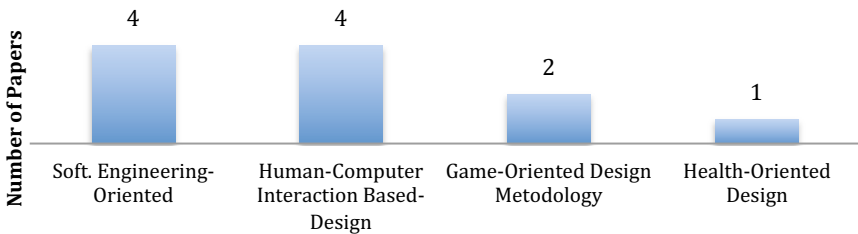
Fig. 3. Game Design Methodology.

4.3 Evaluation

In the following we provide details regarding software evaluation and clinical assessment.

4.3.1 Software-Oriented Evaluation

Papers were analyzed in order to identify what kind of evaluation was performed on the software and how they were applied. 21 papers conducted some software evaluation and one paper used three different criteria. It can be observed that usability was the major aspect considered. On gameplay evaluation, [R15] seniors participated in workshops to discuss game mechanics, and [R6] participants provided the research team with suggestions for improving the instructions for the game and gameplay elements (such as scoring and sound effects). Figure 4 shows what was evaluated and Figure 5 shows that questionnaire is the most common method of evaluation for usability or gameplay.
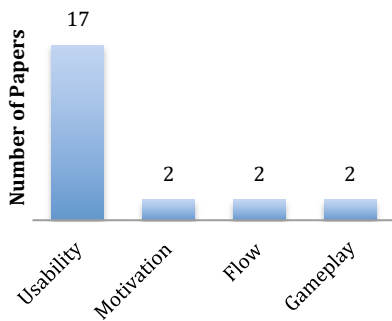
Fig. 4. Criteria used to evaluate the games.   **Fig. 5.** Instruments for software evaluation.
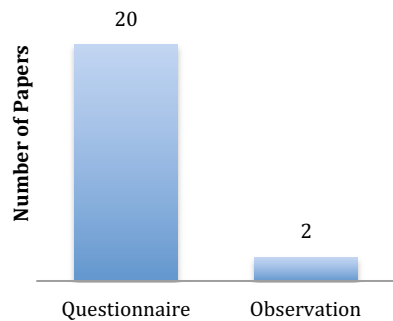
4.3.2 Clinical Assessment

Most of the papers that perform clinical assessment, applied more than one assessment. 18 papers included clinical assessment for balance evaluation, and there was a variety of tests, among them it was found: BBS (Berg Balance Scale); TUGT (Timed "Up & Go" Test); POMA (Tinetti Performance Oriented Mobility Assessment); CTSIB (Clinical Test of Sensory Interaction and Balance); FRT (Functional Reach Test); ART (Anterior Reach Test); 30SST (30-second Sit-to Stand Test); Fugl-Meyer and ABC (Activities-specific Balance Confidence Scale); Computerised Posturography tool NedSVE/IBV; Five Times Sit to Stand (FTSS); Unipedal Stance Time (UST); Timed 10-Meter Walking Test (10 MWT); Stepping Test (ST); Star Excursion Balance Test (SEBT); Isokinetic Dynamometry; Postural Assessment Scale (PASS); Romberg Quotient (RQ); Single Leg Balance test (SLB); Falling Index (FI); Stability Index (SI); Weight Distribution Index (WDI); Dizziness Handicap Inventory (DHI); Hospital Anxiety and Depression Score (HADS); Visual Analogue Scale (VAS); Dynamic Gait Index (DGI); Sensory Organization Test (SOT); Dynamic Visual Acuity (DVA); GaitRite; Senior Fitness Test (SFT); Brief Motor Scale; Digital dynamometer; Force Plate; Personal and Social Performance Scale; Balance Board (BB); Tandem Romberg (TR); One-Leg (OL); Simulator

Sickness Questionnaire (SSQ) and Pittsburgh Rehabilitation Participation Scale (PRPS). Figure 6 shows the distribution of clinical assessments in the SG found.
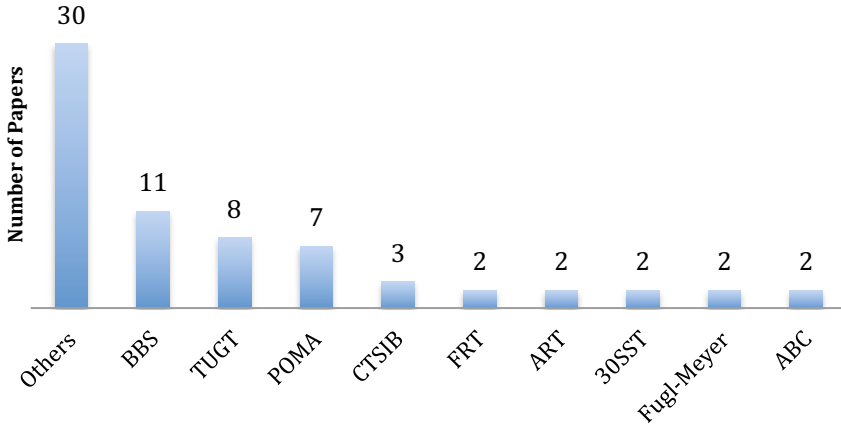
Fig. 6. Clinical assessments used with the video games.

4.4 Game Purpose

25 papers targeted specific pathologies. Figure 7 shows the targeted clinical context where the most common context were stroke.
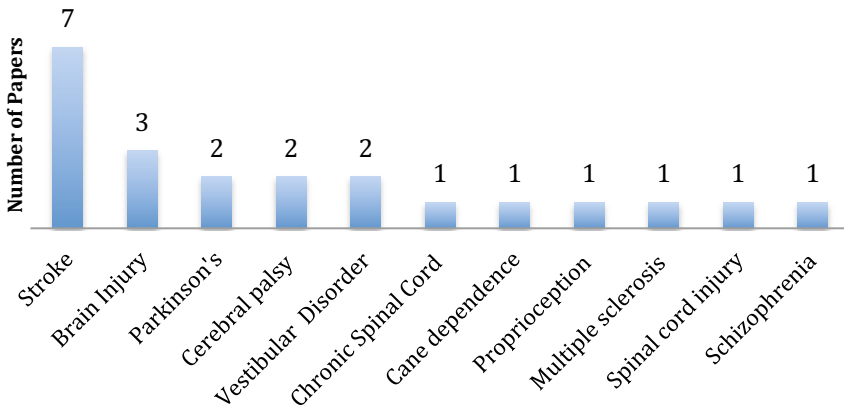
Fig. 7. Clinical context.

The majority of papers did not specified what balance function was stimulated by the video game, as shown Figure 8, and did not specified what population the SG was recommended for, as shown in Figure 9.
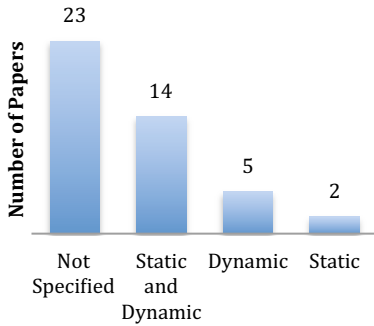
Fig. 8. Balance evaluated.
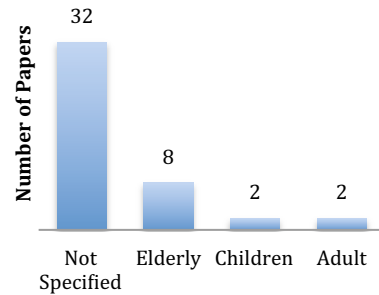
Fig. 9. Targeted population.

5 Conclusion

The present systematic literature mapping identified some serious games to improve balance, as well as, devices, evaluations (software and clinical), game design methodology and game purposes. In the mapping process, it was necessary to use the virtual reality term because searches in titles and abstracts did not have 'game' but actually were games as in the health area it is common to use virtual reality to refer to games, and many other computerized graphical systems [13].

Kinect was launched in 2010 and already is the most used image-based device for balance video games, while Wii, launched in 2007, is the most used attachment-based device. [4] described the potential of Kinect to become a future cornerstone of widely dispersed care and rehabilitation systems. Nevertheless, it was found that a wide variety of other devices have been used, the majority of video games to balance use some sort of device in order to assess the postural status of the player. It was remarkable to observe a lack of design methodologies mentioned to help to get to the games. There seems to be no consensus either on the clinical assessment of the effectiveness of the games among those few that did perform such assessment. On the other hand, regarding the software itself, the majority of games were analyzed against usability.

From this literature mapping, it was made clear that researchers are using serious games for balance improvement and are exploring all sorts of resources to make it become a reality. All seem to be promising but we will have to wait to see which ones pay-off.

6 Acknowledgments

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Information Systems and Technologies Maturity Models for Healthcare: a systematic literature review

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Abstract. The maturity models are instruments to facilitate organizational management, including the management of its information systems function. These instruments are used also in hospitals. The objective of this article is to identify and compare the maturity models for management of information systems and technologies (IST) in healthcare. For each maturity model, it is described the methodology of development and validation, as well as the scope, stages and their characteristics by dimensions or influence factors. This study resulted in the need to develop a maturity model based on a holistic approach. It will include a comprehensive set of influencing factors to reach all areas and subsystems of health care organizations.

Keywords: Stages of Growth, maturity models, hospital information systems.

1 Introduction

Health institutions together with government organizations are realizing that a certain inability to properly manage the processes of health is directly related to technological infrastructure limitations and management inefficiency [1, 2]. Hospital Information systems managers usually look at the mistakes made in these organizations and ask themselves on what they should have done to prevent them. It appears that these errors are usually symptoms of natural growth and organizations maturation. It seems to be the result of the development of the organization to its current maturity [3, 4]. The changes that an organization experiences, from its beginning to maturity, fit perfectly into the principles of Stages of Growth theory. Also, they occur in the current context of healthcare IST.

The maturity models are based on the premise that people, organizations, functional areas, processes, etc., evolve through a process of development and growth towards a more advanced maturity accomplishing several stages [5]. Mutafelija &

Stromberg [6] reports that the concept of maturity has been applied to more than 150 areas of IST. Obviously, the maturity models have also been applied in various fields of IST in the health field.

2 Methodology adopted for the literature review

Aiming to conduct a comprehensive and wide literature review, it was necessary to define a strategy in order to identify and analyze systematically the available literature on maturity models of healthcare IST. An initial review provided criteria to choose the approach and establish the strategies to be applied to this project.

The first strategy by Webster and Watson [7] suggests a structured approach in three basic steps: to identify the relevant literature in main sources (i.e. "leading journals") and recognized conferences. Then, the authors suggest conducting a search in the reference section of the studies identified in the first step in order to identify potential works related; finally, it is suggested the search via Web of Science of works which cite the works identified in the previous two steps.

The second strategy proposed by Tranfield et al. [8] suggests five steps for a systematic review of the literature. The first stage defines terms, keywords and combinations to be used as criteria to be applied in the literature review. A second phase is to identify relevant works that contain the keywords and terms defined above. In the third phase, it is carried out an assessment of identified papers and made a selection of works that meet certain criteria of quality. In the fourth phase, it must be extracted the relevant information from the selected literature. Finally, in the fifth phase a synthesis of data is done.

The analysis of both strategies described above shown that the approach of Webster and Watson [7], although simple and easy to implement, is not completely suited to this work. The literature on maturity models of healthcare information systems is limited in major journals and conferences. With regard to Tranfield et al. [8] approach, it was found that there is not a clear procedure for the identification of relevant work in the second phase. On the other hand, when assessing the quality of studies, the authors state that it is a challenge to define quality criteria for qualitative work. It caused some apprehension due to the fact that most of the work in this area has a qualitative approach.

Despite the concerns referred above, the literature review was carried out based on this approach with minor modifications and simplifications. Therefore, the terms and keywords were defined as literature searching criteria, taking in account that most of the relevant literature on maturity models of health care information systems is written in English. "Maturity Model" and "Stages of Growth" combined with other terms of this knowledge area were used for the search iterations (Table 1).

The searching criteria were applied to the literature review. Given that Tranfield et al. [8] did not suggest any procedure for this stage, it was followed the approach proposed by Webster and Watson [7] introducing two changes: in the first step, the main sources were replaced by major web platforms of scientific literature; and in the third step of this approach, Web of Science platform was replaced by the search engines Google and Google Scholar.

Table 1. Research criteria for the systematic literature review.

Research criteria
"Maturity Model" AND "Health"
"Maturity Model" AND "Healthcare"
"Maturity Model" AND "Hospital"
"Maturity Model" AND "eHealth"
"Stages of Growth" AND "Model" AND "Health"
"Stages of Growth" AND "Model" AND "Hospital"

Then, we look for research works across the platforms AIS Electronic Library, ISI Web of Knowledge, SCOPUS, Springer, Elsevier/Science Direct and IEEE Computer Society Digital Library. Afterwards, we proceeded to a quick data analysis to identify related references, as suggested by Webster and Watson [7]. Finally, given that the disclosure of much of the information on Maturity Models of health care information systems has been accomplished through technical reports, research and white papers projects, we move to a more extended search through the search engine Google Scholar and Google to ensure identification of other relevant work for the study. It should be noted that our study found that research on overall maturity models is in increasing, however, much of the publishing related to health care are not present in the IST leading journals.

After identifying a wide range of work in this area, according to the approach of Tranfield et al. [8] it was necessary to define quality criteria for the selection of suitable studies for this research. However, despite the difficulty in defining quality criteria for qualitative work, it was found that few models presented details of their design process and decisions taken in its development [9]. It was understood that it was convenient to apply a simple and comprehensive criterion of quality. It was established to gather all the studies when it was possible to clearly identify the context (motivation, goal, results, and benefit) and where maturity models were mentioned directly or indirectly. The characterization of each model was done taking in account description, scope, identification of stages and their characteristics, size, influencing factors, methods adopted in the development and validation process.

In the end, after processing of all cases, to some extent conditioned by the perception of researcher on maturity models in the IST health field, we selected 14 models which are described below.

3 Maturity Models of IST in health care

In this section is presented a selection of fourteen maturity models for IST management in healthcare organizations.

Quintegra Maturity Model for electronic Healthcare (eHMM)

The Maturity Model for electronic Healthcare is a model that incorporates all service providers associated with the health process. It is adaptable to any provider at any level of maturity [2]. The eHMM Maturity Model provided by Quintegra illustrates the transformation of an e-health process from an immature stage to a nationwide stage. According to its authors, the stages of maturity of this model provide a roadmap for health organizations to adopt continuous improvement of healthcare processes. Based on the study conducted by Quintegra we have identified several features that illustrate the nature of the progression of maturity. According to this model, the areas that showed progression in maturity are: timeliness of process, data access and accuracy of data, process effort, cost effectiveness, quality of process results and utility or value to stakeholders.

IDC Healthcare IT (HIT) Maturity Model

IDC (Health Industry Insights) developed a maturity model that describes the five developmental stages of hospitals IS. Each step is supported by the capabilities of the previous stage. This maturity model, called Healthcare IT (HIT) Maturity Model, has been used worldwide by IDC to assess the maturity of the hospitals IS (HIS). Also, it has been used to compare the average maturity between regions and countries of different continents [10]. This model has five stages, namely: basic HIS, advanced HIS, clinical HIS, and digital hospital and virtual hospital.

IDC's Mobility Maturity Model for Healthcare

More recently, IDC Health Insights proposed a maturity model for health care organizations. It consists of stages, measures, results and actions to advance along the path of maturity in the context of mobility toward a mobile culture. This model resulted as consequence of new opportunities associated with the value of mobility. It is an answer to the need for exploring alternative technologies, reengineering of business processes, availability of qualified personnel and development and implementation management of platforms and mobile applications [11]. To help healthcare organizations achieving their mobility strategies, IDC Health Insights has developed a maturity model consisting of five stages (ad hoc, opportunistic, repeatable, managed and optimized) and four critical measures (strategic intent, technology, people, and processes). In addition to the model, IDC also has featured a guide with actions for healthcare organizations to move effectively through the stages of maturity model.

HIMSS Electronic Medical Record Maturity Model (EMRAM)

HIMSS Maturity Model for Electronic Medical Record is a model for the identification of various stages of maturity in the area of Electronic Medical Record (EMR) of hospitals [12]. In these times, understanding the performance of EMR in hospitals is a challenge in the health care context [12]. The HIMSS Analytics (Healthcare Information and Management Systems Society) developed an adoption model to identify the stages of maturity of the EMR from the limited ancillary department systems to paperless EMR environment [13]. The model proposed by HIMSS Analytics is named EMR Adoption Model (EMRAM) and consists of 8

stages. According to HIMSS Analytics, the structure of this model ensures that a stage is reached only when all their applications are operational.

HIMSS Continuity of Care Maturity Model (CCMM)

It was created to help the optimization of results in health systems and patient satisfaction. The HIMSS Continuity of Care Maturity Model (CCMM) goes beyond Stage 7 of EMRAM [14]. It consists of 7 stages and it is based on the EMRAM structure. This global maturity model addresses the convergence of interoperability, exchange of information, coordination of care, patient involvement. Its goal is the efficient management of health for the whole of the population and also at the individual level [14]. This model also has the ability to assess the implementation and use of IT by the health service providers in order to optimize clinical and financial outcomes. With regard to the benefits of using this model, we can highlight the guidelines for the design of a solid strategy, at national and regional levels. Appropriate measures are taken in a timely manner and include all stakeholders [14]. As an example of these guidelines, we highlight the standardization of: IT systems, privacy, patient involvement, etc.

Electronic Patient Record Maturity Model (EPRMM)

According to the NHS (United Kingdom National Health Service), there are six different stages of functionality implemented cumulatively until a complete and exhaustive Electronic Patient Record (EPR) [15] is achieved. The adoption of an ERP system has been seen as a goal of health care organizations. In fact, it is intended to improve the efficiency of the organizations in the treatment of patient information, timely provision and needs at the point of care. As it progresses, more information will be available in the information system, whether using traditional computers, mobile phones or portable devices. The EPR system functions as the main source of all patient information. It keeps the complete medical record and will be available online at the point of contact with the patient.

Patient Records/Content Management Maturity Model (Forrester Model)

Forrester Research Inc. has developed a model with three stages for the area of EMR. This model was developed in order to help health care providers to assess their systems, the way they collaborate and interact, the state of the workflow, and most important, determining the map to get to the next phase. According to Clair [16], this three stages model includes four dimensions or influencing factors: access, interoperability, content features and planning and strategy. In addition to the model itself, Forrester Research Inc. has also developed a manual to drive systems to the next stage. The three stages of this model are: Paper- or imaged-based patient records dominate, Access to standalone repositories improves and Access to the complete digital medical record is role-based.

NEHTA Interoperability Maturity Model (IMM)

The provision of health care involves many different stakeholders, including both the technical and organizational informational area. The ability of these actors to interoperate will have a strong impact on the delivery of health care safely and confidence along the stages [17]. The constant evolution of technology and the

changes in clinical practice bring us to assess the ability to take advantage of these developments. The National E-health Transition Authority of Australia (NEHTA) produced an Interoperability Maturity Model (IMM) which is based on three components: five stages CMMI (Capability Maturity Model Integration), a set of interoperability goals, and an evaluation model focused at the national level. The five stages of this model are constrained by organizational, informational and technical dimensions at local, corporate and national level. Interoperability targets for reuse, evolution, standards, scope, scalability, configurability and explanation are shared between the three dimensions. The objectives associated with business and governance are set to the organizational dimension. Informational dimension targets are classified as: data format and semantics, meta-data, ownership and rights, common building blocks. Targets associated with the technical dimension are classified as: interface specification, functional decomposition, communication protocol. n-tier architecture and technical policy separation.

NHS Infrastructure Maturity Model (NIMM^{TM})

The NHS Infrastructure Maturity Model (NIMM) aims to provide a coherent framework for healthcare organizations. The organization will be able to measure its own current technological infrastructure capabilities in specific areas and consequently, to identify and prioritize activities that enhance these capabilities [18]. Therefore, the NIMM is a model of evaluation of maturity technological infrastructure. This model adopts the Key Capabilities Self-Assessment Tool to support IT organizations associated with NHS. It is used for preparing a self-assessment of technology infrastructure assessing the maturity of its capabilities. Furthermore, it helps in the identification of improvement maturity projects. The NIMM has a holistic approach: it takes in account technological and IT infrastructure organizational sides. In fact, it has 72 evaluation capabilities grouped in 13 categories. The categories are divided into technological aspects and organizational issues. The technological aspects are: Common Applications & Services; Operating Systems; Infrastructure Hardware Platforms; Network Devices & Services; IT Security & Information Governance; Infrastructure Patterns & Practices; End User Devices. The organizational issues are: Infrastructure Governance; Business Alignment; Procurement; People & Skills; Financial Management; Principles, Standards, Procedures & Guidelines.

Healthcare Analytics Adoption Model (HAAM)

Health care has moved through three phases of computerization and data management, i.e., data collection, data sharing and more recently data analysis. The data collection phase is characterized by the implementation of EMRs. It does not have a significant impact on the quality or the cost of health care [19]. According to these authors, it will be necessary to invest in practices associated with data analysis and use of data warehouses. In this sense, the HAAM model was developed to accelerate the progress of maturity analytical data in health care organizations. Healthcare Analytics Adoption Model (HAAM) is a model to measure the adoption and use of data warehouses and data analysis in health care [19]. This model was initially developed by Sanders in 2012 [20] as result of years of work in this area. He anticipated foreseeable needs of the healthcare industry. This model is based on

EMRAM model [12]. It received numerous contributions from several healthcare consultants resulting in an update version in 2013. This model has a similar approach as EMRAM to assess the adoption of data analysis in health. It is structured in 8 stages. Each one of them performs through several capabilities that define the path of health organizations to data analysis maturity. In addition, each stage includes a progressive expansion of analytical capabilities in the following four areas: new data sources, complexity, data literacy and data timeliness.

Hospital Cooperation Maturity Model (HCMM)

This model aims to conceptualize an evolutionary path for improving cooperation within hospital and between hospitals [9]. The authors felt the need to develop the model because of the real and observable changes hospitals are suffering. It was intended to cope with increased competition and market dynamics. The model application would force specialization and cooperation. The Hospital Cooperation Maturity Model helps hospitals in the evolution of strategic, organizational and technical capabilities in a systematic way. The model contributes to structures and collaborative processes become efficient and effective. HCMM consults a total of 36 reference points, reflecting three distinct organizational dimensions relevant to the ability to cooperate. On the one hand, the model can be used as the basis for comparative evaluation of the quality of cooperation between a specific hospital and their business partners; on the other hand, it may be applied as a common basis for sharing learning and improvement actions. As mentioned above, the HCMM is structured in three layers or dimensions. The first one is a strategic layer set to measure the ability of a hospital to cooperate with external partners. The second one is the organizational layer set to measure the ability to cooperate within the hospital (i.e., between different departments, divisions, etc.). Finally, the third layer is an information layer used to measure the technical capabilities of a hospital to provide the IT infrastructure needed for internal and external cooperation efficiently and effectively.

PACS Maturity Model (PMM)

The PACS maturity model (PMM) describes the process maturity of hospitals based on PACS. The analysis is developed in terms of functionality and integration of the work flow practice. PMM is a descriptive and normative model. It was developed as a guide for evaluation and strategic planning [21]. In this regard, the PMM can be used for strategic planning. The model incorporates growth paths to reach higher stages of PACS maturity. However, this model omits a relevant issue. The development used in this maturity model will be different in different areas of the same organization. Besides, the maturity maximization cannot be effective or "ideal" in all circumstances [22]. On the basis of 34 scientific papers literature review on PACS and subsequent meta-analysis, Wetering and Batenburg [21] identified three major trends in the evolution and maturity of PACS: (1) Radiological and hospital-wide process improvements, (2) Integration optimization and innovation, and (3) Enterprise PACS and EPR. From there, the authors defined five dimensions (strategy and policy, organization and processes, monitoring and control; information technology, and people and culture) and five PACS maturity stages that hospital can

achieve: infrastructure, process, clinical process capability, integrated managed innovation and optimized enterprise chain.

Telemedicine Service Maturity Model (TMSMM)

The authors [23] consider that this maturity model can be implemented to measure and manage the health system capability to provide clinical health care at a distance. Indeed, this model can be used to measure, manage and optimize all components of a telemedicine system and the health system in which it is applied. The term "telemedicine" was first used in 1970 and refers to the provision health services (medicine) at a distance (tele). The TMSMM model is based on three dimensions. The intersection of each pair forms a matrix, each one with specific meaning and function. First, five domains are defined to provide a holistic view of all the factors that impact the implementation of telemedicine services. Secondly, the telemedicine service dimension is built by five micro-level processes, a meso-level process and one macro-level process per domain. The third domain is the maturity scale, which provides assessment standards for maturity measurement. The domain adopted by this model is the 5 M's ("Man - Users Communities", "Machine - Infrastructures ICT", "Material - EHR systems," "Method - Change Management" and "Money - Financial Sustainability"). The maturity scale is based on the stages indicators of CMM maturity model (Capability Maturity Model). There are 5 stages. Stage 1: ad hoc - service is unpredictable, experimental, and poorly controlled; stage 2: managed - the service is characterized by projects and is manageable; stage 3: standard - the service is defined as a standard business process; stage 4: quantitatively managed - the service is quantitatively measured and controlled; stage 5: optimizing - focus on continuous improvement.

Healthcare Usability Maturity Model (UMM)

The Healthcare Usability Maturity Model helps healthcare professional to assess the usability stages of IST of organizations and how they can advance to the next stage [24]. The authors of this Maturity Model led a Usability Taskforce created by HIMSS [25]. Its objective was to develop a new model for identifying elements and main steps involved in successful integration of usability in a healthcare organization. The development of this model was based on the evaluation of the characteristics of three usability maturity models [26-28] and how they could be adopted in healthcare. In this model, each phase enables organizations to identify their current stage of usability and also includes guidelines to advance to the next stage. The five stages are: unrecognized, preliminary, implemented, integrated and strategic. Within each stage, these elements are taken in account: focus on users, management, process and infrastructure, resources and education.

4   Summary and closing remarks

After the selection of models which are synthesized in Table 2, it was found that the maturity models for health care IST are developed by different types of entities,

including national and international health care companies, research organizations in ICT as well as academic experts in this domain.

It was also found that there are two approaches: in one hand, the highly specialized models that have resulted in a health subsystem and in the other hand, the more comprehensive models, i.e. models representing the hospital IS as a whole. Also, it was found that most of the analyzed maturity models does not disclose the design process nor the research options for development and validation [9], thus compromising the researcher work.

It appears that CMM and CMMI his successor, is the reference model for the design of Maturity Models in the health sector. This model has served as inspiration for dozens of maturity models in the various areas of IST [29]. In fact, 6 of 14 identified models base its structure on the CMM model.

Regarding the number of maturity stages, there are models from 3 stages as the Forrester Model [16] up to 9 stages of HAAM [19].

It is noted that not all the identified maturity models with various dimensions or influencing factors have explicitly broken down the characteristics for each stage of maturity. In fact, from 11 maturity models with influence factors, only 5 discriminate characteristics for each stage [2, 9, 16, 23, 25]. With regard to influence factors, it was detected entries with the same name in different maturity models and entries with different names but with the same meaning or interpretation (result of using different terminology adopted by the authors). Also, the authors did not apply weights to each of the influencing factors, that is, in the assessing process of the overall maturity of health IST, all influencing factors have the same importance.

In the case of adoption of a tool for assessing the system maturity, it was found that most of the models, besides focusing on the assessment of the system's maturity, they pay attention to an improvement path of such maturity. However, not all have a properly systematized process to move to a higher maturity level.

Some maturity models are developed by health national and supranational organizations, mainly corporations, who are dedicated to technological developments, such as IDC Health Insights and HIMSS or even by national health organizations as the NHS or NEHTA. This fact complicates the process of search and analysis of their respective models, since access to information is restricted. Consequently, it is not possible to know the development methodology and validation adopted. Moreover, only a small part of the models were published in IS Journals ([9, 21], while the rest are published mostly in white papers, making it impossible thus attest to its validity in the context of peer review.

As a result of this study, none of the identified models has a sufficiently broad scope covering all areas and subsystems of health care organizations. In this sense, a maturity model with a holistic approach including a comprehensive set of influencing factors is missing. It should be supported by rigorous scientific methods of conceptualization and validation.

Table 2. Summary and comparison of maturity models for IST healthcare

Designation	Health Field	Stages	Research Method	Influencing factors / Dimensions	Assessment Tool	Reference Model	Author / Year
Quintegra Maturity Model for electronic Healthcare (eHMM)	General	7	n/a	Entities; Department; Infrastructure	n/a	n/a	Sharma, 2008
IDC Healthcare IT (HIT) Maturity Model	General	5	n/a	Types of IS	n/a	n/a	IDC, 2008
IDC's mobility maturity model for healthcare	mHealth	5	Survey, Case study	Intent; Technology; People; Processes	IDC's Mobility Maturity Model Guidance	CMM	IDC, 2013
HIMSS Maturity Model for Electronic Medical Record (EMRAM)	EMR	8	n/a	Types of IS	EMR Penetration Assessment Tool	n/a	HIMSS Analytics, 2006
HIMSS Continuity of Care Maturity Model (CCMM)	General	8	n/a	Types of IS	n/a	EMRAM	HIMSS Analytics, 2014
Patient records/content management maturity model (Forrester Model)	EMR	3	Interviews with US healthcare providers	Access; Interoperability; Content Features; Planning & strategy	Guidance To Get To The Next Phase	n/a	(Clair, 2010)
Maturity Model for Electronic Patient Record (EPRMM)	EMR	6	n/a	EPR System	n/a	n/a	(Priestman, 2007)
NEHTA Interoperability Maturity Model (IMM)	Interoperability	5	ODP standards (open distributed processing)	Organisation; Information; Technical	Yes	IMM / CMMI	(NEHTA, 2007)
NHS Infrastructure Maturity Model (NIMM)	Infrastructure IT	5	n/a	Process; People & Organisation; Technology; Security & Information Governance; Strategy Alignment & Business Value	Key Capabilities Self-Assessment Tool	CMM	(NHS, 2011)
Healthcare Analytics Adoption Model (HAAM)	Data Warehouse & Analysis	9	Data gathered by observation and learned in a structured educational curriculum, experts opinions	New Data Sources; Complexity; Data Literacy; Data Timeliness	Healthcare Analytics Adoption Model Self Inspection Guide	EMRAM	(Sanders et al, 2013)
Hospital Cooperation Maturity Model (HCMM)	Networking / Cooperation	4	Interviews, Focus Group, prototype	Strategic; organizational; Information	HCMM Instantiation	CMM	(Mettler & Blondiau, 2012)
PACS Maturity Model (PMM)	PACS	5	Literature review, qualitative meta-analysis approach	Strategy and policy; Organization & Processes; Monitoring and Control; Information Technology; People & culture	Yes	CMMI	(Rogier Wetering & Batenburg, 2009)
Telemedicine Service Maturity Model (TMSMM)	Telemedicine	5	Literature review, workshop with health and IT professionals, case study	Man; Machine; Material; Method; Money	Yes	CMM	(Van Dyk & Schutte, 2013)
Healthcare Usability Maturity Model (UMM)	Usability	5	Literature review, case study	Focus on users; Management; Process & Infrastructure; Resources; Education	Yes	Schaffer UM, Nielsen UM, Earthy UM	(HIMSS, 2011)

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Reducing computation time by Monte Carlo method: an application in determining axonal orientation distribution function

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Abstract. Diffusion MRI (dMRI) is highly sensitive in detecting early cerebral ischemic changes in acute stroke, and in pre-clinical assessment of white matter (WM) anatomy using tractography, thus being an important component of health informatics. In clinical settings, the computation time is critical, and so finding forms of reducing the processing time in high computation processes such as Diffusion Spectrum Imaging (DSI) dMRI data processing is extremely relevant. We analyse here a method for reducing the computation of the dMRI-based axonal orientation distribution function h by using a Monte Carlo sampling-based methods for voxel selection, and so obtained a reduction in required data sampling of about 20%. In this work we show that the convergence to the correct value in this type of dMRI data-processing is linear and not exponential, implying that the Monte Carlo approach in this type of dMRI data processing improves its speed, but further improvements are needed.

Keywords: White Matter, Diffusion MRI, Monte Carlo sampling methods, optimization, axonal ODF.

1 INTRODUCTION

The goal of this work is to establish how much the use of the Monte Carlo method can increase the speed of complex and large numerical data processing. Specifically, we will consider the determination of the white matter (WM) neural circuitry in humans by use of diffusion magnetic resonance imaging (dMRI) data processing, which is often done using the diffusion tensor imaging (DTI) approach [1-2]. Despite the development of improved dMRI WM fiber tracking techniques [3–7], these results are still considerably behind the results that can be obtained using in-vitro data [8]; or in-vitro microscopic studies [9]. Thus, the acquired dMRI data has steadily increased in both size and complexity.

Different WM fiber tracking techniques have different capacities to accurately represent the anisotropic component of the axonal orientation distribution function (ODF). The bigger the amount of different diffusion-sensitizing parameters the data acquisition has, the more information can be obtained [10,11,12,13], but this increases the size of the data set and the corresponding data processing time. A typical example of advanced dMRI data acquisition and processing is Diffusion Spectrum Imaging (DSI) [12]. The end-result of the advanced dMRI data processing is often tractography, which consists on showing the WM connections more likely to exist. The final images of the tractography are typically a spaghetti of lines, Fig. 1(a) (e.g. Ref. [4]); and/or a colored anatomical image of connection probabilities, Fig. 1(b) (e.g. Ref. [5]).

a)   b)
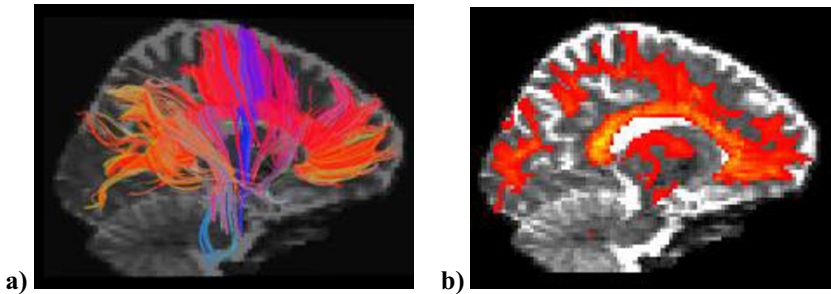
Fig. 1. Examples of human brain dMRI data processing, shown are sagital slices of tractography final images. a) DTI-based spaghetti of lines, b) DTI-based connection probabilities with seed region in corpus callosum.

We used here the dMRI data processing for extracting the WM axonal ODF, h, with an improved estimation of its isotropic and anisotropic fractions. We then calculate how much the use of the Monte Carlo method can reduce the data size required to be within 1 standard error of mean (SEM) from the value obtained using the full data set.

2   METHODS

2.1 Theoretical considerations

To obtain the axonal ODF, h, it is necessary that the experimental dMRI signal is modeled by axons having a certain orientation, and those axons need to have physiologically reasonable properties so that the recovered axonal ODF accurately represents the physiological ODF. Using our model, we determine the parameters which give the best fit of the calculated theoretical dMRI signal to the experimental signal. From the best fit we obtain the experimental axonal ODF, h_{fit}. The experimental axonal ODF can then be separated into an isotropic and an anisotropic component. We proceed to calculate for each voxel the isotropic fraction and the integer k number of WM axes. Then, the number of WM axes in each voxel that are parallel to the WM axes of neighboring voxels is determined by a procedure we developed, which calculates in automatic fashion the WM axes obtained in ref. [7]. Comparing these axis numbers between neighboring voxels, we can quantify the existent number of equally oriented axes in neighboring voxels, we call it framography. This allows us to distinguish between 1-axis connections ($k=1$), which are lines identical to those obtained in DTI tractography; 2-axes connections ($k=2$), which occur when 2 fiber-axes at a voxel are compatible with 2 fiber-axes at a neighboring voxel; and 3 axes connections ($k=3$), which occur when 3 fiber-axes at a voxel are compatible with 3 fiber-axes at a neighboring voxel, similar to ref. [7] (see Fig. 2).
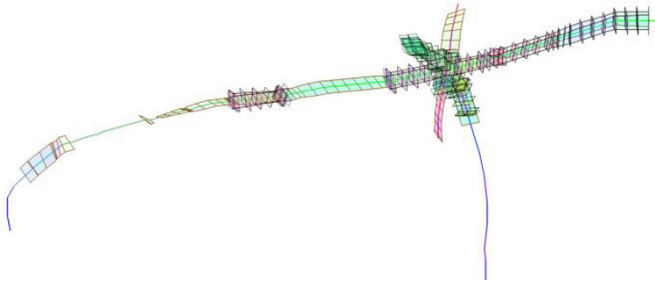
Fig. 2. Example of DSI connections from one seed with colors depend on orientation. The lines are 1-axis connections ($k=1$), planes are 2-axis connections ($k=2$), and crossing planes are 3-axis connections ($k=3$).

2.2 Mathematical representation of dMRI signal

Using the multi-exponential representation of the dMRI signal in ref. [14], a parameter search is done (see 2.4 sub-section) where D_F denotes the diffusion tensor of apparent fast diffusion and D_S denotes the diffusion tensor of the apparent slow diffusion orthogonal to the direction of fast diffusion. If the highest eigenvalue of the diffusion tensor for a single axon is $\lambda_{||}$, and the two smaller eigenvalues are both equal to $\lambda_\perp$, then based on ref. [14] the D_F and D_S for an axon with a $\hat{r}(\theta,\varphi)$ orientation expressed in spherical coordinates (θ,φ), and where I is the identity matrix, are:

$$D_F(\theta,\varphi) = [\hat{r}(\theta,\varphi)\,\hat{r}(\theta,\varphi)^T]\lambda_{||} \tag{1}$$
$$D_S(\theta,\varphi) = [I - \hat{r}(\theta,\varphi)\,\hat{r}(\theta,\varphi)^T]\lambda_\perp \tag{2}$$

The $\lambda_{||}$ corresponds to diffusion parallel to the axon, and $\lambda_\perp$ to diffusion perpendicular to the axon, and they were both collected from Table 1 in ref. [14]; corresponding, respectively, to the D_F and D_S experimental averages in that ref. [14] table.

If we consider $\bar{q}$ as the q-vector given by the product of the proton gyromagnetic ratio γ, with the diffusion-sensitizing gradient duration δ, and the magnetic field gradient vector $\vec{g}$ [10], $\hat{q}$ as the unit-size q-vector, τ as the regularized diffusion-time, and ζ as a scalar between 0 and 1 (from Table 1 in ref. [14]), then the dMRI signal reduction for an orientation (θ,φ) is:

$$S(\theta,\varphi)_{\hat{q}} = \zeta e^{-|\vec{q}|^2 \tau \hat{q}^T D_S(\theta,\varphi)\hat{q}} + (1-\zeta)e^{-|\vec{q}|^2 \tau \hat{q}^T D_F(\theta,\varphi)\hat{q}} \,. \tag{3}$$

The q-vector has units of one over length, and that length expresses the diffusion spatial length scale-order the dMRI signal is probing. We model this dMRI signal reduction starting from the ODF of the WM fiber orientations, $h(\theta,\varphi)$. The WM fiber orientation ODF, h, is expressed as the sum of an isotropic and an anisotropic component, the first of which is given by a sphere of radius R, and the second by a number k of Gaussian-like peaks indexed by j and with standard deviation σ_j.

The theoretical dMRI signal equation E_T is obtained using Equations (1) and (2) on Equation (3) to define S, and then using the defined h to obtain:

$$E_T(\bar{q}) = \frac{\int_0^{2\pi}\int_0^{\pi} h(\theta,\varphi)S(\theta,\varphi)_{\hat{q}}\sin\theta\,d\theta\,d\varphi}{\int_0^{2\pi}\int_0^{\pi} h(\theta,\varphi)\sin\theta\,d\theta\,d\varphi} \tag{4}$$

If the experimentally obtained dMRI signal intensity is E_{exp}, then the difference G_{DSI} between the experimental and theoretical dMRI signal for DSI is obtained by the sum, over all the $\bar{q}$ used in DSI, of the squared differences between E_{exp}, and E_T.

The E_T was compared to E_{exp}, and the parameters that give the best approximation were chosen. The optimal experimentally obtained R, L_j, and σ_j parameters are those that minimize the difference between E_T and E_{exp} for the used data acquisition method, and they define the h_{fit} for that acquisition method. The parameters combinations are described in Table 1 and are based on diffusion parameters from ref. [14], all parameter combinations were assessed for each voxel (Fig.3 is the example for one voxel).

Table 1: The parameters used in our search.

Parameters	R	L_1	L_2	L_3	σ_1	σ_2	σ_3	$\lambda_{\parallel}$	$\lambda_{\perp}$	ζ
Values	1	0:50: 300	0:50: 300	0:50: 300	0:0.1: 0.5	0:0.1: 0.5	0:0.1: 0.5	1.69 x10⁻⁹	0.36 x10⁻⁹	20.91 x10⁻²
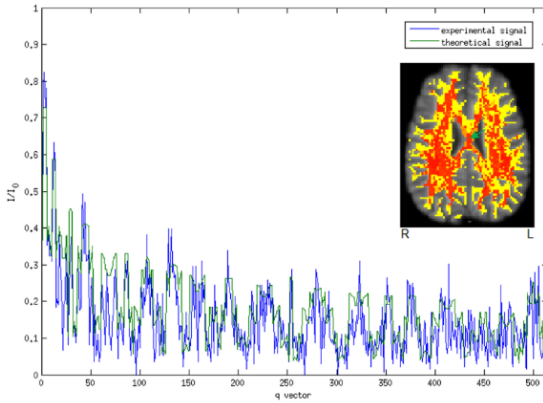
Fig. 3. Experimental (blue line) and theoretical signals (green line) along the corresponding q-vector number. The example voxel is on the position pointed by the green arrow near the ventricles (black triangular shapes) in the brain image overlaid by the isotropic fractions (yellow-red scale).

The isotropic and anisotropic fractions were obtained from the volume obtained from the h_{fit}. The total volume is calculated by:

$$V_{total} = \int_0^{2\pi} \int_0^{\pi} h_{fit}(\theta, \varphi) \sin\theta \, d\theta \, d\varphi$$

$$(5)$$

The isotropic volume corresponds to the volume of the sphere with radius equal to the minimum value of $h_{fit}(\theta,\varphi)$; therefore $h_{fit}(\theta,\varphi)$ in Equation (5) is replaced by the minimum of h_{fit}:

$$V_{iso} = \int_0^{2\pi} \int_0^{\pi} min(h_{fit}) sin\theta d\theta d\varphi \qquad . \qquad (6)$$

The anisotropic volume is the difference between total volume and isotropic volume: $V_{aniso} = V_{total} - V_{iso}$ The ratio between the anisotropic fraction of WM fibers, and the total amount of WM fibers is: $\Xi_{aniso} = \dfrac{V_{aniso}}{V_{total}}$. The ratio for the isotropic fractions (only calculated for WM voxels) is thus:

$$\Xi_{iso} = \frac{V_{iso}}{V_{total}} \qquad (7)$$

2.3 Processing of dMRI data

The Ξ_{iso} of each voxel was correlated with the k values obtained using the approach described in the next section. The study was performed on high quality DSI dMRI data from the Human Connectome Project (HCP). Henceforth, we will refer to these data as "HCP data". The HCP data used in the preparation of this work were obtained from the database of the MGH-UCLA section of the HCP (all the HCP data has been approved by the corresponding ethical committees and internal review boards) [15], the HCP data includes an anatomical T1-weigthed volume. The segmentation of the WM was performed in HCP data using FSL [16]. The anatomical data, and segmented maps were coregistered to diffusion space using FSL. There were available 2 subjects with data suitable for our analysis. Subject 1, was acquired using a maximum gradient of 300 mT/m, 2 mm isovoxels, 514 directions and b maximum of 15000 s/mm2. Subject 2 was acquired at a maximum gradient of 90 mT/m, 2 mm isovoxels, for 514 directions and b-value maximum of 10000 s/mm2.

3   RESULTS

The Diffusion Toolkit/TrackVis software [5] was used to obtain a 181 points ODF surface (not the axonal ODF). The obtained ODF data contains ODF peaks, which are the orientations for which the ODF is higher. The ODF peaks data binary data takes the value of 1 if the value of the ODF is a local

maxima, and zero otherwise. For each peak, there is a peak pointing in the opposite direction with almost equal amplitude. If the ODF contains more than 3 pairs of opposing peaks, only the 3 highest ODF pairs of opposing peaks will be used. Furthermore, we also used the anatomical labeling provided by FSL; so that WM can be distinguished from gray matter (GM), from cerebro-spinal-fluid (CSF), and from everything else that is not WM. The anatomical image had its intensity inhomogeneity corrected, contrast adjusted, voxel re-sampled, and co-registered to the dMRI data.

We call the orientation of a pair of ODF opposing peaks, an axis. In an axis, a connection to a neighboring voxel can be made by either advancing or retreating along that axis. We developed an automatic approach method based on previous works [7], which is a WM axis extension approach where for each WM point it is determined the number of axes parallel to the axis of another WM point. The obtained topological structure is a 3-plane crossing grid, such as occur in Fig. 2.

The number of coincident axes between two neighboring points is denoted by a non-negative integer k, implying that in the same voxel there can be different k values depending on which neighboring WM points are considered. The value of k between two neighboring points defines the number of parallel fiber axes between the two sets of 3 axes, one set per point. The axes extension and parallelism detection are only performed for WM voxels, Fig. 4.

The isotropic fractions are higher near the vicinity of GM, as it is expected, since the fibers theoretically become less organized and with a less defined main direction. The regions with lower Ξ_{iso} are mostly located in the Corpus Callosum (CC), superior longitudinal fasciculus, and corticospinal tracts (Fig. 4). The regions with lower isotropic fraction are in agreement with bigger k values from the tractography method. It is apparent that high k values correspond to low values of Ξ_{iso}. This was confirmed by calculating the mean values of the Ξ_{iso} for each group of voxels with a given k value, Table 2.

The relation between the percentage of voxels used (x-axis) and the value of Ξ_{iso} represented as a fraction of the Ξ_{iso} obtained when all voxels are used (y-axis) appears in Fig. 5. We obtain the relations between the percentage of voxels used (x-axis) and the percentage of sub-partitions whose averages are within 1 standard error of the mean of the true average (y-axis) (Fig. 6). These results were obtained for each of the three axis connections possibilities, specifically, $k=1$, $k=2$, and $k=3$. For both Fig. 5 and Fig. 6 the voxels are randomly sampled without replacement using a Monte Carlo method.
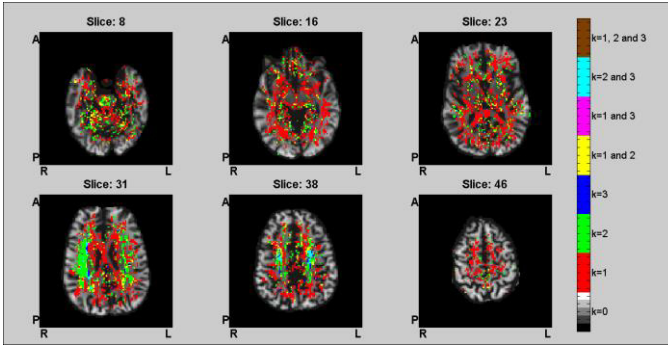
Fig. 4. Example of results using HCP DSI human data overlaid on HCP anatomical MRI.

Table 2. Isotropic fractions' Ξ_{iso} relation to k values for two subjects. Only k values with more than 5 voxels were considered statistically significant.

		k=1	k=2	k=3	k=1 V 2	k=1 V 3	k=2 V 3	k=1 V 2 V 3
Subject 1	$\langle\Xi_{iso}\rangle \pm SEM$	63.1±0.5	41.3±0.8	38.7±1.8	43.0±1.4	53.7±6.2	35.9±2.4	N/A
Subject 1	Number of voxels	5777	2322	247	708	27	124	4
Subject 2	$\langle\Xi_{iso}\rangle \pm SEM$	53.6±0.4	37.4±0.7	38.4±2.0	38.8±1.3	46.0±7.0	33.0±2.4	47.1±9.8
Subject 2	Number of voxels	8251	3342	280	867	29	146	12
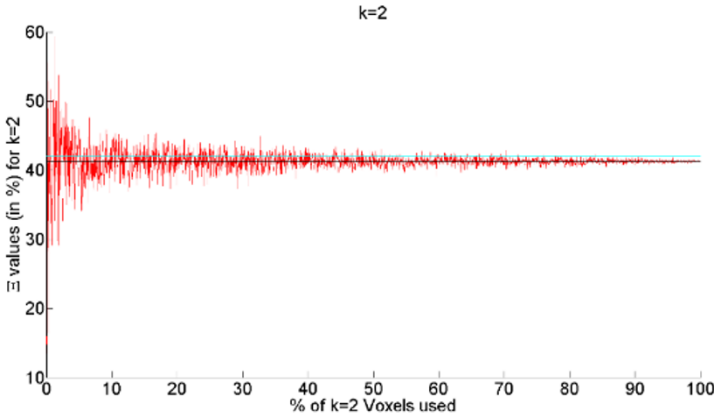
Fig. 5. Comparison of Ξ_{iso} calculated with all the voxels (straight line ± 1 standard error of the mean) versus Ξ_{iso} calculated with a Monte Carlo fraction of the voxels (y-axis) as a function of the fraction of the Monte Carlo-selected voxels (x-axis) for $k=2$, the results for $k=1$ and $k=3$.are similar.
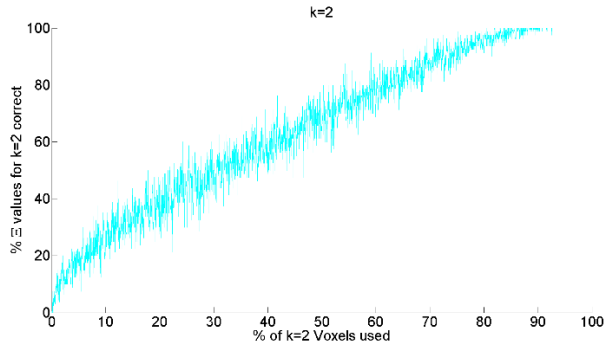
Fig. 6. Calculation using Monte Carlo method of the fraction of voxels with Ξ_{iso} within a standard error of the mean of the Ξ_{iso} calculated with all the voxels (y-axis) as a function of the fraction of the Monte Carlo-selected voxels (x-axis) for *k=2* (results for *k=1* and *k=3* are similar).

4   CONCLUSION

The high processing time required for the search of the model parameters limited the search of more optimal parameters, e.g. larger variations of $\lambda_{\parallel}$ and $\lambda_{\perp}$. Our model is simple, but it provides a good approximation to the real axonal structures in the brain.

We found that the regions with higher *k* values correspond to regions with lower Ξ_{iso}. An arrangement *k=3* between voxels suggests a lower isotropic fraction, which means that the 3-axis arrangement of the axons is a good representation of the majority of the axons' distribution, in agreement with ref. [7]. The simpler the arrangement, respectively *k=2* and *k=1*, the higher the isotropic component of axonal distribution.

The use of Monte Carlo voxel sampling obtained the correct result within 1 standard error of the mean 100% of the times using only about 80% of the data. Thus, using the Monte Carlo method is capable of reducing the computation time by about 20% without loss in result quality.

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Enabling data storage and availability of multimodal neuroimaging studies – A NoSQL based solution

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Abstract. Multimodal neuroimaging studies are of major interest in the clinical and research setting, enabling the combined study of the structure and function of the human brain. However, the amount of procedures applied, associated with the production of large volumes of data creates obstacles to the organization, maintenance and sharing of neuroimaging data. Taking this into account, we developed a NoSQL based solution that automates the process of organizing and sharing neuroimaging data. This system is composed by an application, which recognizes the files to be stored through the use of a standardized nomenclature of the files generated in the processing workflows. Additionally, the system is distributed in order to store data as documents enabling users to upload and retrieve files to/from the system in different locations. The prototype enhances the research process, through the simplification and reduction of the time spent organizing and sharing information.

Keywords: MRI, NoSQL, Storage, MongoDB, multimodal neuroimaging.

1   Introduction

Information sharing and storing is one of the fundamental practices in neurosciences research, in particular, and in modern society, in general. This paradigm, together with the vast amount of data continuously generated and requested, creates the   need for specific tools to ease its management. The acquisition, processing and analysis of Magnetic Resonance Imaging (MRI) data involves a vast set of processes and tools which eventualy generate extra amounts of data. This type of analysis can be extremely important at different levels in the context of neuroscience research and clinical practice, from the definition of basic

concepts of brain functioning and organization, to the identification of hallmarks of several pathologies and even cirurgical planning [1,2,3].

Neuroimaging studies are usually group studies, tipically with one control group and another group having the condition under study, each of these composed by several participants/subjects. Each subject tipically undergoes a multimodal imaging protocol with several different imaging modalities, each of these tipically generating several 3D (e.g. structural acquisitions) or 4D (e.g. funtional acquisitions) datatsets. In a typical neuroimaging study, composed of 100 subjects, each with a functional MRI (fMRI), structural MRI and diffusion MRI (dMRI) acquisition, more than 160000 files and 500 GB of data can be generated.

In addition to the large amounts of generated data, images commonly undergo several processing steps [4]. In this sense there are some specifically established processing streams for analysis of MRI brain images, such as the one used in BrainCAT application for joint analysis of fMRI and dMRI images [5], or Freesurfer workflow for the automated segmentation of structural MRI images [6]. This processes can also vary, depending on the analysis in question, and the same dataset can be used in several analysis, greatly contributing for the increase in the amount and dispersity of data to be managed.

The lack of standardized procedures, coupled with the inadequacy of data organization platforms, also makes the reuse, sharing and collaboration between projects and institutions oftenly difficult and counterproductive. This considerably increases the probability of information loss and loss of research potential, in addition to not providing secure and automatic means for storing, acessing and sharing data. The possibility of committing errors in the combination of studies and analysis techniques also increases, which could further compromise results. In this sense it is necessary an extra effort to maintain the coherence of the generated information [7].

Important work has already been done in establishing the foundations for this kind of platform. One available example for the management and storage of MRI like data is the ANIMA architecture [8]. ANIMA is an online repository of published meta-analysis neuroimaging results. The information is organized in individual studies, tipically stored in the NIfTI image format, along with essential information describing these studies. Any user can submit their own study information, which will be first analyzed by the administrators of the database (DB), for security and data integrity reasons. Finally, ANIMA has been developed in order to allow imported data to be easily queried and organized locally by the user. Another solution is the Extensible Neuroimaging Archive Toolkit (XNAT) [9]. Information can be entered in the system as XML or forms, being initially stored in a virtual quarantine until an authorized user validates it. Access to the repository is done via a secure web application, providing search capabilities for specific and combined data types, detailed reports, experimental data lists, import/export tools and access to laboratory processing streams. XNAT also includes an online image viewer for the neuroimaging formats DICOM (Digital Imaging and Communication in Medicine) and Analyze.

2 Processing MRI data

The lack of standardization of processes is a major obstacle to the organization and cooperation between researchers/clinicians, reducing efficiency, speed and increasing the likelihood of errors and consequent obtainment of incorrect results. In this regard it is common practice to define data processing pipelines [5]. In this section we intend to provide an example of a typical data processing workflow for structural, functional and diffusion analyses, from the acquisition of data to achieving results. Figure 1 presents an existing complex and structured processing pipeline intended to demonstrate the variety of steps present in the realization of multimodal brain MRI studies.
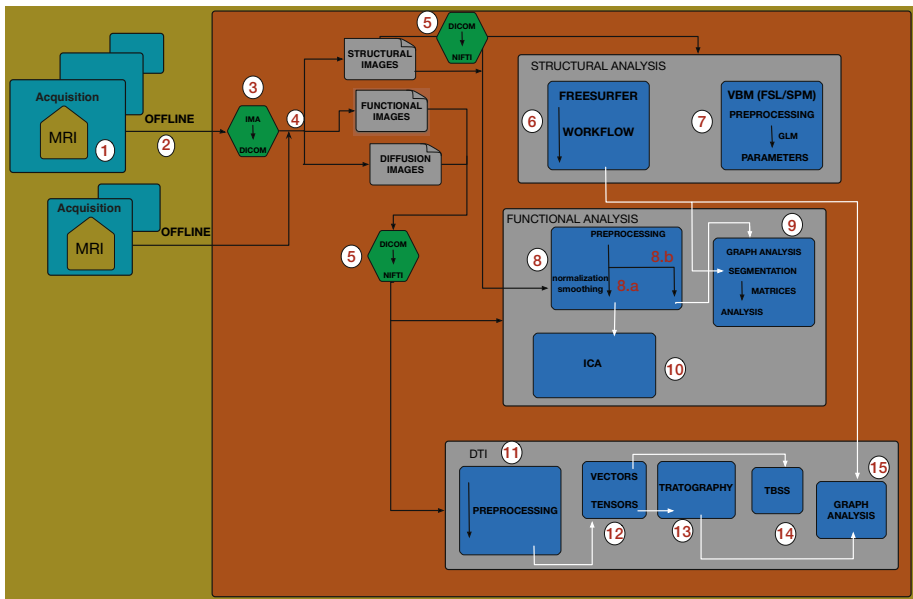
Figure 1. Example of a processing workflow for multimodal analysis of brain MRI. Black arrows within blue blocks represent streams of sequential data processing steps.

The process starts with the acquisition of the data (1), which is then exported from the MRI system and then transported offline to the data processing center (2). Then the images are converted from IMA to DICOM format (3) and then structured in folders, according to the type of acquisition (4). Images are then converted from DICOM to NIfTI format (5). The structural data enters two independent streams of data processing: region of interest segmentation using the Freesurfer workflow (6) and preprocessing and analysis of structural images for Voxel Based Morphometry (VBM) analysis (7). Regarding functional data, it can be preprocessed with the typical preprocessing steps, including normalization and smoothing steps (8.a) in order to undergo Independent Component Analysis (ICA) or task-related general

linear model (GLM) analysis (10); or it can be preprocessed without smoothing (8.b) in order to be used for graph theory analysis (9). This kind of analysis might use the segmentation of the structural data in order to define the nodes of the functional brain networks, represented as 2D matrices of connectivity [10,11]. Similarly, the diffusion data is initially preprocessed (11) and then, the Diffusion Tensor Imaging (DTI) model is applied **(12)** generating the tensor data, which can be used in order to perform tractography (13), and scalar maps that can be analyzed with Tract-Based Spatial Statistics (TBSS) (14). The tractography can be combined with the segmentation of structural images in order to perform graph theory analysis of diffusion data (15) [12].

The completion of these steps results in a large amount of information that needs to be accessible to the researcher(s) involved in any particular study.

3 Hierarchy and File Nomenclature

The need for standardization in the processing of MRI studies is essential to maximize the organization of the large volume of data generated. In this regard, it was important to choose a solution that would facilitate the entire processing flow describe in Figure 1, as well as the organization, cooperation and sharing of the data. To this end we opted for the use of a file hierarchy similar to some existing workflows in order to facilitate the adoption of the proposed solution.

As stated above, multimodal MRI studies usually involve several subjects, various types of analysis and preprocessing steps that are reflected in the production of numerous files that matter to locate and reuse. In order for the adopted hierarchy to optimize the process of organization it is essential to understand the parameters that best define a file.

It is intended that the higher hierarchical degree of coverage for a file is the study to which it belongs. From this, diverge the subjects included in each study. To each subject may belong a set of analysis/acquisitions, involving the use of different software and files: *MRIDCM* - DICOM images resulting from structural acquisition; *FMRIDCM* - DICOM images obtained from functional acquisition; *DTIDCM* - DICOM images resulting from diffusion acquisition; *FMRI* – files obtained from the preprocessing of functional images; *MRI* – files collected from the preprocessing of structural images; *DTI* – files resulting from the preprocessing of diffusion images and production of vectors and tensors; *TRKVIS* – files needed in deterministic tratography via TRKVIS software; *BEDPOSTX.bedpostx* – files needed for probabilistic tratography via BEDPOSTX and PROBTRACKX software; *Freesurfer* – files resulting from the Freesurfer software for segmentation of strucutral images.

After defining the hierarchy of folders to use, it is essential to define for each file a specific nomenclature and description. The use of a strictly defined nomenclature, plays a fundamental role in the organization and sharing of studies. Through this, it is possible to identify automatically the contents of a file over the relationship between its name and what it represents. For such, a dictionary has been set. In order to better understand the usefulness and use of this dictionary some examples are shown:

- *Filename* : [*Id*]_diff_dtifit_FA.nii.gz;
  - *Context* : fractional anisotropy map (FA), obtained by using FDT *dtifit tool* in preprocessed diffusion images;
  - *Folder* : DTI;
  - *Description* : Fractional anisotropy map.

- *Filename* : [*Id*]_str_crop.nii.gz;
  - *Context* : file resulting from the conversion of DICOM functional images to NifTI;
  - *Folder* : MRI;
  - *Description* : Raw Data.

In the above list, *Id* is the identifier of a particular subject to which the file belongs. A total of 63 file types were defined in the dictionary, representing essential information obtained in the implementation of a multimodal processing pipeline. Once defined, this dictionary of files and respective folder structure, it is possible to integrate them into the developed computer application (BrainArchive).

In this type of studies it is often necessary to manipulate the existing files. As such it becomes imperative to have a local copy of the files that comprise the study to be performed. Thus it was decided to create a folder designated MyBrain. In this folder, each user can put all files resulting from the described processing flow, ideally fullfilling the folder hierarchy and nomenclature described. If this is satisfied the BrainArchive application here described will automatically recognize each file, more specifically the study, subject and analysis to which it belongs, as well as the type of file it represents. This folder allows the dual purpose of automatically add multiple files to a repository (described below), and create a local copy of a study in the repository that was not processed locally, keeping the structure in which it was originally included in the implemented repository.

4   BrainArchive

Given the need to develop an user interface to support the storage, organization and sharing of multimodal studies of brain MRI, a computer application was developed, named BrainArchive, using Python as programming language. Python was chosen due to several benefits that it presents compared to solutions like Java or C: scalable cross-platform development; simple syntax; high level language; powerful data structures; ease of implementation and a extensive standardized library [13]. For the development of the Graphical User Interface (GUI) we opted for the combination of PyQt and Qt Designer. Thus, customizing windows and dialogs is possible using a drag-and-drop approach, with testability in different styles and resolutions. Widgets are easily integrated with code via a signal mechanism, which allows the allocation of behaviors to graphical elements.

The developed application consists of three key elements (Interface, Controller and MongoDB Driver) that establish correspondence with a development model in which the implementation of the interface is independent of the behavior and status changes of the objects that compose it.

The typical approach to store documents (e.g. images) consists in storing them in the file system while storing the documents' paths in one DB. Considering the large number of files and the size of those files, this solution would present several drawbacks in terms of scalability, availability and backup management. As such, for the development of the repository, an approach capable of being distributed and scalable was considered beneficial. This simultaneously discourages the use of relational DBs and benefits the use of document-oriented DBs. Due to the lack of standards in neuroimaging processing, the capacity of storing unstructured data is also a great advantage of document-oriented DBs.

Document-oriented DBs are one of the main categories of a group of non-relational DBs designated NoSQL (Not only SQL) [14, 15]. In these systems, the DB is not organized in tables and generally SQL is not used for data manipulation. NoSQL architectures are developed for large-scale data storage (structured and unstructured) and massively parallel processing over multiple commodity servers. The data model in a NoSQL DB is tipically one of three types:

- A *Key-value* data model, where a key corresponds to a specific value, which allows higher query speeds, support for mass storage and high concurrency;
- *Column-oriented*, stores data in one extendable column of closely related data;
- *Document-based*, stores and organizes data as collections of documents in JavaScript Object Notation (JSON) or Extensible Markup Language (XML) format.

Taking into account the previous considerations, it was decided to use the document-based NoSQL DB MongoDB. This solution is ideal for file storage, saving objects in a binary format called BSON, presenting itself as an effective solution in the maintenance of large data volumes.

MongoDB has a flexible schema, that does not enforce document structure, unlike SQL DBs. This flexibility facilitates the mapping of documents to an entity or an object. Each document can match the data fields of the represented entity, even if the data has substantial variation.

Besides one can use advanced queries in order to filter files based on associated metadata thanks to the GridFS specification [16]. MongoDB also allows the horizontally scaling of the DB through the technique known as sharding. This allows distributing the data over several physical partitions, in order to overcome hardware limitations. It also supports the creation of replica sets, an automatically managed fault monitoring mechanism. Figure 2 illustrates the communication mechanism between BrainArchive clients and the MongoDB server.
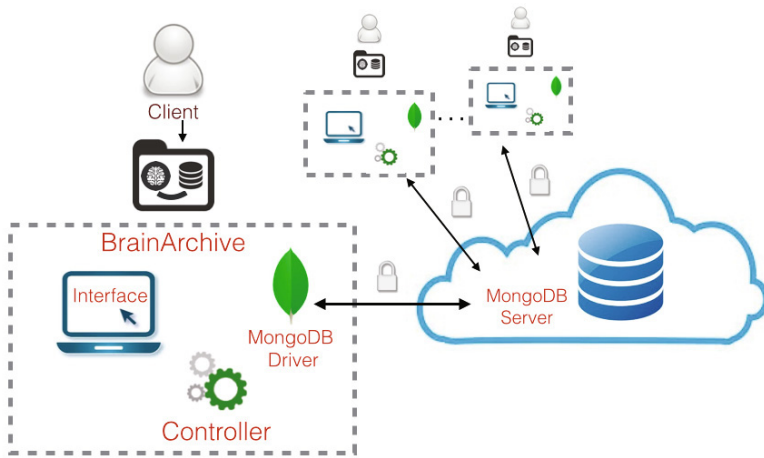
Figure 2. BrainArchive global architecture.

The primary objective of BrainArchive is to implement an efficient and automated way of organizing, storing and sharing data of multimodal brain MRI studies, taking advantage of the hierarchy of folders and the defined file nomenclature. Thus it is possible to export (introduce local files in the MongoDB repository) a full study in a single step, for example. This same study may in turn be composed of a given number of subjects, each consisting of multiple files. Given this feature, the sharing process of data is facilitated, since it is not necessary to export or import (extraction of files from the repository to the local folder) each file individually. In addition, each automatically exported file, presents a set of information that characterizes it, without the need for manual setting by the user. The file export interface of the BrainArchive application is shown in Figure 3.

This same information allows the user to filter the files in the repository, using parameters that define them (e.g. study identifier, subject identifier, analysis and type of file). This way it is possible to extract only the desired data, depending on the purpose. The interface used for the filtering process and subsequent extraction of files is illustrated in Figure 4.

In addition to the presented features, security issues and access permissions to data were also considered. In this sense, besides the need of authentication to login in the BrainArchive application, it was intended to ensure the security of data transfer using Secure Sockets Layer (SSL), linking BrainArchive and the MongoDB. Moreover each user can in every moment, change other users' access permissions to the data exported by him. In this way it is possible to manage the availability of files in the repository, making it only accessible to user who inserted the data, specific users or to every user.

The developed interface is compact and with a simple aspect, focused on the features that it intends to address.
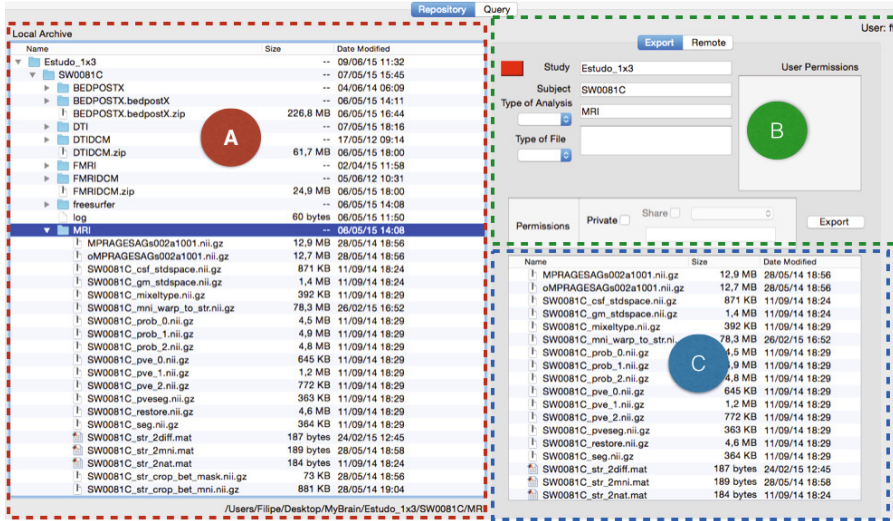
Figure 3. Logical division of the initial interface in BrainArchive (Repository tab). (A) Local studies for a user. (B) Export section of files/studies. (C) Structure of subfolders descendants from the location selected in (A).
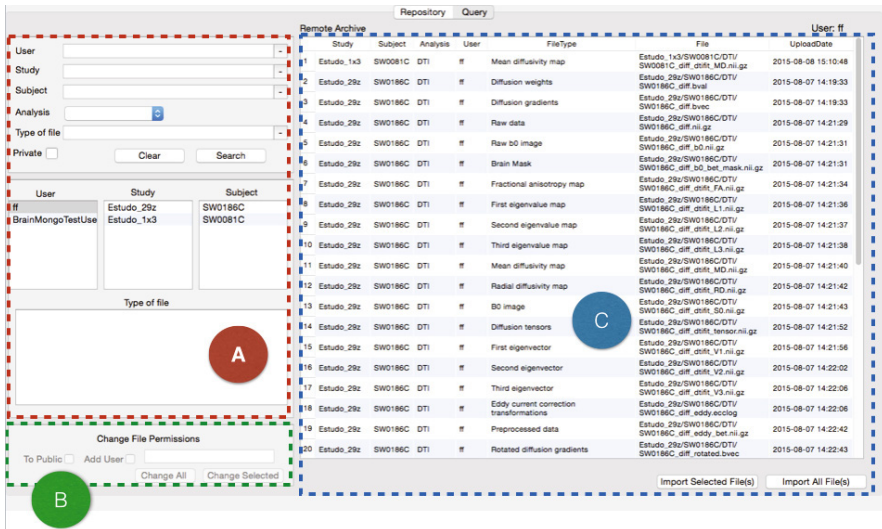
Figure 4. Query and import interface in BrainArchive (**Query tab**). (A) Files filtering section. (B) Change file access permissions. (C) Display and import section of files present in the repository.

5   Discussion

Nowadays, images obtained from standard clinical MRI scanners are nearly always stored in Picture Archiving and Communications Systems (PACS) [17]. PACS store the image data, as well as other demographic and technical information in the DICOM format. However there is no widely accepted DICOM standard for a large number of complex MRI datasets [18]. Other systems use commercially available relational DB management systems to store the medical imaging data and to create data access interfaces to store, retrieve, modify and query the data present in that repository of data e.g. ANIMA, XNAT or Global Alzheimer's Association Interactive Network (GAAIN) [19].

Despite the existence of generic advantages among these solutions, BrainArchive was developed with the intention to facilitate the user throughout the organizational process and sharing of studies' data. The incorporation of a specific hierarchy and file nomenclature allows the identification/classification of large volumes of information, without requiring individual and manual setting what each file represents, thus significantly reducing the time required for this process. Simultaneously, it enables data recovery, reuse of information and simplifies collaboration among health entities. Aditionally, our system also enables the access to the data independently of the system used or location, greatly simplifying the process of sharing data between researchers/clinitians and/or institutions.

In this sense, we believe this is a novel approach in neuroimaging archiving, since it grants the automatic distribution of brain MRI data to researchers and health professions, regardless of where they do the analysis. This might ultimately catalyze new findings in neuroscience research, foster the dissemination of relevant clinical finding and improve the adoption of complex multimodal neuroimaging techniques in the clinical settings. Although the projected system was primarily designed for brain MRI studies, it can be easily extended to other medical imaging modalities that deal with large number of data files.

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Towards Automatic Screening of Idiopathic Scoliosis using Low-cost Commodity Sensors – validation study

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Abstract. This paper presents some preliminary validation study results pertaining to our ongoing attempts to develop a noninvasive scoliosis and other spine disorder automated diagnostic solution implemented using commodity sensors only, thus limiting its overall cost, but still achieving adequate precision. The cost of many such commercial solutions is prohibitive to have them acquired and used by student healthcare institutes in countries such as Serbia, thus we are developing a low-cost one. If proven effective our solutions will be open-sourced.

Keywords: automated scoliosis screening, commodity sensors, low-cost.

1 Introduction

This paper presents a noninvasive scoliosis spine disorder automatic diagnostic solution implemented using commodity devices, limiting cost, but achieving adequate precision. Automated spine disorder diagnostic solutions can use various diagnostic methods. Some of those test methods used are based on manual deformity testing, topographic visualizations, or sensor inputs (such as laser, infrared, ultrasound scanners, etc.), magnetic resonance imaging (MRI) and/or radiographic imaging i.e. ionizing radiation. The most widely used are manual deformity tests done by sufficiently trained medical practitioners, that are conducted with or without additional aids (such as scoliometers [1]), but such tests take up valuable resources in terms of assigning personnel and time. Additionally, the second most widely used test method for spine deformity disorder diagnostic is radiographic imaging. However, since the recommended age for scoliosis testing is between ages 10 to 14, and testing is done twice within the same period for females [2] with a positive diagnosis rate of ~5%, avoiding radiographic imaging would be beneficial for non-positives. Also, the recommended number of radiographic imaging does not include potential post-diagnostic imaging follow-ups for positively diagnosed adolescents, thus the total amount of exposure to cumulative radiographic ionizing radiation could be greater. Obviously, development of alternative noninvasive methods and techniques came from a need to reduce negative effects of harmful cumulative ionizing radiation on adolescents when imaging exposure was still high [3].

1.1   Existing and prior work, literature and commercial products

Some of the first noninvasive methods for diagnosing scoliosis not using ionizing radiation or manual deformity tests came about 1970, with Moiré topography [4]. Moiré topography represents a morphometric method in which a three dimensional (3D) contour map is produced using the interference of coherent light, as the observed object gets flooded with parallel light projected from two or more sources. Depending on the particular amplitudes of light waves, their phase difference and their frequencies, the interference can cause illumination to either grow or dim in certain spots, which in turn produces darker or lighter lit zones. During the 70-ies and early 80-ies of the last century, methods that are more refined were developed for diagnostics of some spine deformity disorders using the aforementioned Moiré topography [5–7]. Those also triggered a rise in the research of modelling human spine surface curvatures [8, 9] initially measured from regular optical images. However, in the late 80-ies and the early 90-ies, advances in development of other sensor technologies and greater accessibility of more precise sensor devices, such as laser scanners, came about. That started substitution of silk fabric blinds and Moiré topography contour maps produced through regular optical means, with more precise 3D models of human back surfaces. Along with more point precise 3D models those advances also produced even more interests into research and formulation of trunk surface metrics and indices used for evaluation of scoliosis and other spine and posture deformities. Some such popular indices compared in a systematic review [10] are Posterior Trunk Symmetry Index (POTSI), Suzuki Hump Sum (SHS), Deformity in the Axial Plane Index (DAPI), etc. In the same review the two indices, POTSI and DAPI, were also compared by specificity and sensitivity. POTSI has high specificity and low sensitivity, whilst DAPI's case is vice-versa, meaning that a high specificity index has a low rate of false positives, i.e. the number of normal patients classified as scoliotic is small. A high sensitivity index on the other hand has a low rate of false negatives, i.e. the number of scoliosis positive patients classified as normal is small. Additionally, those two indices are based upon back surface points measured in independent planes, coronal and axial, thus combining the two actually increases scoliosis screening accuracy for fringe patient cases as it did in [11]. Those same characteristics also made us investigate the use of combined POTSI and DAPI indices, however instead of building an average model of scanned back surfaces, we initially combined them along with some neural network approaches back in 2014 [12], during the IPA (cross-border cooperation program) project SpineLab [13]. The Faculty of Sport and Physical Education conducted that project locally in Serbia, using a commercial hardware and software solution for professional motion analysis named TEMPLO (Contemplas, Germany). Contemplas[1] solution was used to assess posture of over 800 school-aged children. That project was based on earlier estimates that the portion of school age children with scoliosis spine deformity in some Serbia's towns exceeds 15% [14]. The acquired commercial solution used multiple regular optical cameras which previously had to be calibrated to acquire visual data which could later be processed in software. Unfortunately, the process of camera calibration was lengthy, and because the solution had to be portable, used quickly at multiple

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[1] CONTEMPLAS - Motion analysis software, http://www.contemplas.com/

school locations, Faculty of Technical Sciences' Department for Computer Science members were approached to investigate additional portable data acquisition methods.

After some research, another commercial solution named Formetric (Diers, Germany) was found. Diers[2] Formetric 4D was capable of scoliosis screening, but too expensive to acquire also. Thus, development of own solution based on a commodity sensor devices was actively pursued henceforth, at much lesser costs. Since the SpineLab collaboration started back in early 2014, one such locally available device at the time was the 1st generation Kinect[3] (Microsoft, USA). So using that version of the commodity depth sensor alongside expensively acquired Contemplas solution, proved sufficient for capturing posture, but lacking for doing some more precise topographic body surface measurements, which will be explained more in the next chapter.

This paper's research continues that real-life need to develop and implement novel, effective and predominantly economical solutions for automated diagnostics of spine disorders such as scoliosis. Considering that various relatively low-cost smartphone platforms and sensor devices are currently available in Serbia and lesser developed regions of the world, this paper presents some of our efforts to build on top of such platforms and devices, aided by the Institute for Student Healthcare in Novi Sad. Our ultimate goals are to produce a suite of hardware and software solutions for automated diagnostics of various spine disorders, which could even be used by non-medically trained school personnel for the purpose of detection spine disorders early. That is because when physical therapy is applied early, along with braces, the two prove to be most effective, helping avoid other means of clinical therapy by noninvasive ones [15].

This paper is laid out in the following sections: this first section gave an introduction into the research being conducted, along with an overview of some related work either done, or identified, by us both in academic papers and available commercial solutions, as well as the historical and personal motives driving our such and similar research. Section 2 provides an overview of some methodologies and solution design choices. Section 3 goes over some implementation details, and Sec. 4 and 5 give some of our preliminary validation results and our conclusions and future plans.

2   Methods and Design

SpineLab research project unfortunately ended prior to acquiring consent from each assessed minor's parent to extend posture assessing into complete spine disorder exam, preventing us to use those scans here. So, a new collaboration with a local Institute for Student Healthcare in Novi Sad and their staff of more than a half a dozen general practitioners (GP) conducting daily health checkups on all University of Novi Sad students, was initiated. In addition, as all students of the University of Novi Sad are legally adult, that reduced consent acquisition for conducting the research to just their own and the Institute's, which was provided. However, considering amount of effort put in prior collaborative work on assessing posture of local elementary school-aged children, we were inclined to continue using that work's methods and design, such as using a depth sensor camera for scanning 3D surface topography. However, due to

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[2] DIERS - Biomedical Solutions from Head to Toe, http://diersmedical.de/
[3] Kinect - Windows app development, https://dev.windows.com/en-us/kinect.

noise in those topography scans introduced by the structured light pattern used for 1st generation Kinect depth sensing, and less successful attempts to reduce it using iterative closest point (ICP) algorithms such as KinectFusion [16], our new project ended up reusing just some of those methods. Mainly, the ones used to achieve better precision and increase 2nd generation Kinect's field of view (FOV).

Increased FOV was needed because 2nd generation Kinect lacks a motorized tilt present in generation 1 sensor, to encompass the whole body of height-tall subjects, tall up to and even over a two meters (2m) from approximately 2m distance. That also required us to secure the sensor vertically using a tripod, instead of its regular horizontal position (fig. 1 left). That position allowed the 2nd gen Kinect's specified horizontal 70° FOV to effectively be used as a vertical FOV and vice-versa. That minimized losses when scanning ~2m subjects at the same distance (fig. 1 center) and a height of 1m, due to potential cut off and vignetting effects which occurred in the scan periphery using 2nd generation Kinect's regular 60° horizontal FOV.

All subjects, university-attending students, were scanned standing upper back of trunk exposed for a simultaneous exam by the observing GP. For modesty purposes, all stood facing the wall of the examination practice (fig. 1 right), not exposing their frontal figure while being scanned in their regular posture stances, feet apart. Additionally, subjects were scanned three times in two slightly different standing poses. The initial regular standing pose was scanned twice, with and without markers placed by the observing GP on relevant body landmarks such as most protruding shoulder blades, the bulge of spinous process near C7 spinal vertebra, etc. As the latter protrusion varies and depends on muscular structure and BMI, the subject assumed additional pose prior to the third and final scan, bowing their head forward (fig. 3). That pose mimicks a typical procedure perfomed by medical personnel when locating the spinous process of C7 vertebra on subjects when the bulge is not protruding enough, or when it is not clear whether the bulge is being formed by other adjacent vertebrae, either C6 or T1 vertebra.

Fig. 1 – Kinect sensor position in the GP examination office illustrating its vertical FOV

To avoid having to resort to some empirically determined periods of standing still prior to starting the scan (such as approx. 15 second wait time used by our Faculty of Sport and Physical Education colleagues during their SpineLab project scans using the Contemplas solution), an additional feature integrating the Wii Balance Board (WBB; Nintendo, Japan) commodity sensor was developed. Scans in all poses could initiate

only after the subject was being still or not moving enough to affect the quality of the scan. The WBB tracks standing subjects' center of gravity (COG) and its movements throughout scanning, disallowing initiation until the subject settles into their stance. Also, immediate visual feedback allowed us and observing GPs (fig. 3 top) to inspect the subject's posture, determining if the subject equally spread their weight, reducing scans performed with bad posture, serving as a replacement low-cost podoscope device [17], albeit providing lesser information than such more expensive commercial devices.

Finally, after completing all the scans, the screened subjects were instructed to assume the Adam's forward bend (AFB) test position [18], when the observing GP used their smartphone's accelerometer as a scoliometer estimating the angle of the trunk rotation (ATR). ATR of 5° or larger is considered cutoff for AFB tests [1], which are current golden standard tests for manual physical examinations detecting scoliosis, and its higher value suggests subject should be follow-up examined, usually via x-ray. To increase the precision of measurements some polystyrene extensions for placing small smartphone devices level were built, with grooves for accommodating placing and moving them along the spinous processes of vertebrae (fig. 2). Extreme ATR values were recorded for each subject measured usually by two observers in order to track inter-observer errors and on different types of either smartphone devices running our own or 3rd-party developed scoliometer smartphone apps to reduce intra-observer error.

Fig. 2 – Various polystyrene extensions for smartphones with own or 3rd-party scoliometer app

3   Implementation details

The idea to use various smartphone platforms and apps first came from our attempt to emulate a specific iPhone (Apple Inc., USA) app without programming Objective-C. The app named Scoligauge was used in a study published in 2012, validating it against a standard Scoliometer (Orthopedic Systems Inc., USA) screening aid, which found that app to be a near match in output to the actual aid [19]. Unfortunately, at the time when our screenings were conducted that app was not available in the AppStore,

although the website of its publisher was [20]. However, another website reviewing that and various other scoliometer apps on iOS and Android smartphone platforms, was found [21]. So instead, we used those other available apps in our own attempt to develop comparable smartphone scoliometer apps. In our first iteration, since multi-platform compatibility was required, we investigated developing an HTML5-based application built on top of the Apache Cordova[4] framework. That idea was abandoned because although it allowed for an easy development of an app working across most smartphone platforms, its performance on low-end devices was slow, achieving low framerates.

Alternative native development path then provided fewer frameworks, given support for top three platforms was wanted, so we decided upon using the Xamarin[5] framework. That framework is available for free to students with access to Microsoft DreamSpark[6] program, which made its use low-cost to us. Also, using a graphing control from the OxyPlot[7] open-source plotting library made our app an easy-to-use visual aid with added calibration features not present in the actual aid. Prior to conducting ATR measurements, the observing GPs are instructed to perform a one-off calibration, making sure the platform subjects are instructed to stand on is level. The ATR measurement itself is calculated from the current smartphone accelerometer readings, which were accessed through a Xamarin extension plugin component, allowing for the same C# natively compiled code to be run across various smartphone platforms. Although we also investigated using more sensors, like magnetometer and gyroscope for increase of the angle reading accuracy via so called "sensor fusion" [22], adding a low-pass filter to accelerometer readings proved sufficiently accurate when placing the smartphone running our application in a still position for two seconds or more. This added feature is named "averaging mode" in our application and effectively averages accelerometer readings during a fixed time period calculating the ATR as:

$$\text{ATR} = \arctan\left(\frac{avrg(AccelX)}{avrg(AccelY)^2 + avrg(AccelZ)^2}\right). \qquad (1)$$

Finally, our ScolioMetro app has subsequently been open-sourced and published on Github, allowing for future improvements and new feature additions to be made by the public, including potential sensor fusion improvements if any new use case require it.

Although the smartphone application uses a simple implementation to average the accelerometer readings across multiple coordinate axis, at the time of development we were also considering using a functional reactive programming extension such as Rx.NET[8] to accomplish the same more elegantly. However, as this brought some overhead to mobile applications it was dropped because of performance concerns on low-end smartphone devices, but Rx.NET was still utilized on the desktop Kinect Fusion scanning application (fig. 3). It allowed for integration of elegantly written piece of C# code into the desktop application that was responsible for tracking and measuring observed subject's COG movements, disallowing scanning initiation prior to the subject standing still enough so as not to affect the quality of the scan.

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[4] Apache Cordova, http://cordova.apache.org/.

[5] Xamarin – Mobile App Development & App Creation Software, https://xamarin.com/

[6] Microsoft DreamSpark, https://www.dreamspark.com/

[7] OxyPlot, http://oxyplot.org/

[8] Rx.NET – ReactiveX, http://reactivex.io/
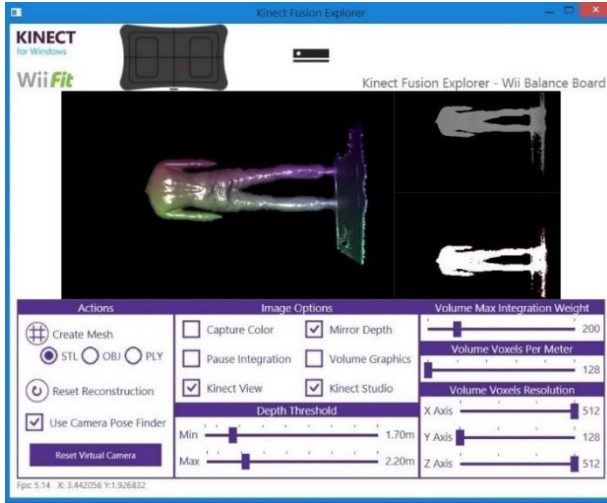
Fig. 3 – Subject scanned standing with head bowed forward

As said, the desktop application provided near real-time positioning of observed subject's COG, giving observing GPs more feedback information on their standing posture. The WBB senses movement through 4 pressure sensors whose resolution is 100Hz [23], sending data wirelessly via Bluetooth to a desktop-class PC (Surface Pro; Intel Core i5 3317U CPU with HD4000 GPU) which gets buffered and subsequently used to calculate the COG position and its movement, making sure the subject stands still prior to enabling the "Create Mesh" action. Since achieving interactive frame per second (FPS) speed using KinectFusion ICP algorithm requires a desktop-class GPU (not present in a Surface tablet which uses integrated GPU), we added a "Kinect Studio" feature to capture and locally save various Kinect sensor data streams in a file format suitable for repeatable playback through the Microsoft Kinect SDK application named the same. That way, instead of performing 3D point cloud reconstruction from live Kinect data streams on an ICP-underpowered PC, the creation and processing of suitable 3D meshes could be transferred onto another PC, or in our case the Azure[9] cloud service. In case 3D mesh models were not suited for automated computer processing, but served for validation of body back surface landmark detection results by humans (preferably by medically trained personnel), the feature "Capture Color" influences the locally saved files by adding an uncompressed color data stream to the depth and IR data Kinect data streams captured by default. We found that creation of such 3D mesh models, containing color information (fig. 4) was best suited for human interaction when some non-present GPs were asked later to pick out body back surface landmarks by using MeshLab[10] software, comparing their markings to the ones made by the observing GPs using actual markers. However, the size of locally saved files containing color information is much larger due to the uncompressed color stream size of ~120MB/s, compared to ~13Mb/s for recording depth or IR streams [24], making such files impractical for uploading and use with automatic algorithms.

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[9] Microsoft Azure: Cloud Computing Platform & Services, https://azure.microsoft.com/en-us/
[10] MeshLab, http://meshlab.sourceforge.net/
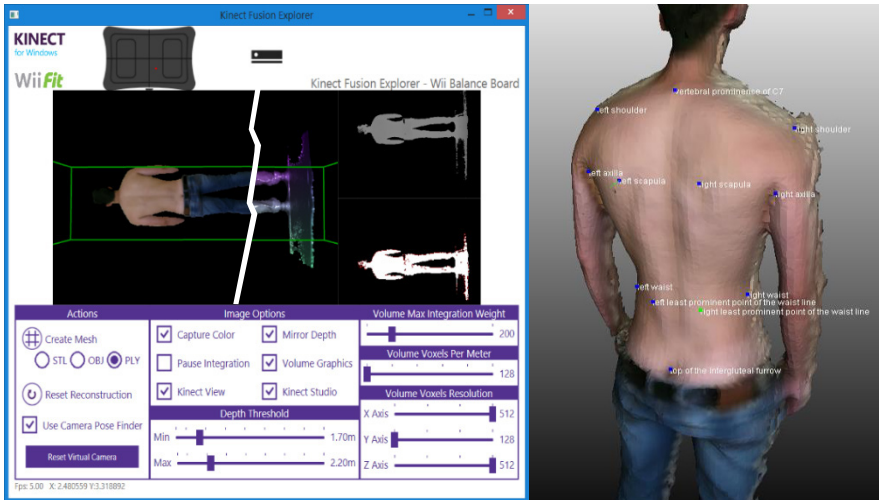
Fig. 4 – Subject scanned in normal standing position illustrating use of 3D mesh with color

The algorithm which processes color-free 3D mesh models produced by the scanning software, fit inside a virtual box whose volume is set by "Depth Threshold" and "Volume Voxel" features, attempts then to automatically detect the following body back surface landmarks needed to determine values of POTSI and DAPI: a) vertebral prominence of C7; b) the top of the intergluteal furrow (exposed by slightly lowering underwear); c) left shoulder (cross of the tangents to the shoulder and the arm); d) right shoulder; e) left axilla; f) right axilla; g) waist, left; h) waist, right; i) most prominent point of the left scapula; j) most prominent point of the right scapula; k) least prominent point of the waist line, left; l) least prominent point of the waist line, right. However, explaining that algorithm was not the subject of this but another paper, so we only listed the algorithm steps with short explanations here: 1. sagittal and coronal plane leveling of a box-fit 3D mesh (since Kinect stands vertically, its camera pose estimation feature must be done by us), 2. ICP artefacts and standing platform removal (the standing plane is identified using RANSAC [25] and subsequently removed along with any artefacts produced by KinectFusion's ICP integration of multiple point cloud scans in a mash), 3. detection of cusps and curvatures (used to detect some landmark points on axial, coronal and sagittal mesh plane slices - such as landmarks c, d, e, f, g, h), 4. height map and normals processing (used to detect landmarks such as b, i, j, k, l) and finally 5. ICP mesh registration and salient point detection (used to initially align two meshes of one subject scanned in normal standing and in head bowed forward positions, subsequently detecting salient points near the neck area sliced in the sagittal plane, thus identifying landmark a, whilst mostly disregarding the potential lack of C7 prominence in the normal standing position among subject's possessing large BMI or heavily developed musculature). Once the positions of all landmarks are detected, calculating POTSI and DAPI indices is as simple as calculating Euclidian distances among landmark pairs or projections and inserting those in their respectable definitions given in paper [11].

Values of DAPI ≤ 3.9 and POTSI ≤ 27.5 indicated absence of scoliosis, whilst either value exceeding their corresponding limits suggests a presence of scoliosis pathology.

4 Validation Results

To date, we have produced 3D meshes of student subjects attending physical examinations and their annual regular check-ups done on the Institute for Student Healthcare during workdays' fortnight period of late summer semester. In total 84 student subjects: 38 males and 46 females, mean age 21.07, height range 159-201cm, weight range 46-113kg, max BMI 31.3 were scanned. However, POTSI and DAPI value calculations were only performed on a single daily number of scanned student subjects manually first. The points corresponding to the body back surface landmarks were identified by consensus of several GPs within MashLab using its "PickPoints" feature on 3D meshes with color in a normal standing position manually (fig. 5). This was done prior to applying the mentioned automatic algorithm and calculating values of POTSI and DAPI automatically, to serve as a measure of indices' method validity compared to findings made by observing GPs and two specialists of physical medicine and rehabilitation or sports medicine, who were on-call at the time those students made their instructed referral specialist visits. In addition, the consensus of picking landmark points on 3D meshes was made between both GPs present and non-present during scanning, to estimate and reduce any effects of inter- and intra-observer errors.

Among such selected 8 student subjects, calculated POTSI and DAPI index values almost fully matched the GP's and specialists' findings, excluding one borderline non-pathologic case in which both POTSI and DAPI had values less than cut-off, but the specialists diagnosed scoliotic posture, thus functional and not structural scoliosis.

5   Conclusion and Future Plans

In order to continue our research, we first produced this compact validation study, corroborating usefulness of topographical indices as a valid alternative to screening methods usually administered by Institute's GPs and their specialists during visual and manual exams using AFB tests along with medical aids such as scoliometers. The correlation by which POTSI and DAPI do not greatly defer from findings of the medical personnel who conducted their own scoliosis screening visually or manually was encouraging, proceeding our study further towards developing automatic screening of idiopathic scoliosis using low-cost commodity sensors. We will further present our research in follow-up papers publishing results of a 3D mesh automatic processing algorithm attempting to achieve same results on body types, trying not to be influenced by factors such as BMI or muscular structure as other solution was [11].

Additionally, new features such as automatic assistance to scoliosis-diagnosed patients with prescribed noninvasive physical exercises and brace fitting will be further researched and possibly developed.

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Part II
Information Technologies in Education

Singularities of the university spin-off in northern Argentina

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Summary- In recent decades, argentinian universities, are inserted into the productive environment from creating business incubators university, turned into one of the mechanisms for technology transfer reference. These companies, known as Spin-Off, ideally arise from the knowledge generated within universities. This paper presents a brief summary, the findings of a study of the main characteristics and current status, degree of technological linkage of argentinian universities geographically located in the north, to the conversion of scientific research in business and commercial value.

The information was obtained through semi-structured interviews with a representative sample of spin-off members of accredited at the Ministry of Industry of the Nation and of secondary sources for the analysis of the factors affecting the growth of these companies interviews.

The creation of companies born in the university is a complex phenomenon to study multifactorial reasons for intervening in it. This exploratory study can give some guidance to universities not copy a system, but that adapt best practices to their regional needs, academic infrastructure and economic investments and to obtain optimal results in the creation of technology-based companies.

Keywords: university R & D + i, business incubators of technology-based spin-off, characterization

1 Introduction

An important component in the development of university education is the emphasis on the link with the following dimensions: the demands of the labor-business-professional market, the requirements of society and the management of human self-realization. The university, the productive sector and regional governments are the main actors in the dynamics of the relationship University - Market - State.

Technology transfer is understood as a process by which technology is loaded through the limits of two entities that may well be countries, companies and even individuals, depending on the viewpoint of the observer or investigator [3]. The aim of the transfer of a particular technology is to allow the receiver to use the technology under the same conditions and with the same benefits as the supplier for its purposes of technological innovation. In fact, talk of a shift implies that there is a consensus

agreement (license, project incorporation of person between the provider and the recipient of the technology) for this purpose.

With reference to Perez & Botero [6] technology transfer can be 3 ways: commercial, noncommercial and start-ups; the commercial mode arises between the university and its counterpart either the industry or the state is done through consulting, joint research among others; in the non-commercial way it develops from the university through publications and seminars among others without any commercial interest and contracts and finally the creation of new enterprises with the emergence of the "Spin-Off" mode university.

In the academic literature, Conti et al [1] defines the university spin-off companies that germinate as a university, where a group of researchers make the business unit with a view to the exploitation of knowledge and research results developed in own University. However, it is clear that the phenomena considered as a spin-off are not homogeneous [8]. Thus, companies created by an engineer recently received a researcher who wants to commercially exploit certain results of their research or teacher to rearrange its advisory to industry, are examples of phenomena that are included in the field of spin university off. Therefore, university spin-offs are very heterogeneous phenomena whose borders can vary significantly depending on the perception that they are stakeholders in the field and authors. In the following section different criteria for assessing the diversity of phenomena that contains the concept of university spin-off, concluding with an approach to the characteristics and peculiarities of the Argentine university spin-offs they are identified.

2   General factors affecting germination and development of the Spin-Off northern Argentina

For the study of the spin-off the amount of incubators were considered college based in Northern Argentina. A total of 40 incubators registered with the Ministry of Industry accredited by the Access to Credit and Competitiveness, to mention those located in the north (Table 1).

When moving into the issue of Spin-off university, a wide field, heterogeneous, it characterizes him with a variety of concepts used to appoint a fact also diverse, which exemplifies the many approaches you can acquire the establishment of this business is observed. Within our scientific community - technology, the classic profile of the entrepreneur in developed countries is difficult to find. There may be creativity, desires, good projects, but the spirit and businesswoman methodology, known play in the business world, "street", usually is not present. That is denoted by factors such as:

- Entrepreneurial deficit: Scientific institutions usually have not developed a policy to promote entrepreneurship and the characteristics of an entrepreneurial university. There is no social culture related to risk and failure to accept the usual operations Spin-Off type of high commercial risk. From a personal standpoint, for most researchers, creating a business from their knowledge and results is not only far from their interests, but also promoted as an alternative to route a student or professional future graduates.

- Organizational deficits: The generic function of supporting research, not directly addresses the need or desirability of creating the Spin-Off, although some universities have started pilot programs including incubators and basic support services.
- Deficit experience of the promoter of the idea team: generally the promoters of new ideas with commercial potential have no knowledge and managerial experience. The number of entrepreneurs with business knowledge and strong scientific and technological training, is insufficient to deal with potential ideas in the future should fill the Spin-Off.
- Capital deficit or economic resources: The funding cycle is underdeveloped, with little experience in some of its instruments. There is little tradition in venture capital, lack of investors, and few specialized investors in Spin-Off high risk.
- Sustainability deficit arising from business incubators. Unconsolidated development models involving continuous review and adjustment of the variables of business survival

Incubators	Location
• Agencia de Desarrollo del Norte Misionero • UNCUTEL • Parque Tecnológico Misiones • UNNETEC – INNOVAR • UNCAUS • INTECNOR • INCUBA SALTA • Universidad Santo Tomás de Aquino • Facultad de Ciencias Económicas y de Administración. Universidad Nacional de Catamarca • Centro de Empresarios de Famaillá	Puerto Esperanza - Misiones Parque Tecnológico de El Dorado – Misiones Misiones Corrientes Pcia. Roque Sáenz Peña.- Chaco Resistencia.- Chaco Salta.- Tucumán.- Catamarca.- Tucumán.-

Table 1: Incubators In The Northern Argentina

(MISIONES – CORRIENTES – CHACO – FORMOSA – JUJUY – SALTA – TUCUMAN – SANTIAGO DEL ESTERO – CATAMARCA)

Paradoxically, the issue of Spin-Off is not unknown, is quoted as a strategy in many economic development plans or policies on science and technology, not only in countries like Colombia, Peru, Ecuador and Chile; but also as part of Educational Strategic Plans in Argentina. This allows us to infer that there is awareness of the importance which involves the generation of spin-off for economic and technological development of the countries, particularly Argentina, but lack urging members and supporters to achieve satisfactory results [10].

3 Singularities of the Spin-off

The diversity of phenomena that occur in the context of university spin-off involves a diversity of characteristics in terms of the realities they cover. Occur, then identified the various characteristics, supported by the literature, which allow the assessment of singularities.

a) According to the attitude of the university.
   - Spin-off spontaneous, passive or pull spin-off: university spin-offs created by members of the university community but have received no support from the university.
   - Spin-off planned, active or spin-off push: university spin-offs created under a voluntary support policy carried out by universities, in order to facilitate and promote the transfer of knowledge and entrepreneurial initiatives its members [7].

b) According to the status of people that have given rise to the idea.
   - Spin-off academic: university spin-offs created by one or more members of the scientific community, or even people outside the university community, in order to commercially exploit a part of the knowledge developed in the framework of its research . Within this group it is included teachers, assistants, researchers, doctoral students, etc.
   - Spin-off of students: university spin-offs created by students at the end of his university studies, have decided to form his own company intends to use a portion of their knowledge by way of the provision of services or through activities production in order to exploit a business opportunity in sectors with generally weak barriers to entry and low technological component. Within this group are observed current or former students of degree or continuing education, which are called start-up.

c) As if the researcher becomes an entrepreneur.
   - Spin-off promoted by the researcher, academic spin-off created by one or more members of the university scientific community in order to commercially exploit a part of the knowledge developed in the framework of the research activities of the university.
   - Spin-off promoted by foreign entrepreneurs: academic spin-off created by people outside the university scientific community in order to commercially exploit a part of the knowledge developed in the framework of its research activities [9].

In the same vein, whichever is the role taken by the researcher who is at the origin of the idea, are distinguished:
   - Spin-off Orthodox: academic spin-off in which a transfer to the new company produces both technology and the inventor.
   - Spin-off hybrid: academic spin-off in which a transfer to the new company knowledge is produced, but the inventor remains in college, but somehow participates in the scientific advice to the company.
   - Spin-off technology: academic spin-off in which a transfer of knowledge to the new company occurs, but the inventor remains in college and maintains no connection with it.

Also in this line, depending on who carried out the greatest efforts for the spin-off is established, are distinguished:
   - Spin-off led by the inventor: academic spin-off in which the effort for its creation is conducted by the inventors of the technology that exploit.

- Spin-off led by a buyer: spin-off academic in which the effort for its creation is carried out by external entrepreneurs interested in creating companies to exploit university inventions through a license granted by the technology transfer unit of the University.
- Spin-off directed by an investor: spin-off academic in which the effort for its creation is held by investors, typically private equity risk, interested in creating companies to exploit university inventions through a license granted by the technology transfer unit of the university and seeking, then an entrepreneur who is responsible for its creation.

d) Depending on whether proprietary knowledge is transferred.
- Spin-off based on patented technology: university spin-offs are created to exploit the licensed technology patented by the university [4].
- Spin-off based on non-proprietary technology: university spin-offs to exploit knowledge created not patented by the university, usually more generic or may be based on expertise or know-how.

The university spin-off based on codified knowledge and, where appropriate, patented often geared to offer a product to market, while based on tacit knowledge are often geared to providing a service. This different orientation is important because the profile of the university spin-off vary considerably in terms of activities, management of intellectual property rights, financial needs for the development of prototypes, resources required, growth prospects and relations with the university . Thus, academic spin-off based more on codified knowledge develop an industrial manufacturing and selling products or technology development and sales. They are directed from its beginnings to regional markets with high growth potential. The academic spin-off based on tacit knowledge preferably develop a consulting activity. Target regional or national markets, given the importance of customer proximity for good service delivery. Knowledge based on the spin-off is often developed by a single investigator.

e) According to minority participation in the capital of the spin-off.
- Spin-off with foreign capital: academic spin-off received in its initial stage financing of large companies, business angels or venture capital entities.
- Spin-off without foreign capital: academic spin-off that do not receive funding at an early stage of large companies or venture capital entities.

Although financial support of venture capital institutions is possible and desirable because they add credibility, management experience and network of relationships, in practice are insufficient and therefore impact on a small number of spin-off [5]. An alternative is resorting to financing through venture capital is looking for an industrial partner or private investors.

f) Depending on the type of activity.
- Consulting and research services: academic spin-off exploiting core competencies of researchers through an extension of its research activities.

- Product: academic spin-off created around the concept of products or processes, which are responsible for developing, producing and marketing. These spin-off correspond to the classic entrepreneurial model.
- Technological assets: academic spin-off created to develop technologies that will later be marketed through different mechanisms. Its business model is based on the creation, development and management of technology assets.
- Software: has some common features with the previous case, as the software product often results in licensing agreements, but differs from the previous in that often include a software production process, since in this case are low economies scale.

g) Depending on the model of development followed by the spin-off.
- Growth-oriented academic spin-off seeking a global market for technology. They are characterized by strong capitalization, and participate in capital specialized external institutions. They have highly professional management teams, have strong focus on growth and its ultimate goal is making profits through dividends ..
- No growth-oriented: academic spin-off seeking sufficient to sustain a comfortable life of the founder and his family market. They are characterized by low capitalization, the capital in the hands of the founder environment, low management capacity, little or no focus on growth and its ultimate goal is survival.

Given the foregoing, it can be said that the phenomenon of spin-off covers a wide casuistry and the limits of the concept of spin-off are diffuse [2].
The study of the spin-off of northern Argentina has been made considering the following criteria: a) Cover the largest possible number of common phenomena, b) Establish what attributes or behavior patterns that distinguish according to the local context are.

4 Conclusions and Discussion

 Some factors in creating company are consistent with common points: The promotion of entrepreneurial culture, patent protection, conflicts of interest regarding royalties and contracts, all of these are completely solved with government regulations science and Technology; The maturation time of their companies have averaged five years, contracts management solution is well established, the financing offered is through seed capital, EMPRETEC Foundation, Fondapymes, Venture Capital, among others. Another point in common is the support offered among which courses, infrastructure, business plan, academic downloads, etc.

Also, small differences are related to each college has its own system of entrepreneurship appropriate to their regional needs, academic infrastructure and economic investments and technological base.

Although the information collected is still insufficient, the first statements about the Spin-Off University can be summarized as follows:

1) The leading role of the University in creating spin-off based on the current growth and local economies, but the low comparative reference models for the development of these companies,

2) The importance of policies to stimulate entrepreneurship in the University as a tool for conversion of scientific research in business and commercial value,

3) The relative terminological imprecision in the use of the Spin-Off concept, especially in the academic as well as poor dissemination for clarity on all issues related to technology transfer.

4) The incipient development of strategies and logistical entrepreneurially planned medium and long term, with regard to transfer market research methods: determining the size of the market, agree the contribution that generate customer, define the capacity to meet the market, obtaining financial resources, among others. This situation does not promote the organization to plan a draft Spin-Off focused I+D+I, with difficulties to timely warn the market needs and demand relationship - offer.

This research intended to be addressed in the future to a deeper comparison between universities to encourage the creation of companies based on knowledge, where knowledge transfer to the productive sector to provide competitive advantage to countries that are committed to the generation and transfer of knowledge and university technology.

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Integrated technological resource in the construction of the teaching and learning of technical nursing course

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Abstract. This paper shows the importance of a high-fidelity human simulator as a methodological tool able to make a significant contribution to the learning process of nursing technician students of the Federal Education, Science and Technology Institute of Roraima (IFRR). From this simulator you can build several scenarios of specific nursing procedures for the Intensive Care Unit (ICU) in order to be efficiently used in the teaching-learning process. The academic literature contributions available regarding the use of simulators in the teaching process of Health Science were evaluated. The use of this methodological resource should be seen as a trend in the clinical reasoning of nursing students, improving their knowledge and developing psychomotor skills.

Keywords: Human Simulator, Teaching and Learning, Intensive Care, Nursing.

1 Introduction

A survey conducted by the Federal Council of Nursing Care (COFEN), pointed out that approximately 80% of the nursing professionals consist of technicians and nursing assistants representing, therefore, a significant inclusion in the work market [1].

However, many technical training courses use a curriculum and an array of traditional teaching methodologies and teaching materials that may not be enough and

suitable for the students' motivation to a reflective-critical development of their professional activities. This can lead to a reduction in the handling of certain Medical-Hospital Equipment (MHE) [2], as you can see in this study.

Having this overview, the quality of the teaching process in the education of these health professionals becomes insufficient. Given this, a pedagogical proposal that enables a participatory and reflective learning can greatly contribute to the recovery of the autonomy of the future professional, regarding the safety to the health services provided to the society [3].

As a way to improve the teaching-learning process for professional growth it is used technologies in nursing teaching, allowing the contact with real situations through the professional practice and the improvement of the clinical judgment meeting the demands of medical ethics [4].

A tendency for a secure environment in learning is the use of the simulation, used in the Medical curriculum and other areas of health sciences due to the multiple scenarios and educational strategies that this instrument allows. It can be modeled to be applied in the teaching and learning of the courses regarding the scientific and technical skills of the students, such as: decision-making, teamwork and leadership [5].

Among the technologies used in the simulation process, attention should be paid to the following advantages: program the setting according to the educational content of the course; domain of technique; the repetition of the procedure to improve the technique; no health risk for the patient to get practical experience [3]. In this context, it is refered to the SimMan, a robotic mannequin, of the Laerdal company [15], as a modern and advanced technology in terms of time-saving and efficiency compared to other methods available on the market [4].

The SimMan simulator is classified, among its main qualities, according to the high human characteristics similarity, among which are: anatomy, sounds and noises emission, breathing sounds, eye movements and others characterizing it as of a high-fidelity category [6].

The Technical Nursing Course at IFRR Boa Vista Campus - Roraima has equipped its laboratory with the human simulator SimMan, allowing teachers of the Practical Nursing Education to develop, evaluate and validate circumstances so that the future professionals can work and develop the theoretical contents shown in the classroom and the learning interactive active method, adapting it as a strategy to improve the content taught [7].

According to studies [6], Regional Council of Nursing of the State of São Paulo (COREN-SP) until May 2009, there was, at least, one mannequin (human simulator, not mentioned of loyalty category classification) for each 868 Nursing Institutions. This fact brings few publications in scientific journals about the study, affirming that there is an inconsistent relation between the discussions and the use of the mannequin in the nursing laboratories in Brazil. In the reference [8], the article portrays the results of the mannequin simulation and its contribution to the acquisition of psychomotor skills and self-confidence by the nursing students.

In view of the [6] concern, this article aims to contribute to the research and to point out results aimed at experience reports, the importance of simulation can be inserted in academic environment, providing innovative teaching practices.

2 Development

The descriptive study originated from a literature review on the use of simulation as a technological resource in the construction of the Teaching and Learning of the Technical Nursing Course at IFRR. The research was based on the exploration of national and international data on the use of the simulator, in order to structure this work. Therefore, it was included scientific articles, books and research in COFEN site.

The research method presented in this article was the literature whose nature is qualitative. Among the criticisms of the educational practice limitations based on a fragmentary approach of the knowledge and focused on the theoretical aspect, it was noticed that the students, during the lessons about specific curriculum components of technical training, are often limited to empiricism [9].

When teachers act in a way that seem to ignore the scientific spirit, stuck in a sterile routine, for example, to start a class based on doing exercises, formulas demonstration repeating them step by step, sometimes disregarding the previous knowledge, make difficult the perception of the theory-practice articulation, besides it is not about acquiring an experimental culture, but rather to change the experimental culture, breaking the barriers already incorporated by the everyday life [9].

To help break these barriers, the computer came as a technological resource, aiding in experiments, eliminating fear and insecurity in the procedures and implementation of techniques by the students. Furthermore, it planned practices through simulations, as per the requirements of the curriculum subjects, so that the logical sequence for learning is growing and being effective in education and health care of future patients [8].

There are scholars who criticize the fact that most teachers do not base their classes in scientific theories of learning or activities, relying only on their long teaching experience and life. In addition, the memorization exercises applied serve only as mere examples [10], to justify the content taught, but do not match the student's actual experience. So, do not combine the student's needs and form a collapsing cascade. To be clearer, without motivation there will be no need for cognitive knowledge "the know-how" [11].

This methodological proposal highlights the challenge of suggesting strategies for ensuring the realization of a pedagogical practice that can innovate in the state of Roraima, since it brings as its base the principles of creativity, promoting the arousal of the students' interest, because according to [10] motivated student will produce prioritizing the quality of learning and the motivation of the students contemplating interdisciplinary and transdisciplinary in their actions.

The Pedagogical Plan of the Technical Nursing Course, reformed in 2014, presents the course constituted by a Theoretical/Practical duration of 1200 hours added 600 hours of internship. It is structured into four modules, containing forty-three subjects, it is a technical course of two years taking into account the required determinations by the Ministry of Education (MEC) for Environment, Health and Safety Management courses [12].

Among the methods of teaching, the course requires students' attendance and "subsequent" (meaning that it is necessary that the student has completed secondary education), and the profile of the graduated student is to be a professional that meets

the demands of society in general as the requirements of the socio-economic development and potential workplaces: Basic Health Units (BHU), Public or Private Hospitals, Clinics and companies [12].

Having in mind the Technical Nursing Course coordination concern with an educational solution relating the ICU scenario in the subjects: Patient Care in situations of Urgency and Emergency; Critical Patient Care I and Critical Patient Care II whose workload is 40 hours respectively [12]; would be the use of an Augmented Reality (AR), whose definition is "the real world combined with the virtual one fostering real-time interactivity [13]" that, according to [14], became attractive and has evolved considerably, like the Human Simulator known as SimMan of Laerdal company as it can be seen in Figure 1. Therefore its use aims to enhance the resources and teaching and learning aids used in the construction of knowledge [13].

 (a)   (b)
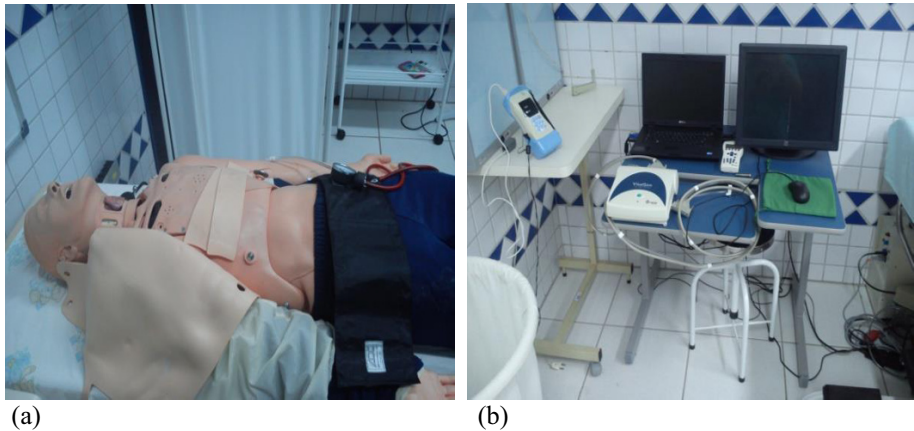
Fig. 1. The SimMan in the IFRR ICU laboratory (a) Side view, (b) Control.

Using the SimMan, it is possible to develop and apply controlled and safe experiences in the IFRR ICU laboratorial with the intention of students becoming familiar with the hospital environment in a realistic way and guiding or applying their technical and scientific skills into the practice [14].

Using the SimMan resources, it is possible to develop and evaluate diverse scenarios of the characteristics [15] shown in Table 1.

Table 1. Simulation features of SimMan [15].

Head	Vocals sounds, Interchangeable pupils, Carotid pulse, CO_2 emission.
Airways	Lockjaw , Glottis edema , Pharynx edema , Laryngospasm , Neck stiffness.
Torso	Cardiac arrhythmias, Spontaneous breathing, Decreased lung complacency, Lung sounds and Cardiac sounds, Pneumothorax decompression, Stomach decompression, Extensive library of ECG signals, Monitored ECG, Defibrillation, External pacemaker, Chest compression.
Pelvis and Extremities	Male and female urinary catheterization, Training arm IV, Subcutaneous/Intramuscular injection, Blood pressure, Peripheral pulse (radial and dorsalis pedis).

Students interact in real time with the procedures, providing security in their skills to treat the patient, whitout bringing risks and expanding their skills and practices, and improving their clinical judgment and thought [4], [14].

Among the SimMan features, it is highlighted the debriefing, able to record the interaction of students through a webcam integrated to the software enabling the teacher to re-examine the practical actions of that scenario, as well as the consistency between time and procedures performed within the stipulated time and for the students themselves to have a feedback when viewing/checking their own behavior and attitudes to improve their techniques and learning.

In his article [4] states that the teaching method with the SimMan for nursing is the best educational method among others available. The results shows a 87.5% efficiency in the practical Nursing course.

The simulation can be considered as a learning object and some characteristics can be extracted regarding the educational aspects providing the students with the teaching and learning [16]:

- • Quality of content;
- • Appropriateness of the learning objectives;
- • Feedback and adaptability;
- • Motivation;
- • Reusability.

3   Comments

The authors demonstrate the importance of using the SimMan simulator, in the cognitive aspect and as proposition, the use of this technology for the education quality improvement.

The closeness of this simulator with the reality that provides the professionals with the experience for their future reality, will motivate and influence them in their cognitive actions arousing a critical and autonomous reflection-action in both the academic and professional field.

The use of this human simulator in the Technical Nursing Course in will become a referential in the teaching and learning in the state of Roraima, extending the partnership to other public agencies such as: Fire Departments, UFRR healthcare students, the General Hospital workers, among others.

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Dictionaries on Smartphones: Learners' Assessment of Features and Potential of Dictionary Apps as Pedagogical Tools

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Abstract. The growing popularity of *smartphones* with their multiple functionalities have made these devices a valuable asset to teaching and learning. The study presents the assessment of free-download electronic dictionaries for iOS, Android and Windows operating systems. Three monolingual (Portuguese) and three bilingual dictionaries (Portuguese-English) were evaluated by a class of Engineering students at a federal institution. The main objective of the investigation was to find out how participants evaluated the constituent elements of the apps and their usability features. The study also verified how students perceived the apps as valid reference instruments to be used in both formal and informal learning situations, and what school level is suit to introduce them as pedagogical tools. Data were collected using a questionnaire with mixed-type questions, including the students' habits of consulting dictionaries. Results may serve as parameters for eventual selection of this educational resource for both teachers and learners.

Keywords: m-Learning; Smartphones; Monolingual and Bilingual Dictionaries.

1 Introduction

The increasing use of ubiquitous technologies[1,2] worldwide, and in Brazil in the case of this study, poses issues and challenges for educators and learners. For Henry Jenkins [3], contemporary society is experiencing a change in the way we produce and consume information. In line with this, education has become more learner-

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[1] According to eMarketer [1], Brazil led the Latin American mobile market in 2015: 141.3 million users, with user penetration of 69.2%. The leading operating services are Android (90%) and Windows Phone. iOS shares only 1% of the market in Brazil due to its high cost in the country.

[2] Google Play Store leads the rank of apps downloads in Brazil, making it the 2nd largest world market [2].

centered, individualized and collaborative, and resourcing to M-Learning (ML) to keep pace with the needs and demands of current learners .

According to the "Policy Guidelines for Mobile Learning" drafted by UNESCO [4], ML "involves the use of mobile technology, either alone or in combination with other information and communication technology (ICT), to enable learning anytime and anywhere". The growth and value of ML are also emphasized in "The Technology Outlook for Latin American Higher Education 2013-2014" report, issued by the New Media Consortium [5]. This document highlights that, besides demanding the use of digital technologies in educational contexts, students tend to consider their electronic devices as extensions of their personality and lifestyle.

Koole [6] says that learning via mobile devices enable individuals to make effective and better evaluation and selection of relevant information, reconsider their objectives and understanding of concepts in an ever-increasing and ever-changing set of references and data. Churchill and Churchill [7] list a number of benefits that justify the use of smartphones for educational purposes, including these: (i) they are multimedia tools; (ii) they allow for social interactivity and collaborative work; (ii) they are ubiquitous and, (iv) they facilitate individualized and independent learning. In addition, if we consider their wide range of features and applications, smartphones have changed student behavior, as they increase interaction and opportunities to independent learning [8].

This study focuses on electronic dictionaries which, as a digital text genre, can be constantly updated and enhanced with hypermedia. Nesi [9] explains that paper dictionaries, besides being heavy and static, cannot store information in the comprehensiveness required by contemporary society. In digital dictionaries, entries are not necessarily accessed by alphabetical order - they can be found by class, function, meaning, idioms, collocations, and examples in sentences.

The objectives of the investigation aimed to find out:

 (i) which free-download dictionaries (three monolingual and three bilingual) received better reviews by the students;
 (ii) whether students perceived these software applications (apps) as a valid tool in both formal and informal learning situations.
(iii) what school level participants find adequate to introduce these devices as learning resources.

The survey was administered, with assistance of the authors, to a group of undergraduates. They analyzed each app and answered two questionnaires (one for monolingual Portuguese apps, and one for bilingual English-Portuguese dictionaries).

The comparative analysis of the apps, as well as the investigation on how students perceive them as potential pedagogical tools, may contribute to assist learners and teachers in the selection of which dictionary suits their teaching and/ or learning purposes.

The following section discusses the use of mobile devices for educational purposes, as well as a literature review on electronic dictionaries. Section 3 focuses on the methodology used in the investigation. This is followed by a discussion of the

findings in Section 4.

2 Mobile Devices in Education

The use of Information and Communication Technologies (ICT) is a growing trend in Brazil; Brazilian institutions have been adopting apps into their programs, and modifying "websites, educational materials, resources and tools so they are optimized for mobile devices" [10].

Nevertheless, it is important to stress that many states and municipalities in the country have banned cell phones from the classroom - an action regarded by many as a step back in contemporary teaching approaches. One common justification for these legislations is the fact that mobile phones may cause distraction of students in the classroom, affecting performance of learners and teachers as well. Regardless of school bans, one must acknowledge that mobile devices (MDs) represent a paradigm shift in social practices (relationships, identities etc.), which means they should be incorporated into school programs.

Two major models are popular for m-Learning (ML) in formal education: (i) one-to-one (1:1) programs, in which the school provides MDs to students; (ii) Bring Your Own Device - BYOD, initiatives that rely on student-owned devices and school subsides for those who cannot afford them. The former is more common in poorer countries, while the latter is usual in more fortunate communities [4].

The 2014 NMC Technology Outlook for Brazilian Universities [10] lists these features of MDs and apps as relevant for teaching and learning:

- Development in mobile software present "sophisticated tools" that enable "scientific experiments from anywhere easier for students", as they can process large amounts of numbers, create 3D images, and "record environmental observations".
- Organizing information and collaborating on projects have been made easier by apps such as Evernote, Dropbox and Google Drive.
- Worksheets tend to be replaced by interactive apps that offer activities and games.
- Due to their lower cost, MDs are "an economic, flexible alternative" to conventional computers.
- Built-in features in mobile apps allow learners "to share their questions or findings with each other in real-time".

A successful ML experience involves good student acceptance towards this strategy. Liaw et al. [8] name the following factors that play a significant role on the acceptance of an ML system: "enhancing learners' satisfaction, encouraging learners' autonomy, empowering system functions, and enriching interaction and communication activities".

Koole and Ally [11] emphasize that the use of MDs in educational contexts must consider the following aspects, among others: physical features (size and weight), input and output devices (keyboard, touch screen, audio functions, camera etc.), storage capacity, processor speed, easy handling, clear help manuals.

Digital natives, especially,   make wide use of the multiple functions of smartphones. In regards to researching, Palfrey and Gasser [12] stress that it no longer means "a trip to the library", but a search on Google, or "a visit to Wikipedia before diving deeper into a topic". For the authors, speed and easy access to multi-semiotic worlds are characteristics of the web and of digital technologies, in general, that captivate digital natives.

As stated by Stockwell [13], the use of MDs in education presents "somewhat of a paradox", with enthusiastic teachers and researchers versus pessimistic ones. Many in the optimistic group consider m-Learning as " the next generation of learning", while others hold a more realistic view. Stockwell [13] mentions Dias [14], who points out that students often regard m-Learning "as an intrusion into their own personal space" - a fact that may affect acceptance of MDs in educational contexts. Nonetheless, the benefits of MDs overcome the challenges posed to educators and learners. Some of these benefits are the possibility for students to develop (i) their autonomy to explore and manage learning regardless of traditional school restrictions; (ii) their assessment skills and selection of relevant information [15, 6].

2.1 Dictionaries as Apps

Biderman [16] defines a dictionary as a "systematic organization of the lexicon, by which lexicographers try to describe the vocabulary accumulated in a language in the course of centuries [...] at a given period of time [...]"[3]. According to the author, this is quite an "intangible" task since languages, as living entities, keep growing and changing in geometric progression.

Rangel and Bagno [17] explain that dictionaries can provide a wide range of "services", as they provide the various meaning and functions of words in a given linguistic context . They can, for instance:

- clear doubts concerning spelling, meaning, and different concepts of the word;
- provide synonyms, antonyms, and homonyms;
- provide the domain and/ or the linguistic context in which the word is usually found;
- inform the different functions the word can have in a sentence;
- describe the pronunciation and its variations;
- inform about the origin of the word etymology.

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[3] In accordance with the Federal Constitution, Resolution 003/2001 of the Brazilian National Education Development Fund (FNDE) states that Portuguese language dictionaries are a "constitutional right" of learners, and as such, must be provided by this agency to all learners from grades 1 to 5 enrolled in public schools.
http://fnde.gov.br/programas/pnld/legislacao/res03 2102 2001

   Traditional paper dictionaries have been increasingly replaced by digital versions[4]. As Nesi [9] puts it, these are either heavy and large, or too small without enough entries to support good learning practices. Most importantly, printed dictionaries cannot keep updated content in pace with the ever-increasing amount of information produced on the Web. Electronic dictionaries (e-dictionaries), on the other hand, can store great amounts of data that enable access in various ways, in other words, not restricted to alphabetical order.

   Regarding contents of online dictionaries, Lan [18] thinks they "can be as good as their traditional paper equivalents. If a screen does not contain everything one wants, further lexicographic information can be obtained by clicking on a hyperlink". In his study, Lew [19] says that "what comparisons of paper and digital dictionaries show quite consistently is that the digital medium encourages more frequent consultation". On the other hand, the author stresses that " there is still uncertainty about whether digital dictionaries help immediate comprehension or promote vocabulary learning".

   Digital dictionaries are also hypermedia tools - images and audio certainly make them more attractive to current learners. Lew [19] accredits part of the success of e-dictionaries to "advances in speech recognition". One problem related to the pronunciation function on smartphones relies on "accented speech" and particular phonetic variations. One reason for minor pronunciation problems may be due to the vast number of data in e-dictionaries [18]. One special feature of current digital dictionaries is the "did-you-mean function", which can be quite helpful for those not sure of how a word is spelled [19].

   Some of the positive aspects of e-dictionaries are summarized by Lan [18]. The author says that their strength lies "in their innovativeness: quick search, frequent updating, interactivity, and designer/user collaboration". Lan [18] also emphasizes that "information retrieval by means of the computer's search engine takes much less time than thumbing through the pages of an alphabetic dictionary, and so interrupting one's reading can be kept to a minimum". In Lew's opinion [19], dictionaries on mobile phones are more effective "if they are instantly and unobtrusively available during the activities in which humans engage". The author's point of view is that "as more of our work, study and play is done in an ICT-enhanced environment", e-dictionaries will eventually "blend into that environment", and be used whenever needed.

   As reminded by Zarei and Gujjar [20], use of e-dictionaries on mobile phones present disadvantages too, among them: (i) they have functions that may require time to be mastered by the user; (ii) lighting conditions may affect reading on LCDs.
The following sections present the methodological procedures and results obtained in the study.

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4 Different terms are used to refer to online dictionaries. Lew [19] suggests *digital dictionaries* "as the cover term", while *electronic dictionaries* can be used for "lexicographic applications" in ubiquitous equipment.

3 Methodology

The investigation was aimed at analyzing and assessing free-download dictionaries in smartphones in order to verify their potential and pertinence as a pedagogical resource in both formal and informal learning situations. To achieve the objectives of the study, a group of 21 undergraduate students at a federal institution analyzed six apps and answered printed questionnaires in the classroom.

3.1 E-Dictionaries Used in the Investigation

The selection of the apps for the investigation was defined by the following criteria: they had to be free-download and available for the major operating services used in Brazil (Android, Windows, and iOS). Two sets of e-dictionaries were assessed by students on two different occasions:

(i) November 2014, when they analyzed 3 monolingual Portuguese dictionaries (Priberam, InFormal, Porto Editora[5]);

(ii) March 2015, when they analyzed 3 bilingual English-Portuguese dictionaries (Bravolol; Ascendo; Huang Tiancheng[6]).

The electronic versions have similar content structure with large and continuously updated databanks.

Once the app is downloaded, its content is available off line, a feature found most attractive by users, especially Brazilian students who do not have cheap and comprehensive internet coverage.

Apart from the usual entry search, the apps offer these features: most frequent searches, scientific terminology, slangs, related searches, search history records, geographical variations, linguistic context, verb conjugation, degree of adjectives.

Figures 1 and 2 show screenshots of each app.

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[5] URLs: https://www.priberam.pt/DLPO/; http://www.dicionarioinformal.com.br/; http://www.portoeditora.pt/espacolinguaportuguesa/dol/dicionarios-mobile.

[6] URLs: http://vidalingua.com/; http://bravolol.com/dictionary/; http://pt.appszoom.com/iphone-developer/huang-tiancheng_ebqbp.html.
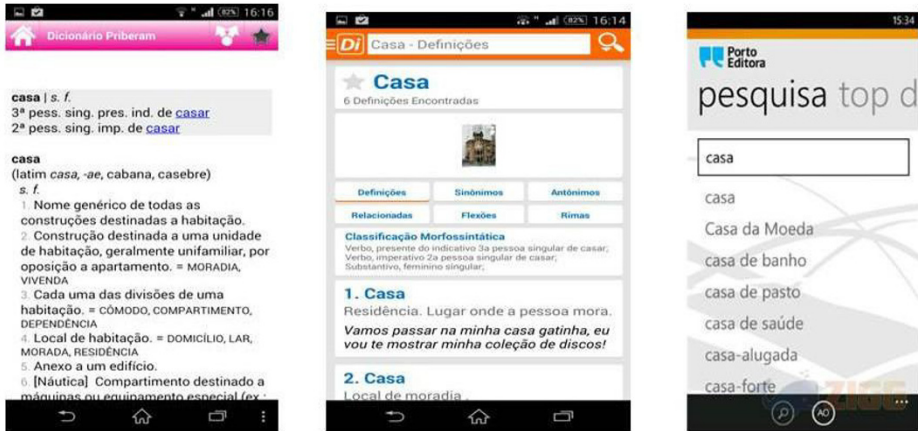
Fig. 1. The same dictionary entry in the three Portuguese apps.
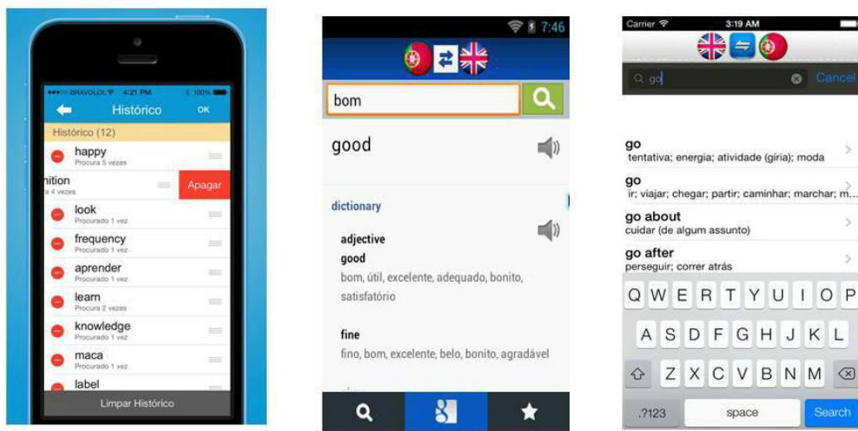
Fig. 2. Different word search modes in the English-Portuguese apps
(left to right: Bravolol, Ascendo, Huang Tiancheng).

3.2 The Survey Questionnaire

Printed questionnaires were administered by the authors in the classroom. Participants answered 15 objective questions related to: (i) their personal profile; (ii) their habit (or lack of) of searching in reference works; (iii) the constitutive elements of the dictionaries; (iv) their opinion regarding the usability and navigability of the software; (v) the quantitative and qualitative evaluation of the apps; (vi) their perception of the pedagogical potential of these resources; (vii) which school level should allow and use this type of app as pedagogical tools.

Students were also asked to rate each app as *poor*, *fair*, *good*, or *very go*od, and justify their ratings. It is worth noting that, even though the survey did not explicit

that participants should assess graphic elements of the apps, they did consider this features in their analyses.

These are the constituent elements of the dictionaries participants were asked to find out in the investigation:

- etymology;
- part of speech;
- gender;
- irregular plural forms;
- verb conjugation;
- audio pronunciation;
- synonyms and antonyms;
- use of the word in sentences;
- idioms;
- more than one definition for words with different meanings.

To avoid aimless and careless analyses, students were requested to start their searches by using the same word entry . They were told to look up the noun "casa" for Portuguese and "house" for the bilingual dictionaries; the irregular verb conjugation of "ir" in Portuguese, and "go" in English. For the monolingual Portuguese language apps, participants also verified the offer of: foreign words used in everyday Brazilian Portuguese, as well as differences and variations between Brazilian and European Portuguese (spelling and meaning).

3.3 Profile of the Investigation Participants

A group of 21 students enrolled in the 3rd term of the Control and Automation Engineering Course at a federal institution[7] participated in the study. When the questionnaires were applied, more than half of the class was less than 20 years of age (52%); the other 47% was between 20 and 25 years of age. The most popular operating service amongst participants was Android (85%).

Due to the nature of their course and being digital natives, these undergraduates use their laptops as a tool in most of the course disciplines, and have good reading skills in English as a foreign language. As their teacher, the authors have noticed that they keep their phones on for either looking up information on a topic discussed in class or for texting friends.

4 Discussion

Data collected in the survey are analyzed and discussed in separate topics of this section.

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4.1 Frequency of Dictionary Consulting

Questions regarding the participants' habits of consulting dictionaries provided the following results.

Table 1. Frequency of dictionary consulting according to type.

Type	Never	Rarely	Occasionally	Frequently
Printed	09%	61%	28%	0%
Desktop or Laptop	20%	19%	33%	28%
Phone	42%	19%	19%	19%

Data in Table 1 show that, regardless of the medium, dictionary consultation is not a standard practice among the survey participants. Empirical observation by the authors at their institution points to frequent and wide use of printed dictionaries in language classes. We think this might be due to the slow pace in which teachers incorporate technology to their practices, and that these results apply to similar groups of students and, to most teachers in Brazil. Nevertheless, since smartphones play, indeed, a significant role in everyday life of current students, and as a new generation of teachers emerge, MDs are likely to become commonplace pedagogical tools.

Leffa [21] actually suggests that dictionaries should be used "sporadically", because interrupting a reading activity to look up a work, and then return to the text, can be highly "obstructive". Leffa's opinion [21] is that e-dictionaries help to prevent readers from "abandoning" the text as they allow faster access to entries than their printed counterparts.

Another result (not shown in Table 1) refers to academic research on smartphones. The large majority of the students (76%) say they "frequently" resource to their phones for doing quick consulting related to some sort of academic task. However, this was reported as personal initiatives, i.e., not part of formal classroom activities, which may indicate that teachers still have difficulties in incorporating MDs into their teaching practices. The "Pockets of Potential" report on mobile technologies for children [22] claim that teachers "do not yet view these devices as educational allies" since "they have not been trained to use new technologies in their classrooms or afterschool settings".

According to Bellay [23], the potential of dictionaries for the cognitive development of learners is not satisfactorily exploited by Brazilian teachers for reasons such as, among others, lack of understanding of the potential of dictionaries,

and proper understanding of the various types of dictionaries (specialized, historical, pocket versions, for children etc.). Bellay [23] emphasizes that it is necessary that teachers be trained to select the proper dictionary for his/ her class, and stimulate their use. Dargel's findings [24] indicate that teachers underestimate dictionaries as a valuable resource in activities aimed at developing the students' lexicon in their mother tongue. Clearly, the same applies to the teaching and learning of foreign languages.

4.2 Assessment of the Dictionaries

As explained in 3.2, analyses of the apps took into consideration their constitutive elements, usability, graphics and quality of the content (extension and variety of definitions, for instance).

Fig. 3 shows that, of the three monolingual Portuguese dictionaries, Priberan and InFormal received similar scores for "good" (37% and 47%, respectively). However, for "very good", Dicionário Informal received the highest score - 19%, while Priberan got 9% in this classification. Some of the positive remarks students wrote about Dicionário InFormal include: "interesting", "comprehensive", "easy to handle", "well structured", "the most complete of the three". Justifications for classifying this app as "fair" or just "good" are illustrated by these comments: "you must be careful with some of the definitions", "just basic, it can be improved", "no examples in sentences".
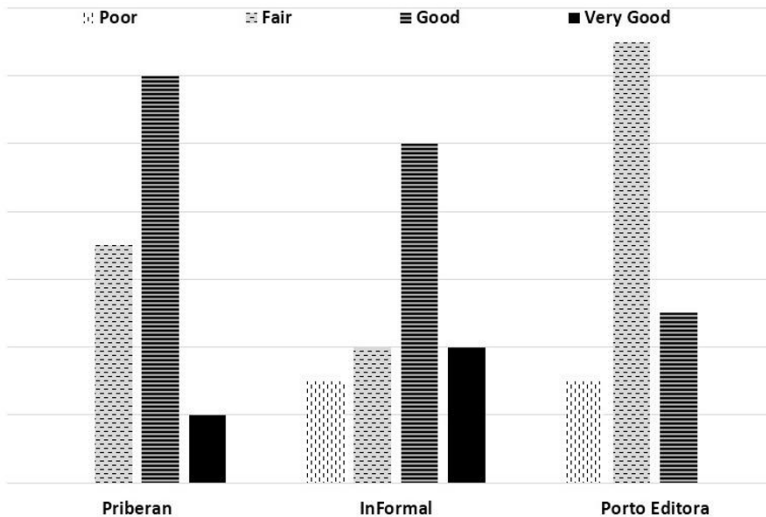
Fig. 3. Ranking of the Portuguese Language apps.

The following graph shows results for the bilingual English-Portuguese dictionary apps.
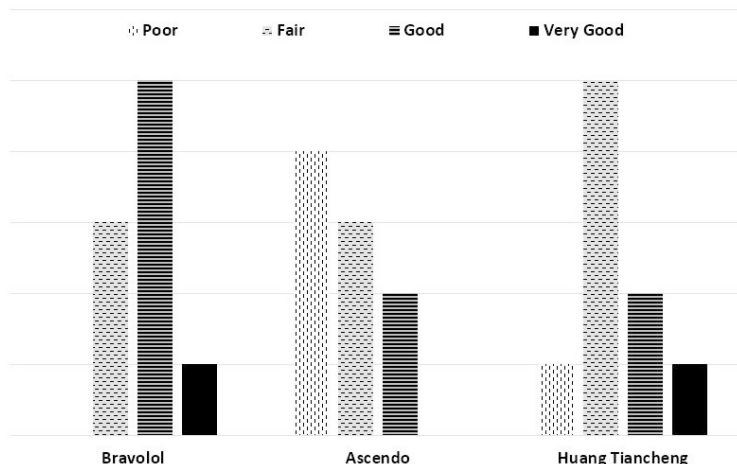
Fig. 4. Ranking of the bilingual dictionary apps.

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Figure 4 shows that the Ascendo Dictionary received the lowest rates (bad: 44%; fair: 33.3%; good: 22%; 0% for very good). No positive statements were written for this app. Some students justify their evaluation of Ascendo when they say, for instance: "very poor resources", "poor definitions (only one word)", "bad layout". It is worth noting that participants, though asked to justify their opinions, did not report what resources they found missing, and why they did not like Ascendo's layout. Comparison of the Bravolol and Huang Tiancheng apps is more difficult to be established, as results are somewhat conflicting. While both apps were equally ranked for "very good" (11.1%), the highest scores were "good" (55.5%) for the former, and "fair" (55.5 %) for the latter. Overall results obtained by Bravolol indicate that this dictionary app was considered as "best" by the investigation participants.

These statements illustrate the participants' perception of Bravolol: "[...] good, but can be improved"; "presents lots of options"; "the best of the three because it presents words in sentences"; "presents important features as audio pronunciation". At the time of the investigation, the Bravalol app presented the largest amount of graphics and search categories.

Some of the students' comments on the Huang Tiancheng Dictionary are: "needs more resources"; "not enough definitions"; "badly organized". One respondent, though, considered this app as having a "great amount of expressions".

This discussion must take into account that students actually doubt whether these apps are a good and / or useful substitute for looking up words on a search engine. Two major reasons given by participants that justify downloading the apps were: (i) they do not require internet connection; (ii) they present easy-to-find conversational phrases. Further inquiry is necessary to verify if respondents continued to use these apps on their smartphones.

Participants were also asked to select which school level they found more suitable to start using mobile phones as pedagogical tools. As seen in Figure 5, the majority agree that mobile devices can be used as early as from 1st grade. Some students justified their opinion by saying, for instance: "nowadays, children use smartphones all the time"; "the more contact with language the better", "[...] it is ok as soon as the child has a certain knowledge of the language".
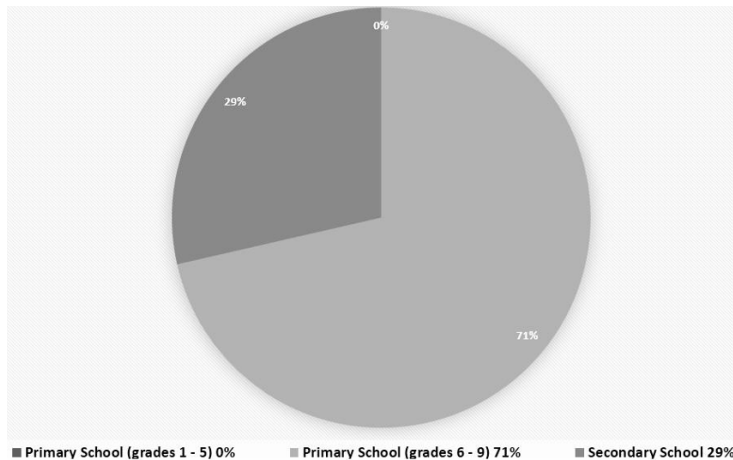
Fig. 5. Preferable **s**chool level for adopting smartphones as pedagogical tools.

The authors did not discuss with participants the many aspects involved in this issue. Results show, therefore, the perception of a group of young adults - digital natives who regard their mobile phones as an inseparable item of their lives - not experts on education or linguistics. therefore their opinion is solely based on their experience as learners and users of mobile equipment.

In informal conversation with respondents, the authors also observed that they find it is "useless" to have rules banning use of phones in the classroom, and that teachers should take more advantage of these tools as well.

Analysis of the answers given in the two questionnaires indicate the following main conclusions as reported by respondents:

- it is not usual in the respondents' learning contexts;
- it is useful for searches non-related to school tasks;
- it is not a tiresome activity;
- it has the benefit of not requiring internet access after downloading;
- it is a potential pedagogical resource for children as of 1st Grade.

5 Conclusion

As ubiquitous technologies keep evolving, mobile phones become prevalent worldwide. These devices possess numerous functionalities, including the possibility

of downloading educational software to support learning practices in the classroom or in out-of-school situations. Due to their rich content and features (sound, animation, encyclopedic information, for instance), as well as the possibility of being collectively enriched by users' contribution, e-dictionaries tend to become effective and commonplace tools [18].

This article presented an investigation carried out with a group of undergraduate students with the main purpose of comparing free-download dictionaries for Android, iOS and Windows systems. The survey included questions regarding the students' habits of using dictionaries in both printed and on-line modes, and critical evaluation of the apps.

Assessment of the dictionaries was based on their constituent elements, quality of the content, layout features, easy handling and navigability. Of the 3 monolingual (Portuguese) dictionaries analyzed by students, Dicionário InFormal received the highest scores; while Bravolol was rated best among the 3 bilingual (English-Portuguese) apps.

Participants also expressed their opinions on the potential of the apps for educational purposes, as well as the school level they find adequate to incorporate mobile phones into learning activities. Even though respondents admit that consulting a dictionary on their phones is not a common practice, they do find such devices useful educational resources. Students stressed the fact that these apps, once they are downloaded, have the benefit of not requiring access to the internet. Regarding appropriateness and potential of the apps in different school levels, 71% of the participants say they should be introduced as of 1st Grade.

The comparative analysis of the apps described in this study, as well as the investigation on how students perceive them as potential pedagogical tools may contribute to assist learners and teachers in the selection of which dictionary suits their teaching and/ or learning purposes. However, because of the frequent evolution of software, the authors emphasize that the apps analyzed for this study may have changed in regards to their functions and constituent elements since the investigation took place.

Future research by the authors includes observation of how dictionaries on smartphones are used by high school students in classroom language activities specifically designed for the investigation. We also intend to have the apps shown in this paper assessed by teachers of Portuguese and English languages.

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Collaborative Learning supported by mobile devices: A case study in Portuguese High Education Institutions

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Abstract. Collaborative learning has been getting more importance in educational environment as one type of mobile learning application. In this learning environment there are a shift of learning approach, i.e. in a traditional approach the focus is on the teacher and in static and repetitive contents, oppositely with a collaborative learning the learn is centered in the students where they have a critical apprehension of contents that goes beyond the classroom, students could learning in different places. Learning supported by mobile technologies is becoming a new approach towards education, and it is single in the way that offers opportunities to learn anywhere and anytime. This paper introduces the foundations of collaborative learning supported by mobile technologies as well as presenting and analysing the evolution of collaborative learning supported by mobile devices in Portuguese (North region) Higher Education Institutions between 2009/2010 and 2014/2015.

Keywords: Mobile learning, Collaborative learning, mobile devices, anywhere, anytime.

1 Introduction

Mobile technologies, particularly Tablets and Smartphones, are quickly becoming powerful technologies enough to override personal computers in several tasks with the advancement of wireless and mobile technology. While these technologies has dramatically transformed our society in the way we communicate, create, retrieve and share information, collaborate and socialize each other, the application of these technologies is still relatively young [1].

Mobile learning has become a research field of interest of practitioners in the different phases of education to facilitate learning in different contexts [2]. The key aspects of this interest are the growing importance and their use, in the day-by-day, of students in the most several activities, and the increasing portability of these technologies, as well as the reduction in their cost and services [3].

Learning supported by mobile technologies is becoming a new approach towards education, and it is single in the way that offers opportunities to learn anywhere and

anytime [4], [5]. On the other hand, collaborative learning has long been believed to hold great value for education, but creating a collaborative learning experience inside and outside of the classroom is a challenge with which teachers continue to struggle, since there are several obstacles e.g. their own preparation for the introduction of this learning approach [6]. Additionally, there are no consensuses in interpreting collaborative learning. Since, it varies in focus according to the literature (see section 2.1). However, new educational application - educational apps [7] have, at least in some contexts, begun to transform the way teachers teach, students learn, and teachers and students interact.

This work analyses the evolution of mobile technologies in Higher Education Institutions (HEI) in Portugal (North region) between 2009/2010 and 2014/2015, being an evolution of the work [8] analyses and discusses more general results.

The paper is structured as follows. Section 2 critically examines previous definitions of collaborative learning and mLearning and comes up with a definition that seems best to serve the learning of individual and collaborative mLearning. Section 3 presents the state of the art in collaborative learning with mobile devices in Portugal in HEI. Section 4 presents the methodology. Section 5 summarizes the results and discussion of the research and lastly, section 6 presents the study conclusions.

2   Background

In this section, are considered some of the current pedagogical paradigms that support learning, with particular emphasis on collaborative learning, whose aim is to demonstrate the potential that this paradigm has in the use of mobile devices.

2.1   Collaborative learning

The current educational paradigms aim to motivate students to learn, with the help of teachers, technology and other students, which would potentially contributed to the effective development of their academic and/or professional activities [9]. These new educational views are closely related to the pedagogical theories [10], [11], such as the constructivism [12], the behaviorism [13], the situated learning [14], the problem-based learning [15], the learning-oriented context [16], the social learning [17] and the collaborative learning [18].

According to Panitz [19] collaboration is an interaction philosophy and a personal lifestyle. In this context, it is possible to state that the collaborative learning is more than a classroom approach; it is a way to deal with people that respect and emphasizes individual skills and contributions of each member of a group. All group members share responsibilities and authority, thus giving a more active role to stakeholders in the learning process.

According to Harasim, Calvert, and Groeneber [20] collaborative learning is an oriented approach that promotes a dynamic and collaborative participation, promoting a greater cognitive development when compared to individual activities. The great challenge is to develop a culture of participation and responsibility of those involved

in learning. That involvement is established through the formation of groups or learning communities.

Additionally, Wiersema [21] points out that a more efficient learning, as well as a more efficient work, is collaborative and social rather than competitive and isolated.

To Stahl [22], the process of social sharing on what is understood by the group, central phenomenon of collaboration, could be studied through collaborative negotiation sequences, during the interactions between the participants of the working group.

Group learning can be interpreted in several ways: (i) presential or virtual learning; (ii) synchronous or asynchronous. This type of learning allows the effort made by learners can be fully together or through the division of tasks. Therefore, the practice of collaborative learning may assume multiple characterizations, although there might be dynamics and results of learning to each specific context, namely when the means used are diverse, from the personal computer to the mobile devices.

The collaborative learning [23] is part of a set of pedagogical trends: (i) Movement of the New School; (ii) Theories of Genetic Epistemology of Piaget; (iv) Socio-cultural Theory of Vygotsky and; (v) Progressive pedagogy.

According to the same authors the pedagogy of the New School the Progressive, together with cognitive theories formulated by Piaget and Vygotsky, generate the foundations of collaborative learning, which have led to the movement of classes focused on the teacher, with static and repetitive contents for   classes focused on the students and a critical apprehension of contents.

2.2   mLearning

Mobile Learning (mLearning) concept is not new and, it is important to understand/analyze its evolution. For example, Viteli [24] finished his article, written 15 years ago, with the following statement: "*The concept of mLearning is yet very unknown. On 15th of September 2000 the Google provided 40 links to mLearning and 29.900 to eLearning.*", while Costa and Xavier [25] by performing a search on Google in July 2014 found approximately 252 million links to eLearning and 231 million links to mLearning.

mLearning can be defined as a way of learning that makes use of mobile communication technologies and gives to the students the capacity to learn anywhere and anytime. This definition is based on the definition presented by [26] "Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies." Mobile learning can be defined as the learning that occurs linked to mobile devices [27]. Mobile devices include mobile equipment (Laptops, Tablets and Smartphones) which have been undergoing a very strong evolution from the point of view of capacity, reliability and, at a more economic perspective, a great reduction in prices. They have come to endow their installations with wifi networks, which by on the one hand, promoting and fostering the use of those devices and, on the other hand, allow the evolution of the teaching-learning process (TLP).

mLearning, according to Traxler [28], offers five features that potentiate new learning opportunities: (i) contextual learning allows students to respond and react to experiences lived in different contexts; (ii) located learning, learning occurs in the applicable environments; (iii) the authentic learning, with tasks directly related to the objectives that want to reach; (iv) the conscious learning of the context in which is informed by the history and objectives; and (v) personalized learning, that is, directed to the preferences of each student.

Contrary to other kind of learning activities, the TLP with mobile devices began with the assumption that students are always on the go and have activities in line with the context in which they are. In this context, Looi, et al. [29] argue that mobile devices provide the integration of education in school and beyond, with continued learning experience. In the same direction UNESCO [30] has prepared its guidance projects for mLearning and recognizes the value of mobile technology is significantly higher when students continually learn from their mobile devices (BYOD - Bring Your Own Device) as ubiquitous mediators between types of learning, for example collaborative learning.

3   State of the art

According to the literature the use of mobile devices for educational purposes using different methods and devices has been conducted around the world. All across the globe, students from elementary school through high school are increasingly engaging with advanced wireless devices to collaborate with peers, access rich digital content, and personalize their learning experiences. Always-on, always-connected, Smartphones and Tablets provide today's students with a ubiquitous gateway to a new ecosystem of information, experts, and experiences, regardless of the physical assets and resources in their own communities.

Baran [31] presents a study with a review of research on mobile learning in teacher education where 37 papers were analyzed. In the analysis the following categories were considered: subject domain, type, method, data sources, reliability, validity and trustworthiness report, mobile technology used and country context. From this study it was possible to conclude that there is no study on mobile technologies in education, particularly in Higher Education Institutions in Portugal (North region), thus making it relevant and justified.

4   Research methodology

The purpose of this section is to describe the procedures used to collect data that are the basis for this research. The main feature of the scientific method is an organized research, strict control of the use of observations and theoretical knowledge. The present study was based on quantitative research methodology.

For the present study, we used the methodology of quantitative research, since it is more appropriate to determine the opinions and attitudes of the respondent based on structured questionnaires. In this approach, data is collected through structured

questionnaires, and clear goals in order to ensure uniform compression of the respondents and a consequent standardization of results.

The method of the questionnaire, according to [32], is recommended when you want to know a population, to analyze social phenomena and, in cases where it is necessary to inquire a great number of people about a certain subject. The questionnaire before being delivered was subjected to the evaluation of four experts in the field. The objective of this study was to obtain answers that will measure the influence of the utilization of mobile devices in HEI. The quantitative study was based on a questionnaire with 16 questions (Q1-Q16). As a matter of space we will just present the analysis of the comparison between two questions (Q15 and Q16) and these results crossed with questions Q1, Q2 and Q3.

5 Analysis and discussion of results

The surveys presented to the students had a few changes depending on the academic year (2009/10 and 2014/15), since there are some equipment and technologies that were important in 2009/10 and today are no longer used, for example PDA, or technologies that are now part of the daily lives of students.

In the survey conducted in the academic year 2014/15 were included questions related to Tablets and new technological solutions. In this context, the section will be divided into three subsections, the first one with the sample characterization information [8], the second dedicated to the use of mobile devices to support learning (Q15) and the third subsection dedicated to the use of mobile devices supporting collaborative learning (Q16) through the analysis and discussion of the comparative study of the common questions of the academic years 2009/10 and 2014/15, as well as the intersection of these issues with the course (Q1), age (Q2) and gender (Q3). Data were collected and treated with the use of IBM SPSS Statistics 20.0 software. In this paper will not show all the results obtained due to the number of pages limitation. Thus, the results of Q15 and Q16 questions will be presented as well as its intersection with the characterization questions (Q1, Q2 and Q3).

5.1 General characterization

The study sample consists of 151 students in the 2009/10 academic year and 273 students in the academic year 2014/15, distributed among the courses Electrical and Computer Engineering (from now on will be referred to throughout the text as Engineering), Economics/Management and Law in HEI in the north of Portugal. Age-related question (Q2) revealed some differences between the two academic years of study (20109/10 and 2014/15). For example, while in 2009/10, the percentage of students aged 18 years was 4.6% in 2014/15, the percentage passing to 25.3%. In contrast, the trend in higher class (> 20 years) has a reversal of the proportions, i.e., 45.7% and 28.9%, respectively. In both academic years the percentage of female students is approximately 60% (Q3).

The distribution of students attending the courses (Q1) is as follows: in the academic year 2009/10 responded to the survey 21.85% of law students, 40.40% of

students of Economics/Management and 37.75% of students engineering; while in the academic year 2014/15 responded to the survey 28.94% of law students, 34.80% of students in courses Economics/Management and 36.26% of engineering students, with a clear trend of using mobile devices in TLP.

5.2   Mobile devices to support learning

Evaluating the answers to the question "*Do you consider come to use mobile devices to support learning?*" (Q15) is prevalent in both academic periods, the percentage of students who responded positively. Should be highlighted that is even more apparent the percentage of positive responses in the period 2014/15 to 93.4% of "*Yes*" against 87.3% in the previous period (2009/10). The positive prevalence is relevant whatever the frequented degree (with particular regard to the period 2014/15). Therefore, when we perform Chi-square test to assess whether there is association between the questions and the course we conclude that there is no significant association (*p-value = 0.343* and *p-value = 0.912*, respectively). It seemed so interesting to analyze whether there are differences of opinion on this question by student course area. Considering the areas - Science and Humanities Courses, the results are in Tables 1-2.

Table 1. Frequency of use of mobile device by Course area (year 2009/2010).

		Science courses	Humanities courses	Total
	No	13	6	19
		68,4%	31,6%	100,0%
		11,1%	18,2%	12,7%
	Yes	104	27	131
		79,4%	20,6%	100,0%
		88,9%	81,8%	87,3%
Total		117	33	150
		78,0%	22,0%	100,0%
		100,0%	100,0%	100,0%

Table 2. Frequency of use of mobile device by Course area (year 2014/2015).

		Science courses	Humanities courses	Total
	No	13	5	18
		72,2%	27,8%	100,0%
		6,8%	6,3%	6,6%
	Yes	179	74	253
		70,8%	29,2%	100,0%
		93,2%	93,7%	93,4%
Total		192	79	271
		70,8%	29,2%	100,0%
		100,0%	100,0%	100,0%

By observing the two tables above and performing Pearson Chi-square associations with continuity correction (*p-value = 0.434> 0.05* and *p-value = 1.000> 0.05*, respectively) found that there are no differences of opinion by areas of knowledge.

We also performed an analysis in order to assess whether there were differences in the opinion of students according to their gender concluding that in both periods are predominant positive responses, regardless of gender. Finally, we find it of interest to assess whether age (group 1 - 18/19, and group 2 - 20 years or more) had influence on the opinion of students on the use of mobile devices to support learning. In both periods, we conclude that there are no significant differences with values obtained for the p-value exceeding 0.9, since the predominant "Yes" regardless of age group.

Among the mobile devices we were also assess, for the two periods, if there was an association between the frequency of use of each of the mobile devices (PDA, Laptop, Mobile Phone, Smartphone and Tablet) and the Course, using for this the association test Pearson chi-square (Table 3).

Noted that, regarding the PDA device, this was only assessed in 2009/10 because it was replaced with more modern technologies, such as the Tablet (only emerged for evaluating the period 2014/15).

Table 3. Values of the p-value for the crossing of the devices that are more used for the Course.

	Academic year 2009/10	Academic year 2014/15
Laptop	**0,043**	0,000
Mobil phone	0,125	0,000
Smartphone	0,257	0,000
PDA	1,809	-----
Tablet	-----	0,082

For the school year 2009/10, it is only significant association between the use of the Laptop and the course, this is because we find that although predominate positive responses to any course, from among negative responses, is very relevant the value obtained for the Law degree (21.2% of "No" against the 8.2% and 5.3% for other courses).

As for the most recent period, we highlight some findings of interest only to the intersections that revealed the existence of a significant association. In the course of Engineering, nearly all students use the Notebook (97%) and the Smartphone (87.9%) and only 26.3% use the Mobile Phone. In the Economics/Management course, Laptop and Smartphone are also the most used devices though a lesser extent (about 65%). Already in Law course, the most widely used device is the Laptop (81%), and the Mobile Phone and Smartphone used respectively by 57% and 55.7% of students.

Finally, comparing the evolution of the use of mobile devices in the two periods, the verified transition is evident, regardless of course, for the use of a technologically more advanced device. While the first period was more frequent Mobile Phone use, the most recent period, the Mobile Phone has been exceeded by the use of Smartphone (Fig. 1).
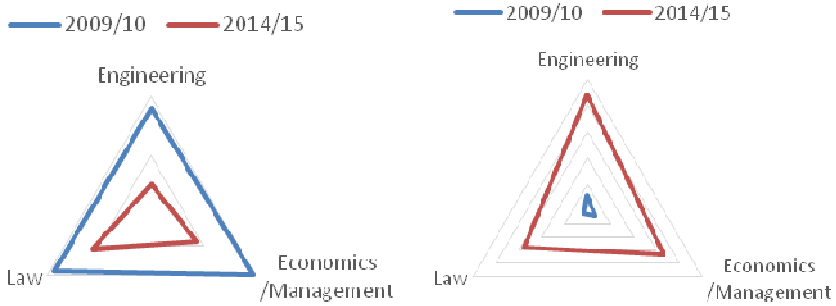
Fig. 1. (a) Evolution of the use of Mobile Phone in the three courses for both academic years and (b) Evolution of the use of Smartphone in the three courses for both academic years.

5.3   Mobile devices in supporting collaborative learning

Evaluating the answers to the question "*Do you consider come to use mobile devices in collaborative learning environments?*" (Q16) predominance of positive responses ("Yes") in any of the periods and whatever the course attended. However, while that for the school year 2009/10 we conclude that there is a statistically significant association (*p-value = 0.040 <0.05*) between the course and the responses to question Q16, this situation no longer holds for the period 2014 / 15 (*p-value = 0.307> 0.05*). The existence of an association in the period 2009/10, was due to the fact that the percentage of positive responses in the course of Law, though high, (69.7%) was significantly lower than those obtained for the Engineering (83.6%) and Economics/Management (90.2%) courses.

Then examined whether there are differences in the use, or not, of mobile devices in collaborative learning environments depending on the gender of the students. We conclude that, as to the question Q15 (analyzed above), are prevalent positive responses, regardless of gender, for both periods. Similarly, we evaluated also to this question (Q16), whether age influences the opinion of students. Once again, we find similar behavior to that obtained for the Q15 question, i.e., no significant differences in both periods (predominance of "Yes" to the two age groups).

So we think it would make sense to evaluate if the answers to both Q15 and Q16 questions were related or not (Table 4). By carefully observing the Table 4 and having regard to the values obtained for the respective p-value (*p-value = 0.000 <0.05* in both periods), we conclude that these two questions are related in the sense in that students most consider come to use mobile devices in learning are also the most likely to consider using these devices in the collaborative learning (the same kind of behavior is found for those who do not consider come to use).

Table 4. Crossing of the questions Q15 and Q16 for both academic years.

		2009/10			**2014/15**		
		Q16			**Q16**		
		No	**Yes**	**Total**	**No**	**Yes**	**Total**
Q15	**No**	16	3	19	13	5	18

	84,2%	15,8%	100%	72,2%	27,8%	100%
	64%	2,4%	12,8%	52,%	2,0%	6,6%
Yes	9	121	130	12	241	253
	6,9%	93,1%	100%	4,7%	95,3%	100%
	36%	97,6%	87,2%	48%	98%	93,4%
Total	25	124	149	25	246	271
	16,8%	83,2%	100%	9,2%	90,8%	100%
	100%	100%	100%	100%	100%	100,04%

6   Conclusions

Collaborative learning seems to be a learning innovation whose time has come. It will make a student actively engage in building their own knowledge. Basically, collaborative learning supported by mobile technology allows that on one hand the students have access and share materials and acquire skills that promote working in group and sharing ideas and knowledge.

In a collaborative learning environment there are a shift of learning approach, i.e. in a traditional approach the focus is on the teacher and in static and repetitive contents, oppositely with a collaborative learning the learn is centered in the students where they have a critical apprehension of contents that goes beyond the classroom, students could learning anywhere and anytime.

In order to understand the developments in the use of mobile devices in higher education in Portugal ((North region) a research was carried out in two separate academic years, separated by five years (2009/2010 and 2014/2015), in very heterogeneous courses (Law, Management/Economics and Engineering). As previously discussed the result clearly shows a high growth rate of the use of mobile technology and the collaborative learning supported by these technologies in higher education institutions in Portugal (North region) just like other countries already studied.

The goal of future work within the same target (higher education institutions in Portugal – North region) is to identify and analyze the introduction of mobile technologies and tools in the teaching/learning process and its advantages and disadvantages. Additionally, we will study how HEIs are promoting courses or course contents specifics for mobile learning.

Portugal – North region) is to identify and analyze the introduction of mobile

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Calculation of sleep indicators in students using smartphones and wearables

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Abstract. Data produced by the use of mobile devices (smartphones and wearables) can be used to obtain patterns and indicators of user behavior. This paper focuses on obtaining sleep-related indicators to apply them in educational settings. Initially the most relevant indicators defined in the literature and available in existing mobile platforms are studied. Based on them, we propose new indicators that can be calculated automatically and transparently analyzing the data generated by mobile device sensors. The ultimate goal of these indicators is to facilitate the construction of software services (recommenders and detectors of risk situations) to improve the learning processes of students.

Keywords: learning analytics, sleep pattern, wearables, smartphones.

1   Introduction

Wearables are bound to the quantification of people's daily activities and vital signs. This trend can be primarily observed on sports fields, healthcare or lifestyles. The calories consumed or the exercise routines are indicators used to extract a first approximation of how healthy are the habits of a person.

In this article we focus on a new field of application of these techniques and technologies: education and learning. Scientific studies have shown the influence of biometric variables (activity level, stress level, exercise routines, sleep patterns, etc.) on health, academic achievement and student learning. These variables are useful indicators to predict the behavior of a student and identify potential problems in the course of their learning. However, the calculation of these variables usually requires active participation by the user. But, the popularization of mobile devices, opens new chances to collect data and calculate variables easily and automatically.

Among all the available features related to education and learning our piece of research is focused on sleep. In the literature the variables or indicators focusing on sleep have always had special importance. There are research projects that study the relationships between these variables and cognitive/learning processes indicators: relationship between student motivation and sleep in class [1]; the impact of sleep deprivation in performance [2]. Some pieces of research show in a positive correlation between sleep quality and academic performance [3]. Similarly, other works observe

a positive relationship between alterations of sleep rhythms and levels of care when working with high level of concentration, like the study of a subject [4; 5]. Nevertheless, other authors didn't find any correlation between sleep and academic performance [6].

The aim of this work is to identify indicators of sleep that can be calculated automatically and transparently to the user. The key idea is to take advantage of the features of wearables and smartphones related to autonomous operation and variety of available sensors. The results will be used to provide students information about their sleep habits (to estimate how well you slept, to warn of possible high degree of fatigue, to detect a pattern of rest, to assess their chronotype, etc.), and otherwise facilitate the construction of alert services and recommendation facilities (e.g. to present a plan of personalized study).

The paper is organized as follows. In the next section sleep indicators in the scientific literature are reviewed. Section 3 analyzes the sensors present in the most popular mobile devices and the possibility of calculating the indicators found in the specialized literature using data from their sensors. As long as the calculation of these indicators involves several issues, in Section 4 some new indicators are proposed. Finally, in Sections 5 and 6 some initial results and conclusions of this work are presented.

2   Sleep Indicators in the Scientific Literature

In the scientific literature various proposals for indicators of sleep and ways to measure them can be found. A priori there are two types of techniques for obtaining the values of indicators: i) subjective tests, where the person fills test questions based on their memories; and ii) objective tests: clinical test where an expert makes some tests in a specialized center, and then fills the test questions. The main advantage of the first technique is that it does not require many resources. Its main drawback is the lack of rigor in the answers.

Many pieces of research about the detection of sleep indicators can be found in the scientific literature. We focused on the most relevant ones taking into account its internal consistency, widespread recognition and use in clinical studies. From all of them, we have chosen the following ones:

-   **Sleep Quality Index (SQI) using test of Pittsburgh Sleep Quality Index (PSQI)** [7]. This test is a subjective questionnaire that assesses sleep quality and disturbances over a 1-month time interval. It consists in 19 questions and has a Cronbach alpha coefficient of 0.83, a sensitivity of 89.6% and a specificity of 86.5%. It makes a very good measurer. The variables used in this indicator are reflected in the Table 1.
-   **Sleepiness test.** Different methods have been proposed to calculate this value, both subjective and objective:
    -   **Sleepiness scale of Epworth** [8]. This test is an instrument used to measure average daytime sleepiness. It consists of 8 questions. It has a high Cronbach alpha coefficient in the range of 0.73 to 0.88.

       o **Multiple Sleep Latency Test (MSLT), Maintenance of Wakefulness Test (MWT) and OSLER test** [9]. The MSLT is an objective test, the people is observed in a room for performing a number of micro-sleeps. The MWT and OSLER tests study the ability of the person to stay awake at a low stimulation. The common variables in all of them take into account the start and end of the sleep period and testing, and their REM periods.

      Table 2 contains the variables used in these tests.

- **Chronotype calculated using the questionnaire morningness-eveningness Horne and Östberg** [10]. This test is a subjective questionnaire to determine morningness-eveningness in human circadian rhythms. It consists in 19 questions. It gets the time chosen by the user to sleep if shall enjoy complete freedom to choose it. In addition, the test also inquires about the periods in which the subject believes it has increased performance and welfare for detect his chronotype. The variables used in this test are presented in table 3.

We made a summary table 4 containing all the variables in a simplified form to facilitate the study of the variables in the tables 1, 2 and 3. Some purely perceptual variables are ignored, such as "Perceived sleep quality user" and the variables that correspond to the same measurements but in different contexts have been unified (for example "Fatigue level after awaking" or "fatigue watching TV", "fatigue sitting, after eating" and similar have been grouped into the fatigue variable). Also in this table is included the relation between the variables and the indicators.

Table 1. Variables in PSQI.

Variables		
1. Bedtime	7. Bad Breath	13. Perceived sleep quality user
2. Fall as sleep	8. Snoring	14. Drug ingestion
3. Rise time	9. Feel cold	15. Somnolence developing a activity
4. Real Sleep duration	10. Feel hot	16. Mood and energy developing a activity
5. Awakes	11. Nightmares	
6. Awakes to the toilet	12. Pains in the night	17. Number of co-sleepers

Table 2. Variables in Sleepiness test.

Epworth	MSLT/TMV/OSLER
1. Fatigue watching TV	1. Start test
2. Fatigue in a public place	2. Sleep start
3. Fatigue as a passenger of a car in silence	3. REM start
4. Fatigue in a comfortable place	4. End test
5. Fatigue sitting, talking to another person	
6. Fatigue sitting, after eating	
7. Fatigue sitting in a car waiting for the traffic	

Table 3. Variables in Chronotype.

Variables	
1. Rise time without obligations	11. Time with maximum performance
2. Bedtime without obligations	12. Level of fatigue at 11 pm.
3. Need alarm	13. Sleeping in an abnormal time, when you awake
4. Easy get up	
5. Alert level after awaking	14. Having guard between 4 and 6 am when sleep
6. Appetite level after awaking	
7. Fatigue level after awaking	15. Time with high performance for physical work
8. Bedtime without liabilities	
9. Physical exercise between 7 and 8 am	16. Physical exercise between 10 and 11 pm
	17. Five hours with maximum performance
10. Time when subject feel tired.	18. Time of day with maximum comfort.
	19. What perception has its own chronotype

Table 4. Variables in tests used to calculate scientific literature sleep indicators.

	Variables	SQI	ST	CT		Variables	SQI	ST	CT
1.	Bedtime	X	X	X	11.	Ambient temperature	X		
2.	Rise time	X		X	12.	Pain level	X		
3.	Fall as sleep	X			13.	Nightmares detection	X		
4.	Awakes	X			14.	Drug ingestion	X		
5.	Phases of sleep	X	X		15.	Alert level			X
6.	Breathing per minute	X			16.	Appetite level			X
7.	Blood Oxygenation	X			17.	Physical exercise & Activity			X
8.	Snoring level	X			18.	Fatigue and concentration level	X	X	X
9.	Noise level	X			19.	Comfort level			X
10.	Body temperature	X							

3   Smartphones and Wearables for Sleep Detection

This section analyzes the calculation of the scientific literature sleep indicators using data retrieved from mobile devices. Table 5 shows the available sensors in smartphones / wearables. This table is the result of the synthesis of data from various websites of manufacturers and known sources like www.gsmarena.com and vandrico.com/wearables. It is important to notice that each mobile device includes only a subset of these sensors, although it is increasingly common to find very complete smartphones and wearables. Some of the sensors, such as UV sensor, GSR sensor or brain also are now strange.

Table 5. Sensors in *smartphones/wearable*.

Environmental sensors	Biometric sensors
GPS	Heart Rate (HR)
Accelerometer / pedometer	Respiration rate
Gyroscope	Saturation oxygen (SpO2)
Compass (magnetic sensor)	Galvanic Skin Response (GSR)
Light sensor	Body temperature sensor
Proximity sensor	Brain sensor
Pressure sensor / barometer	Fingerprint sensor
Temperature sensor	Gestures detector
Humidity sensor	
UV sensor	
Microphone	
Camera	

After an analysis of the variables identified in Table 4 and from data collected by the sensors available in mobile devices, we have compiled Table 6. This table shows the sensors that can be used to calculate the different variables.

Table 6. Sensors used to calculate the variables of sleep.

Variables	Indicator	Sensors
Bedtime/Rise time/Fall as sleep/Awakes/Phases of sleep	ICSP Chronotype	Accelerometer
Breathing per minute/Blood Oxygenation	ICSP	Respiration rate/SpO2
Noise level/Snoring level	ICSP	Microphone
Body temperature/Ambient temperature	ICSP	Body-temp/ Temperature/Humidity sensors
Physical exercise and Activity	Chronotype	Accelerometer/HR/SpO2/ Respiration rate/GPS
Fatigue and concentration level/Comfort level/Alert level	ICSP Chronotype	Accelerometer/Brain sensors/GPS/Respiration rate/SpO2/HR

Subsequently several conclusions are reached:
1. No solution was found to calculate 4 of 19 variables: pain level (12), nightmares detection (13), drugs ingestion (14) and appetite level (16).
2. To answer some of the questions used in the tests, it is necessary to know the context in which they occur. Table 7 shows how to get information about some of these contexts.
3. For the ICSP indicator we can approximate the response of a total of 14 questions, these questions correspond to variables 1-10 and 13-15 present in the table 1. Therefore, only 26% of the test has a subjective character.
4. The indicator of sleepiness both in objective and in subjective versions becomes too complicated to get through sensors. In the first case the importance of the moment of measurement is very high, for example data like "reading" or "co-pilot

is sitting" is very difficult to obtain. In the second case the objective tests have a rigorous execution order that the use of sensors could replace but not in an automatic way.

5. Replacing part of the questions raised in the Horne and Östberg test is also problematic. However, the use of sensors, such as a sensor Brain, would provide answers to 13 out of 19 questions, corresponding to the variables 1-3, 5, 7-10, 12-14, 16 and 18. Only 32 % of the questions could not be calculated.

Table 7. Device utilities used to calculate the variables of sleep.

Context	Indicator	Utilities / sensors needed
Obligations or scheduled tasks, holidays, medicines a day	ICSP Chronotype	Analysis of the user's calendar: it is not an analysis extracted directly from a sensor, it is obtained from the app available in the vast majority of devices
Detection of the use of the alarm / Number of postponed alarms	Chronotype	The analysis of mobile / wearable be provided if there are any active alarm and whether it has postponed

In addition to the previous analysis, there are several applications on the Android and iOS markets for analyze sleep specifically. But We focus on wearables for its advantages in individually collect data and comfortable.

In wearables, we find companies as Fitbit, Microsoft Band, etc. They have applications to collect information through their quantify bands. They provide information on the start and end of sleep, number awakes, time to fall asleep, HR throughout the nigh, and efficiency sleep. All these applications get this information using the accelerometer sensor with actigraphy techniques [11]. These companies have a public API that allows access to the information clearly and automatically.

4   New Sleep Indicators for Education

The results shown in the previous section indicate that total and automatic collection of variables is difficult. At this point we decided to propose our own indicators. The goal is to support learning and education. A main requirement is that they have to be calculated from mobile and wearable sensors data, exclusively, without any active participation by the user. To do it, we try to combine variables of the questionnaires, with sensors and variables generated by sleep analyzer applications. Wrist wearables were selected in accordance to its comfort, profusion and growth potential in the coming years [12]. Sensors selected are: the accelerometer and the HR because they are the more common sensors in wearable devices of the major market actors: Google, Apple, Microsoft, Fitbit and Jawbone. The body temperature sensor is considered important to provide more exhaustive indicators, but currently it is not a common sensor and its use is optional.

4.1 Quality sleep

This indicator uses the 4 fields included in the PSQI. The goal is to provide an estimation of how well the student has slept. The variables are related to the time he has slept, time to fall asleep, the time of awakened, the number of hours actually asleep, the number of times it has awakened and the average body temperature.

The 4 fields are considered under specific sub-indicators. Each sub-indicator is calculated separately and related through constants of relevance. The level of disturbance is discriminated, because it has less data than those present in the PSQI sleep disturbance component. The result is a value between 0 and 100. From this indicator we can estimate patterns of sleep and generate alerts based on the calculated value. Message to the student: "You need to sleep more!"

-   **Sleep Latency**. Time fall asleep.
    o   Range: [t<60, 60-31, 30-16, 15>=t].
    o   Score [0, 1, 2, 3].
-   **Sleep duration**. Time in bed.
    o   Range: [h<5, 5-6.1, 6-7, 7<h].
    o   Score: [0, 1, 2, 3].
-   **Efficiency**. It is the relation between sleep time [light + relaxed] and sleep duration.
    o   Range: [p<65%, 65%-74%, 75%-84%, 85%<=p]
    o   Score: [0,1,2,3]
-   **Disturbance level**. It relates the number of times the person has awakened and the average body temperature, if any of these parameters has no data the result will not be weighted by 2.
    o   Number of awakes.
        ▪   Range: [n>=3, 2, 1, 1>n]
        ▪   Score: [0,1,2,3]
    o   Average body temperature.
        ▪   Range: [t<=30, 30-33, 33-35, 35-36, 36-37, 37-37.5, 37.5<t]
        ▪   Score: [0,1,2,3,2,1,0]

$$QS = 100*\frac{(\frac{3}{10}*LS + \frac{3}{10}*TD + \frac{3}{10}*Ef + \frac{1}{10}*\frac{DL}{2})}{3} \tag{1}$$

4.2 Sleepiness level

This indicator tries to warn the student of a possible state of drowsiness, relaxation and sleep, during hours of study. The accelerometer is used as a pedometer to detect if the user is moving or still in class. If he is moving the value of sleepiness is 0. Otherwise we use the HR (mean values at an interval of 20 seconds) to compare with the average of the HR_minimum detected along the last 15 days overnight. This value corresponds to circumstances of maximum relaxation and comfort. If HR is in a certain threshold the accelerometer is used to know the level of restlessness while sitting. If the person is not walking the HR is checked in the following way:

$$HR \leq HR\_min\_avg \rightarrow S = 1 \tag{2}$$

$$HR\_min \_avg < HR \leq 1.2^* HR\_min \_avg \;\; \rightarrow \;\; S = 1\text{-}(\frac{HR}{HR\_min\_avg}\text{-}1)/0.2 \tag{3}$$

$$HR > 1.2^* HR\_min\_avg \rightarrow S = 0 \tag{4}$$

If the percentage is higher than 0.80, the algorithm checks the accelerometer. If module values of the accelerometer in the last two minutes are less than 0.5, an sleepiness alert will be triggered during this period. Message to the student: "Wake up: You are getting sleep! You may need a break."

4.3   Basic chronotype

This indicator seeks to identify the student chronotype. This can be used to propose an individualized study plan during exams, for example. The hours he has slept/raised taking into account differences between instructional/holidays days and the need to use the alarm clock will be used by the algorithm. The analysis needs at least a month of samples and the result corresponds to the estimated student chronotype. We used part of the questions and ranges in the tests morningness-eveningness. We have proposed a numerical range on questions such as the "needs clock to weak up". The total score is used to get the type of chronotype in Table 8.

Table 8. Score and rank equivalent to chronotype.

Score	Type	Start Sleep	End Sleep
0-4	Definitely evening	02:00-03:00	10:00-11:30
4-16	Moderately evening	00:45-02:00	08:30-10:00
8-12	Neither	22:00-00:45	06:30-08:30
12-16	Moderately morning	21:30-22:45	05:00-06:30

- If the user has needed the alarm clock to weak up during the teaching period.
    o Range: [0%-30%, 31%-50%, 51%-80%, 81%-100%]
    o Scores: [4, 3, 2, 1]
- Difference between the regular time and bedtime on school days.
    o Range: [0-30 min, 31 min-1 hour, 1hour-2hours, 2 hours or more].
    o Scores: [4, 3, 2, 1]
- When the student gets up if he has slept several hours later than usual?
    o Range: [At the same time and he doesn't sleep more, at the same time and he takes a nap, at the same time and he goes back to sleep, two hours later than usual].
    o Scores: [4, 3, 2, 1]
- The student goes to bed later than 6 a.m., what happened?
    o Range: [He sleeps after 6, he takes a nap before and sleep after 6, he sleeps before 6 and takes a nap after, he only sleep before 6].
    o Scores: [1,2,3,4]

5 Preliminary Results and Applications in E-learning

In this section we present the results of our new sleep quality indicator confronting it to Microsoft and Fitbit indicators. We have studied two subjects, one with an irregular profile of sleep and another with a more regular profile, but with abnormal periods.

Fig. 1 shows the efficiency sleep provided by Fitbit (straight line without raises) and our proposed indicator (line with raises and descents) occurs. The result has been generated through an inconstant user in her sleep routines involving days with few hours of rest. Our indicator reflects this behavior, while the indicator provided directly by the device is practically a straight line.

Fig. 2 shows sleep indicator provided by Microsoft. As in Fitbit, he takes very high and very similar values. Our indicator has small descents how result of anomalies in short periods of time. The data used corresponds to a user with a constant pattern but with small anomalies in his number of awakes and his sleep duration on specific days. We can use our indicator to detect values under the average level, and detect for this reason his anomalies in his pattern sleep.

In conclusion and in the absence of more time to validate the indicators, we can say that the results reflect the benefits of our indicator. It provides values more consistent with changes in sleep patterns of both subjects, revealing that the relationship between real sleep and total sleep hours used directly for this wearables is not sufficient.
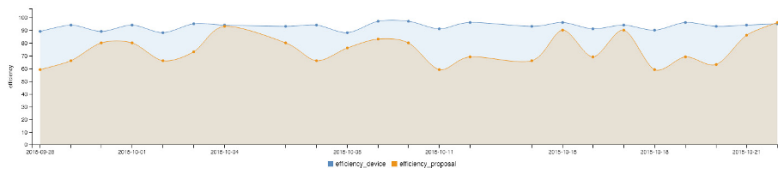
Fig. 1. Comparison chart between Fitbit indicator and indicator proposed.
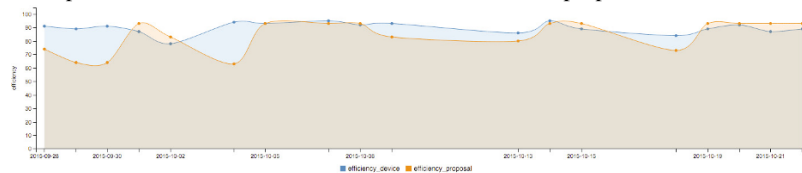
Fig. 2. Comparison chart between Microsoft indicator and indicator proposed.

6 Conclusions

The use of mobile devices to provide sleep indicators is viable to a long extend. The mobile devices usually include some types of sleep indicators, but these solutions are not enough rigorous to support students in educational contexts, for this reason we present in this article news indicators 100% calculated with mobile devices. They can be used to prevent restlessness of students and improve their performance and motivation. You can use the similarity between variables to detect specific sleep patterns and anomalies, inform students of their level of sleepiness in class and use the chronotype to create working groups with similar profiles (to match a high

percentage of hours) or opposite profiles (to work individually and in groups according to the time zone). This project is in the initial stage of implementation and therefore further experiments in test environments will complete this study, but this was postponed for future analysis.

7 Acknowledgment

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Design of a Programming Paradigms Course Using One Single Programming Language

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Abstract. Undergraduate students of a Software Engineering degree must be able to select the appropriate paradigm to solve a problem. They must also be able to know the foundations of concurrent and parallel programming. In the Software Engineering degree taught in the University of Oviedo, both competencies were assigned to the Programming Technology and Paradigms course. In this article, we present the approach we followed in the design of that course to teach object-oriented, functional, concurrent and parallel programming to second year undergraduate students with basic knowledge of Java. Due to the time limitations of the course, the proposed design uses one single programming language besides Java. We describe the most important challenges we faced and how we addressed them.

Keywords: Programming paradigms, functional programming, concurrency, parallelism, object orientation, meta-programming, C#

1 Context

In the Software Engineering undergraduate degree taught at the University of Oviedo, an *objects-first* approach [1] is followed to teach programming in the introductory courses. We use the BlueJ environment in the first programming course, following the object-oriented approach proposed by Barnes and Kölling [2]. In that course, the students learn the basic object-oriented abstractions (classes, objects, methods, fields and built-in types). In the second semester, the Eclipse IDE is used to develop Java applications. That second programming course introduces the concepts of inheritance, polymorphism, dynamic binding, abstract classes, interfaces and exceptions.

A defining factor for many programming courses is the choice of a programming paradigm. Indeed, half of the six introductory course models identified in the ACM/IEEE computer science curricula explicitly refer to a specific paradigm: objects-first, functional-first and imperative-first [1]. The degree mentioned includes a mandatory course, Programming Technology and Paradigms, taught in the second semester of the second year. In this course, two main competencies must be obtained: analyze, design, build and maintain software applications choosing the right paradigm abstractions; and know the basis of concurrent and parallel programming.

There is no other course that introduces a programming paradigm different to object-orientation. Besides, this is the only programming course where parallelism

and concurrency are taught. The course is imparted in the second semester of the second year, with weekly sessions of theory (2 hours) and laboratory classes (2 hours): 6 ECTS credits. This is a new course in the degree; it is not an adaptation of a previous one.

This paper presents the design of a programming course to teach the functional and object-oriented paradigms, concurrent a parallel programming, and advanced programming features such as meta-programming. One of the main challenges was the selection of a single programming language, since the utilization of various languages seemed to be infeasible in the context of the course. Other issues were the definition of the course contents (Section 2), choosing a programming language (Section 3), teaching different paradigms (Sections 4 and 5) and technologies (Sections 6 y 7). Related work is discussed in Section 8 and Section 9 presents the conclusions.

2   Course Contents

These are the course contents and a brief description of each unit:

1. Programming paradigms. The main programming paradigms are described. The students must be able to identify the main abstraction provided by each paradigm, and its suitability for the nature of a programming problem.
2. The object-oriented paradigm. This unit covers advanced elements of the object-oriented paradigm (e.g., generics, design by contract and type inference) not taught in previous courses (Section 4). This unit is also aimed at clarifying the different elements provided by most object-oriented languages (inheritance, polymorphism, dynamic binding, encapsulation, information hiding…)
3. The functional paradigm. Students must be able to design and implement applications in this paradigm, using the suitable elements provided by the programming language (Section 5). At the same time, he/she must be able to compare the functional approach with the object-oriented one.
4. Concurrent and parallel programming. Students must be able to know and apply the basic techniques of concurrent and parallel programming (Section 6).
5. Meta-programming and dynamic typing. Dynamically typed programming languages have influenced the development of software in the last years [3]. Therefore, this last unit identifies and discusses the distinguishing features provided by these languages (Section 7).

3   Choosing a Programming Language

One important decision in the design of a programming course is the selection of a programming language [1]. In this case, the language must provide object-oriented and functional abstractions, concurrent and parallel programming, dynamic typing and significant meta-programming features.

Since the introductory courses use the Java programming language, we first evaluated its utilization in our course. However, Java has some limitations in the way generics are implemented [4]. Its type erasure approach [5] involves some well-known limitations such as not allowing the instantiation of and cast to generic types, the creation of arrays of generic types, overloading methods with generic parameters or the usage of built-in types as generic ones.

Regarding the new functional features added to Java 8, there are some other lacks that prevented us to use it as the main language for this subject. The most important one is that Java 8 does not provide functions (or methods) as first-class entities; instead it provides an automatic conversion of methods to "Functional" interfaces [6]. Java 8 does not provide continuations, lazy evaluation, pattern matching and comprehension lists either.

Another alternative is the use of a functional programming language such as Haskell, ML or Erlang. This approach is ideal for teaching functional programming but it does not cover the advanced features of object-orientation and, with the exception of Erlang, concurrency and dynamic typing. We also considered the approach of using different programming languages, depending on the unit being taught [7]. However, teaching more than one programming language in a 6 ECTS credit course for second year students might be infeasible. For this reason, we discarded this alternative.

We finally chose the C# programming language for the following reasons:

− Object-orientation. C# was created as an object-oriented language with advanced features (Section 4); later it included functional features.
− Functional. C# 3.0 provides functions as first-class entities, lambda expressions, closures, a form of continuations and comprehension lists (Section 5).
− Concurrency and parallelism. Multi-threaded applications can be created with asynchronous message passing and explicit thread creation. Data and task parallelization is supported by TPL (Task Parallel Library) and PLINQ (Parallel Language Integrated Query) (Section 6).
− Dynamic typing, included in C# 4.0 with the `dynamic` type (Section 7).
− Meta-programming features, including introspection, structural intercession and dynamic code evaluation (Section 7).
− Standardization in the ECMA [8] and ISO [9] organizations, and implementations for Windows, Mac and Linux operating systems.
− Widely used in both professional and academic contexts, being in the fourth position of the Tiobe language popularity ranking (September 2015) [10].
− Its syntax is similar to Java, shortening the learning curve of Java students.

Even though C# was the selected language to teach the course, we keep comparing it with Java every time a feature is explained. Therefore, the students learn the new features added to Java8 and strengthen their previous knowledge of this language.

4   Object-Oriented Paradigm

First, this unit strengthens the capability of selecting the basic elements provided by the object-oriented paradigm: encapsulation, information hiding, inheritance,

polymorphism, abstract classes and interfaces. Additionally, new concepts are introduced, such as operator overloading, multiple inheritance, design by contract, generic methods and classes, bounded generics, annotations and type inference.

In the four first laboratory classes, the students must solve programming problems using the object-oriented features of C#, with the Visual Studio IDE. Special emphasis is placed on those C# features different to Java: properties, destructors, partial classes, utility classes, structs, pass by reference, optional and named arguments, implicitly typed local variables, extension methods and nullable types.

5   Functional Paradigm

C# allows us to teach the foundations of functional programming, using a syntax similar to Java –and, thus, known by the students. The success of programming languages that combine the object-oriented and functional paradigms (e.g., Python, Scala and C#) has influenced the design of Java, which includes lambda expressions in its version 8 (JSR 335) [11].

Table 1 shows the correspondence between the main elements of the functional paradigm and the C# features. C# provides *delegates* as types to represent methods and functions (`static` methods). It also provides predefined function types (`Func`, `Action` and `Predicate`) to facilitate the development of higher-order functions. C# also provides lambda expressions that promote to function types. When teaching how C# represents methods, we compare it with Java 8, that uses "functional" interfaces to represent methods and adds the new `::` operator.

Table 1. Correspondence between the main elements of the functional paradigm and C#.

Functional Paradigm	Representation in C#
Functions as first-class entities	Delegates
Higher-order functions	Higher-order functions
Lambda expressions	Lambda expressions
Closures	Closures (functions with references to variables outside their scope)
Currying	Functions must be explicitly curried; operators are not curried
Partial application	Of curried functions (not operators)
Continuations	With the `yield` reserved word (generators)
Lazy evaluation	Does not provide a lazy argument passing mechanism, but `yield` can be used to return collections that are lazily evaluated (generators)
Pattern matching	Not supported
Comprehension lists	LINQ (Language Integrated Query)

When lambda expressions refer to variables outside their scope, the environment is also stored in the function, making up closures. The main difference between C# and Java is that variables in the store are mutable in the former and immutable in the latter.

Neither methods nor operators provide implicit currying. However, methods can be explicitly curried by implementing them as methods that return other methods. Every

explicitly curried method can be partially applied. C# provides the `yield` keyword to support generators: collections that are evaluated lazily. C# does not provide pattern matching. Comprehension lists are provided with a specific sugared syntax defined for LINQ.

A typical exercise in functional programming is the development of a `Map` higher-order function. Figure 1 shows one possible implementation in C#. `Map` is a generic extension method that is added to any collection in the .NET framework: `IEnumerable`. That interface is part of the API; extension methods allow adding method to existing classes without modifying their source code. `Map` receives another function as a parameter (`func`), which is applied to all the elements in the collection. Since the `return` statement uses the `yield` keyword, the collection returned is evaluated lazily. Each time an element of the collection is used, the execution of the `Map` function is restored from the previous `yield`. Therefore, the function returns only those elements in the collection that are actually used.

The `Magnitude` method computes the modulus of a vector ($\sqrt{x_1^2 + x_2^2 + \cdots + x_n^2}$) using the widely known `Map` and `Reduce` (`Aggregate` in .NET) functions [12]. The parameters are two lambda expressions: the first one computes the square of each vector coordinate; the second one sums all the values in the collection. Notice that C# infers the types of the parameters in both lambda expressions.

```
static class HigherOrder {
  static IEnumerable<TDest> Map<TSrc,TDest>(this IEnumerable<TSrc> collection,
                                            Func<TSrc,TDest> func) {
    foreach (var item in collection) yield return func(item);
  }
  static double Magnitude(IEnumerable<double> vector) {
    return Math.Sqrt(vector.Map(item => Math.Pow(item,2))
                   .Aggregate((acc, root) => acc + root));
} }
```

Fig. 1. A `Map` higher-order function used to compute the magnitude of a vector.

As shown in Table 1, the main limitation of C# is that it does not provide pattern matching. We use F# (the .NET implementation of ML) to discuss this feature. Once the students understand the functionality of pattern matching, we describe an exercise to provide a similar functionality in C#, using polymorphism, dynamic binding and higher-order functions, following the Functional C# approach [13].

6 Concurrency and Parallelism

In the Software Engineering degree mentioned, there is not a specific course on concurrency and polymorphism. The degree follows a crosscutting approach to teach these topics in different courses [14]. The present course is the first that teaches the basic concepts and programming elements. Then, an Operating Systems course describes concurrency and parallelism topics from the operating system point of view. Algorithms is another course that requires the understanding of basic concurrent

programming. Finally, a Distributed Systems course applies these topics to the development of distributed applications.

The proposed course first introduces the basic concepts of process, thread, concurrency and parallelism. Then, concurrent applications are developed using the C# asynchronous message passing and explicit thread creation mechanisms [15]. One of the programming exercises is the concurrent computation of vector magnitudes. The number of threads is gradually incremented, and each configuration is executed with one to four cores. Execution time is measured and represented in a graph similar to Figure 2, displaying the execution times for different threads in a 4-core CPU.

The obtained data is used for different purposes. First, it clearly shows the benefits of parallelism, and its dependency on the number of cores. Then, the cost of context switching is discussed; analyzing that execution time with 43 or more thread is higher than with fewer threads. Finally, the thread pooling mechanism implemented by the .NET framework is also explained.
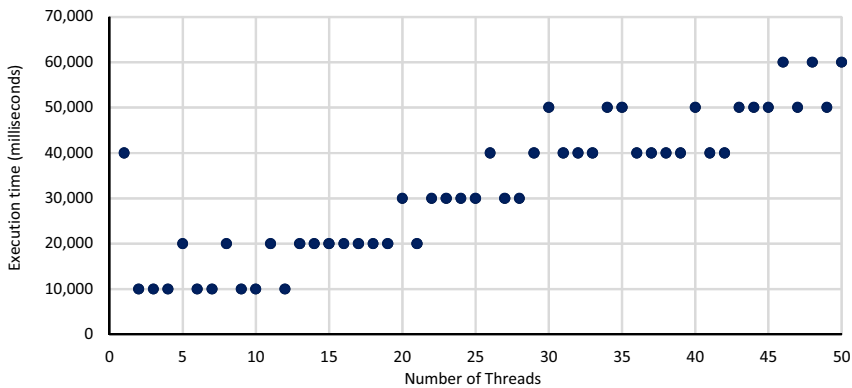
Fig. 2. Execution time of the concurrent computation of vector magnitudes, incrementing the number of threads in a 4-core CPU.

Then, we teach task synchronization mechanisms, race conditions and how to avoid them with mutual exclusion. The problem of detecting and avoiding deadlocks is also discussed. These concepts are explained with an imperative object-oriented approach.

We also discuss the benefits of functional programming –referential transparency, particularly– for algorithm parallelization [12]. The absence of side effects makes parallelization easier. This fact is first shown with the use of TPL, which provides data, task and pipeline parallelization using the functional paradigm. We also use the PLINQ library to show how the functional paradigm can provide a high-level declarative power to parallelize data processing.

Figure 3 shows an example use of PLINQ to parallelize the computation of vector magnitudes. The `Select` and `Aggregate` methods are the .NET versions of the classical `map` and `reduce` functions [12]. The `AsParallel` method analyzes the number of cores of the current CPU and the LINQ query to declaratively parallelize its execution. If it is not safe to parallelize the query, PLINQ just runs it sequentially.

```
static double Magnitude(IEnumerable<double> vector) {
  return Math.Sqrt(vector.AsParallel()
            .Select(vi => vi * vi).Aggregate((vi, vj) => vi + vj));
}
```

Fig. 3. Parallel computation of vector magnitudes with PLINQ.

We measure the runtime performance benefit of the parallel version compared to the sequential one. A discussion is established, concluding that the operations performed in parallel require very little CPU time. Afterwards, the code in the lambda expressions is modified to perform more CPU-intensive operations. The performance benefit of the parallelization is increased, as stated in the Amdahl's law –which is then introduced to the students [16].

Throughout this unit, we introduce the Java syntax of those C# features that are also provided by Java. Particularly, we explain how to create, run and synchronize threads, and the fork / join framework [17].

7 Meta-Programming and Dynamic Typing

In the last unit, we describe the meta-programming features provided by most dynamic languages that allow the development of runtime adaptable programs [18]. Different discussions about the differences between statically- and dynamically-typed languages are established.

C# 4.0 includes a new `dynamic` type to postpone type checks until runtime. Therefore, C# provides both static and dynamic typing, facilitating the comparison of both approaches with the very same programming language [29]. The `dynamic` type is first used to explain *duck* typing [14] and multiple dispatch (multi-methods) [20].

The different levels of reflection are defined [21], showing C# examples about introspection, structural intercession and limited behavioral reflection [22] with `DynamicMetaObject`. Figure 4 shows how fields (`Name`, `Surname` and `Birthday`) and methods (`GetAge`) can be added at runtime to an `ExpandoObject`, using the limited intercession services provided by C#. The example also shows how the `dynamic` type provides duck typing, avoiding the need to use introspection.

In this unit, we also introduce attributes (annotations in Java) and how the programmer can create his/her own custom attributes. Then, using introspection, another program analyzes the attributes of an existing assembly (or itself). As an example, we develop a simple testing framework that inspects a library and executes all the methods annotated with the `Test` attribute. After execution, the number of failed and succeeded asserts are shown.

Finally, dynamic code evaluation is discussed. This is another important feature used for meta-programming. We use the CodeDOM library to dynamically generate and evaluate C# code [23]. Figure 5 shows an application asking for the body of a function receiving a double `x` parameter. The user can write any C# code to express the function body. Then, the program generates a new function with the body provided by the user, invokes that function with the values specified in the `From`, `To`

and `Increment` text boxes, and displays the returned values (right window in Figure 5).

```
class Reflection {
  static void Main() {
    dynamic person = new ExpandoObject();
    person.Name = "John";
    person.Surname = "Doe";
    person.Birthday = new DateTime(1973, 8, 7);
    Func<int> getAge = ()=>(int)(DateTime.Now-person.Birthday).TotalDays/365;
    person.GetAge = getAge;
    Console.Write("{0} {1} is {2} years old.",
                  person.Name, person.Surname, person.GetAge());
} }
```

Fig. 4. Structural intercession in C#.
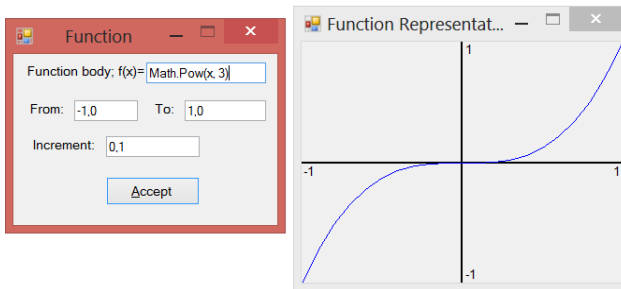
Fig. 5. Dynamic code evaluation.

8   Related Work

There exist different computer science courses aimed at introducing the main programming paradigms. The Programming Paradigms course of Stanford University is one example [7]. This course is available online and, at present, there have been more than 29,000 students enrolled. The contents include an introduction to programming paradigms, the imperative, object-oriented and functional paradigms, concurrent programming, and advanced memory management features. The programming languages used in this course are assembly, C, C++, Scheme and Python.

Another example course is the Paradigms of Computer Programming course by the Université Catolique de Louvain (UCL) [24]. That course covers functional, object-oriented and declarative dataflow programming. They use the Mozart system that implements the Oz programming language [25]. Java is also used to teach the object-oriented paradigm.

The online C# Programming Paradigms course taught by Scott Allen [26] uses C# to introduce a variety of programming styles. It includes object-oriented, imperative

and functional programming. Differences between statically and dynamically typed programming are also covered. Language Integrated Query is another topic of this course.

The Programming Paradigms course of the Chalmers University of Technology (Sweden) describes the main programming paradigms [27]. The course covers imperative, object-oriented, functional, concurrent and logic programming. Different programming languages are used, including C (imperative), C++ (object-oriented), Haskell (functional), Erlang (concurrent) and Curry (logic).

9   Conclusions

Teaching the object-oriented and functional paradigms, plus concurrent and parallel programming in a second-year 6 ECTS course of a Software Engineering undergraduate degree is an important challenge. Due to the important time limitations (28 hours of theoretical classes, plus 28 laboratory hours), we decided to choose one single programming language. After a thorough analysis, we finally selected C#. We taught advanced features of the object-oriented paradigm, common elements of the functional paradigm, foundations of concurrent and parallel programming, and the main distinguishing features of dynamic languages. Throughout the course, the Java features similar to C# were introduced to the students, extending and strengthening their previous knowledge of the Java programming language.

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Data Mining in Academic Databases to Detect Behaviors of Students Related to School Dropout and Disapproval

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Abstratct. This work focuses on data mining in relational databases, aiming to detect behaviors related to school dropouts and disapproval by mapping the factors that influence this dropout. This work is relevant by the fact that the dropout and school disapproval are big factors of concern to all who care about education in Brasil. At the end of it, we intend to point out the need to implement solutions that enable access to results dynamically, thus allowing educators can early diagnose the causes of school dropout and disapproval, and allow for relevant pedagogical actions. This way, we intend to reduce the school dropout and school disapproval, towards a more efficient teaching and learning process at brazilian federal education institution named Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte - IFRN.

Keywords: School Dropout, School Disapproval, Educational Data Mining, Machine Learning, Teaching and Learning.

1 Introduction

The problem of dropout and school failure in federal institutions has generated some challenges to overcome. The high incidence related to these factors, it has been lived in the practical experience of all educators that make education in these institutions. It is known in advance that school dropout and school disapproval are associated with factors such: areas of knowledge of students, educational levels and specific methodologies of teaching and learning. Therefore, it is intended in this work, apply data mining techniques in the academic data base in order to map the factors that are associated with dropout and school failure.

The data spectrum used for evaluation or analysis was not restricted to the academic system database, but also the survey forms applied at the institute, filled in by students and teachers at the end of each school year. This fact allows for a more comprehensive analysis because it involves multidisciplinary teams, with important additional aspects, such as the knowledge acquired by the teaching staff with the interactions with students and their parents, and knowledge acquired by teachers through the school activities with students.

In the context from multidisciplinarity, the information acquired, can represent both an element of support in the teaching-learning process as well as provide sources of information for the continuous monitoring of results obtained by data mining, both by the system specialist, as by the application domain experts. Furthermore, this information can be very important in building models that can be the basis for actions to be taken by the teaching staff and education managers in order to avoid or reduce dropout and school failure.

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the Project Scope UID/CEC/00319/2013. This paper aims to map factors that may be associated with dropout and school failure through machine learning techniques and data mining, with the purpose, allowing proactive actions to stimulate the students, aiming the continuity of students in their respective courses, and thus it can mitigate the risks related to dropout and school failure.

2   School Dropout and Disapproval

The problem of school dropouts in Brazil is not a recent problem, but rather a repeat offender. It is one, of the factors, that concerns educators and public policy makers in our country. According to the Ministry of Education (MEC), school dropouts reaches 6.9% in primary and 10% in high school (3.2 million children and young people, according to data of 2005). There are over 2.9 million students [14] who leave school a year and return the next, thickening other disturbing content: the level-age distortion.

According to [11] [6], school dropout is what happens when a student fails to attend school and is characterized early school leaving, and is historically one of the topics that is part of the debates and analyzes of public education. Several factors can lead to school dropout. Among them, teaching-learning misapplied by inadequate methodologies, ill-prepared teachers, social problems, neglect by the government, and so on.

Historically, one of the first works to systematize the dropout of the problem in Brazil was conducted from a national commission established by Ministry of Education (MEC). The Special Commission for the Study of Dropout in Brazilian universities came within an institutional assessment thread context, defined by indicators of the Institutional Evaluation Program of Brazilian Universities (PAIUB), directed by different educational institutions, specifically the public [14].

Studies prior to this, particularly in the second half of the 80s, emphasized only statistical surveys and case studies in a fragmented way, carried out by the Ministry of Education initiative and public universities. However, these studies did not develop the problem in order to create institutional policies, estimates, administrative and pedagogical actions, that is, side dishes needed to minimize the results [14]. This initiative was a first joint effort of different public higher education institutions (HEI) to systematically organizing a study that defined a single methodology in order to identify causes and possible solutions to the problem. The ultimate goals of this committee was to clarify the concept of avoidance, examine the rates and causes of this phenomenon and standardize a methodology to be employed by the institutions.

The development of the Commission's activities grasps also that, the predominant causes of dropout were with three rows. The 1st related to students, the 2nd related to courses and institutions and the 3rd, the more conjunctural order, called "socio-cultural and economic variables". This last is related to the labor market, social recognition of the chosen career, the quality of primary and secondary education, socio-economic context and government policies. [14]

In studies of the Special Commission for the Study of Dropout [18], we also find research on the performance of European universities and North American in a time series from 1960 to 1986. In this research, the best university system yields was found in Finland, Germany, Netherlands and Switzerland while the worst results occur in the United States, Austria, France and Spain. According to research, the United States dropout rates in the last 30 years are around 50%. A similar number is in France where rates in 1980 were 60 to 70% in some universities. In Austria, in turn, points to a 43% dropout rate, with only 13% of students complete their courses within the time limit [14].

2.1.   School Disapproval at the Federal Institutions Network

The term failed means censored, criticized, condemned, as the word failure means disdain, criticism, contempt. Now the meanings of expressions already reveal by themselves the implications. However, a trivial excuse to justify the act of reproving is that the student spend another year in that series, seeing again the contents that could not assimilate, will be more successful, even in his academic life. This is a great fallacy, because the student who repeats a school year lose motivation, is the embarrassment of being again in that same school year, either by living with smaller colleagues with different interests [12].

To [10], the rejection is now widely questioned. After all, making students repeat the entire year to see the same content again is an outdated solution, dresser, expensive and inefficient. Countries with high-quality teaching and learning found alternatives that work better, through preventive action, such as booster classes throughout the year. In Finland, teachers are advised to devote more time to students who have more difficulties. Result: the failure rate is 2% and the primary education completion rate is 99.7%. In Hong

Kong, when a teacher has more than 3% of students with low performance, a committee will evaluate the teacher's work.

Data released in accordance with [17], Brazil is one of the countries most disapprove. In high school the rate reaches 13.1%. Are almost $ 3 billion / year spending beyond what is necessary, only in the final years of schooling. The worst is that, as shown in qualitative and quantitative research, there is great relationship between repetition and dropout. No wonder that the study recently published by the "Education for All" shows that only 54% of young Brazilians manage to graduate from high school up to 19 years. Of young people between 15 and 17, one in five still in elementary school, accumulating failures. And 15.7% dropped out, certainly after school failure experiences [17].

The fact that the school failure influence school dropout, justifies the importance of the study of these topics.

3   Data Mining in Databases

The constant technological advancement has enabled the rise of technologies such as the internet, social networking, mobile devices, virtual learning environments, sensors to collect different types of data, telecommunication systems and secondary memory for greater storage capacity. Those are some examples of features that are making possible the creation and growth of numerous databases of administrative, scientific, commercial, educational, governmental and social [9].

However, the amount of stored data is closely linked to the ability to extract knowledge of the highest level from them, that is, useful information that will serve to support decision-making, and / or operation and better understanding of the phenomenon that generate data [8] [9].

However, the large amount of data analysis by man is impossible without the aid of appropriate software tools. Thus, it becomes essential to use tools that help man the task to analyze, interpret, and relate these data, so you can prepare and select action strategies in each application area [8] [9].

Therefore, to meet this context, there is an area called Knowledge Discovery in Databases (KDD), which is attracting in recent years, considerable interest among the scientific and industrial communities [9].

3.1.   Data, Information and Knowledge

Every moment in this work, we are talking about data, information and knowledge. Therefore, it is important to note the differences between data, information and knowledge [8].

- **Data**: they can be interpreted as elementary items, captured and stored by the information technology resources. They are strings of symbols and do not have semantics (ie, meaning). Its purpose express real-world facts in order to be treated in the computational context.
- **Information**: the information represents the processed data, with well defined meanings and contexts. For example, the monthly borrowing capacity is a calculated information from the income and monthly expense of each client. In this case, the debt indicates a percentage value as a financial client can contract loans in relation to their monthly income.
- **Knowledge**: knowledge corresponds to a standard or set of standards whose formulation may involve and link data and information. Knowledge can be represented in the form of a conditional rule (IF <condition> THEN <conclusion>). Another way to represent knowledge is through predictive trends.

3.2.   KDD Definitions

The term KDD was formalized in 1989 in reference to the broad concept of seeking knowledge from databases. One of the most popular definitions was proposed in 1996 by a group of researchers [5]. An adaptation of the original definition is shown below:

Definition 1: KDD is a non-trivial, interactive and iterative process to identify patterns understandable, valid, new and potentially useful from large data sets.

- The term *interactive*: It indicates the need for human action as responsible for process control. In fact, there are usually two human actors involved: the **data analyst** and **domain expert**.
- The term *interactive*: it suggests the possibility of full or partial repetition KDD, in the search for satisfactory results by successive refinements.
- The term *non-trivial*: warns of the complexity normally present in the execution of KDD processes.
- The term *identify patterns*: according to the definition, the purpose of performing the KDD process is to identify patterns. A standard is a knowledge representation in the syntactic rules in some formal language.
- The term *understandable*: one of the objectives of the KDD process is to produce knowledge that can be understood easily, thus allowing a clear understanding of the data that gave rise to this knowledge. One possible technique to accomplish this is to present the patterns in a graphical manner that facilitates their understanding.
- The term *valid pattern*: it indicates that knowledge should be true and appropriate to the context of the implementation of KDD.
- The term *new pattern*: a new standard to add new knowledge to previously existing knowledge in the application of KDD. The question of a standard found to be dependent on the new point of view in the scope of the KDD process or in the user's scope.
- The term *useful pattern*: a useful pattern is one that can be applied to provide benefits in the context of application KDD. Namely, the discovered patterns are useful only if they help to achieve the goal of domain expert.

The patterns extracted in the KDD process can be classified into two basic types: **descriptive** and **predictive** [8].

- **Predictive patterns**: they are constructed in order to solve a specific problem to predict the values of one or more attributes, depending on the values of other attributes.
- **Descriptive patterns**: the centerpiece of descriptive patterns is to present interesting information that a specialist application domain cannot yet know.

A standard describes facts (and trends) associated with a data set, with any degree of certainty. Therefore, the KDD process presupposes the existence of a data set. This may involve n attributes, thus representing a hyperspace (n-dimensional space). The greater the value of n and the number of registers available, the larger the dataset to be analyzed [8].

The representation of the degree of certainty with which the standards describe a collection of data is essential to determine how much a system or user can trust these patterns and make decisions from them. In general, the calculation of the degree of certainty of a standard involves several factors such as, for example, data integrity, the sample size used in the process, the existence of some knowledge on the field of application, among others [8].

Definition 2: KDD process consists of a sequence of complex interactions, which extends over a certain period of time, between a 'user' and a collection of data, possibly aided by a diverse set of computational tools [3].

In the definition 2, data analyst is always present and intimately involved with every step of the process. The term heterogeneous set of tools corresponds to the KDD system used by the analyst.

[3] and other authors claim that the interaction of the analyst with the data leads to the formulation of hypotheses about them. The **data analyst** view the data as a whole and decide where to explore based on what he sees in his own experience and knowledge provided by the domain expert. Recently, this type of professional is known as **data scientist**.

3.3. Related areas to KDD

This is a multidisciplinary area and there are already for a long time and originated from several research areas such as **Statistics**, **Machine Learning**, **Pattern Recognition**, **Computational Intelligence** and others.

- **Machine Learning:** one step in KDD process, the extraction of patterns (or data mining), uses machine learning methods (ML) to find regularities, patterns or concepts in data sets. Techniques developed in ML, as the rules of induction and decision trees, connectionist models and learning based on instances, form the core of the methods used in data mining.
- **Statistics:** statistics, together with the Machine Learning area, is considered ancestor of the KDD area. Pattern recognition techniques and exploratory analysis of data from the statistics are widely used in data mining algorithms. Data selection and sampling, pre-processing, data processing and evaluation of extracted patterns are just a few examples of methods widely used in statistics and which are applied during the process of KDD.
- **Database:** A database is an integrated collection of data, organized in a way to facilitate efficient storage, as well as its modification and recovery [4]. It is usually managed by a Database Management System (DBMS), which corresponds to a collection of procedures and mechanisms for recovery, storage and manipulation of databases.
- **Data Warehousing:** Data Warehousing is another area related to the KDD process, and refers to the process of collection and pre-processing of data stored in one or more operational databases in order to serve as a source for Decision Support Systems. As a result of this process we have a Data Warehouse, a collection of integrated data, consolidated and possibly organized in time (historical data).

3.4. KDD Activities

Activities in the KDD area can be organized into three main groups: activities related to technological development, KDD process execution activities and activities involving the application of results obtained in the process of KDD [8].

- **Technological Development:** covers all design initiatives, development, improvement and optimization algorithms, tools and assistive technologies that can be used in the search for new knowledge in large databases.
- **KDD Execution**: refers to the activities related to the effective pursuit of knowledge in databases.
- **Application of Results:** has been achieved models of useful knowledge from data set, activities are focused on the application of the results in the context in which it was carried out the process of KDD.

3.5. Clustering Algorithm and Analisys Services

The Microsoft Clustering algorithm is a segmentation algorithm provided by Analysis Services software. The algorithm uses iterative techniques to group instances in a set of data clusters that contain similar features.

The Microsoft Clustering algorithm, provides two methods for creating clusters and assigning data points to clusters. The K-means algorithm, a "hard clustering" method. This means that one data point can only belong to a cluster and that one probability is calculated for associating each data point that cluster. And the method of Expectancy Maximization (EM), a flexible clustering method. This means that one data point always belong to multiple clusters, and a probability is calculated for each combination of data point and cluster.

You can choose the algorithm to be used by setting the parameter CLUSTERING_METHOD. The cluster standard method is the evolutionary EM.

In EM cluster, the algorithm iteratively refine an initial clustering model to fit the data and determine the probability of a data point exists in the cluster. The algorithm terminates the process when the probability model fits the data. The function used to determine the fit is the probability of log data according

to the model. If empty clusters are generated during the process or the combination of one or more clusters is below a certain threshold, the clusters with low populations will be propagated again in new points and the EM algorithm will run again.

4   Data Mining Application in IFRN Database

Are applied data mining techniques on the basis of data available, to detect which the attributes that are most influencing school dropout and thus draw a profile of the factors that imply the school dropout. It is known that some factors that influence school dropout, are external to the school environment, such as relationships with parents, dysfunctional families, and so on, plus the profiled here can be used along with other factors in order to have a more precise analysis of the problem in question.

First, we did a historical overview about school dropout in IFRN, 2000 to 2013. Figure 1 shows the percentage of dropouts. The graph in Figure 1 shows that for the campus Natal-Central, in 2000 the dropout rate was 20.26%, in 2001 was 43.23%, in 2005 was 34.63%. It is observed that the dropout percentage at Natal-Central campus is always above 15% and in some years more elastic. Without a doubt, it is a high rate, and worrying, and it deserves a detailed study of it. However, it has other data that also deserves to be noted. It is the cancellation of enrollment in courses of federal education network.
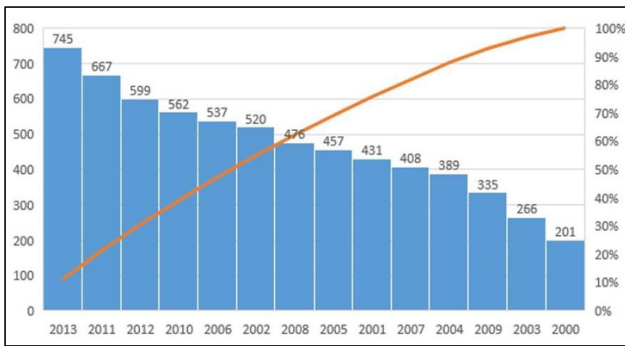
Fig. 1. Graph showing the percentage of school dropout per year at Natal-Central campus of IFRN in years 2000-2013.

Figure 2 shows the evolution of cancellation in enrollment and dropout on campus Natal-Central, between the years 2000 and 2013. In Figure 2, if we analyze the situation for 2007, we have the total of students who canceled their enrollment in courses was around 240, and the total number of students who dropped out of courses was around 650 students. If we add the two factors we have 900 students who dropped out of their courses in that year of 2007. Therefore, the registration cancellation rate must also be taken into account in the assessment of the teaching and learning.
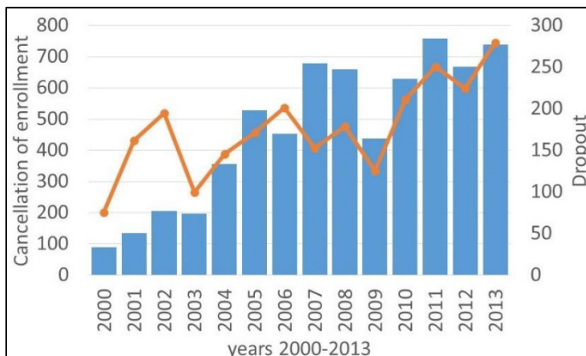
Fig. 2. Cancellation of enrollments at Natal-Central campus of IFRN in years 2000-2013.

Table 1 shows the failure percentage per subject in 2010. It was done in a filter data to show only percentage of failure from 40% to 60%. Then see that many disciplines have very high failure rate. And as was said earlier, the failure rate has implications for the dropout because often may discourage the student to continue on the course.

Based on the data shown in the graphs of Figure 1 and 2, we have the proof of the high failure rates and dropout in IFRN, campus Natal-Central. Therefore, it will be applied to the same data set, some of Data Mining algorithms in order to find something to do in the attributes of the database, you can trace a profile of failure situations and dropout of our students.

Table 1. A sample of the failure rate in some disciplines in IFRN for 2010.

Discipline	Year	Retention	Students	%
Practice as Curricular Component	2010	17	34	50
Foreign Language - English	2010	22	44	50
Work Psychology	2010	63	127	49,61
Algorithms and Object Oriented Programming	2010	58	118	49,15
Differential Equations	2010	20	41	48,78
Conservation of energy	2010	17	35	48,57
Web Authoring	2010	228	473	48,2
Techniques of Food Laboratories	2010	66	138	47,83
Cell Biology	2010	18	38	47,37
Informatics I	2010	61	129	47,29
Differential and Integral Calculus II	2010	80	170	47,06
Environmental Biology	2010	23	49	46,94
TCP/IP Architecture	2010	37	79	46,84
General Chemistry and Experimental I	2010	79	170	46,47
Electrical Systems	2010	26	56	46,43
Soil Mechanics	2010	117	252	46,43
Biology	2010	45	97	46,39
Data structure	2010	24	52	46,15
Open Systems Administration	2010	29	63	46,03
Elements of Physics	2010	89	195	45,64
Optical	2010	26	57	45,61
Electricity	2010	232	509	45,58
Digital electronics	2010	81	180	45

Figure 3 shows a network obtained by the application of decision tree algorithm, using the tool Analysis Services [16] [10]. For this network training was provided as predictive attribute the situation of the student and the other attributes were defined as input attributes to the algorithm. Also in Figure 3, we can see the attributes that influence school dropout. So we can draw a profile for school dropout, analyzing each of these attributes.

The attribute "type of home school", can take the walloons private or public and philanthropic school. The attribute "income" is the family income of the student, the attribute "efficiency coefficient" measures the performance of the student in the course, and attributes "media" and "faults" represent the academic performance of students. The attribute "entry way" indicates how the student entered the course (ESMS, take selection, transfer, and so on).

We will use the cluster algorithm for grouping students with similar characteristics in the same group, and then analyze each cluster to identify the degree of influence of each input attribute shown in Figure 3 in relation to the predictive attribute "Status = Dropout".
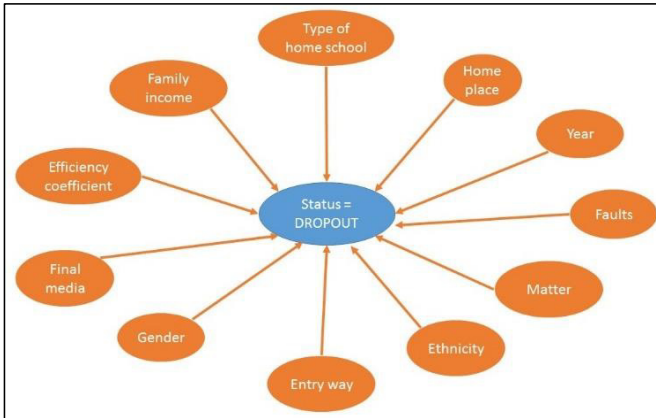
Fig. 3. Network Decision Tree showing the relationships between attributes. Tool used to create the chart was Microsoft Analysis Services [16] [10].

Figure 4 shows the graph generated by the cluster algorithm of Analysis Services tool. Cluster chart shows that the highest concentration of cases of dropout, are precisely those with the most intense blue color. For this ran was selected in the cluster algorithm configuration, the situation of "Dropout" and the clusters with fewer cases of dropout, are those with a less intense color.

Thus, the cluster 5, the darker blue color, means that it is having the largest number of dropout and the cluster 1 has the lowest number of cases of school dropout. Cluster 1 has the highest number of approved.
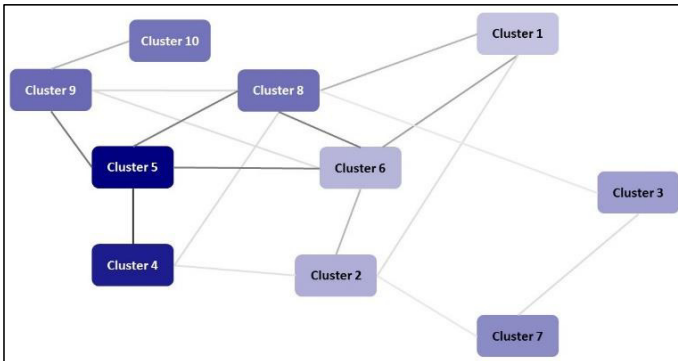
Fig. 4. Cluster chart. Tool used to create the chart was Microsoft Analysis Services [16] [10].

Let's look at the cluster 1 and 5 to see which were the input attributes that influence the composition of them. Figure 5 shows the cluster 1 characteristics, which is concentrated the largest number of approved. Figure 6 shows the characteristics of cluster 5, which is concentrated the largest number of dropouts.

The cluster 1 shows that the profile of successful students are those with final average above 70, GPA above 60, coming from public school, live with their parents and brown ethnicity. Observing the cluster 5 characteristics: it is clear that in cluster formation 5, family income (up to 1 salary) and the situation (deprecated), appear as factors influencing school dropout. Justifying thus the presence of these attributes in relation attributes that influence school dropout, as shown in Figure 3.
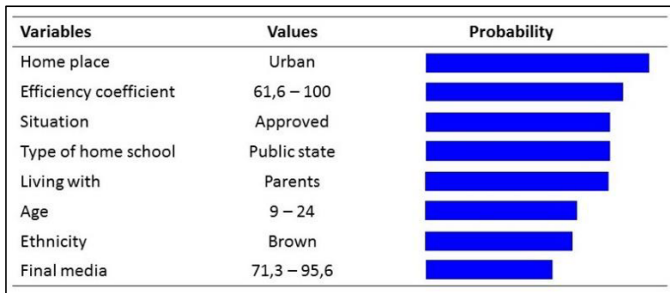
Variables	Values	Probability
Home place	Urban	
Efficiency coefficient	61,6 – 100	
Situation	Approved	
Type of home school	Public state	
Living with	Parents	
Age	9 – 24	
Ethnicity	Brown	
Final media	71,3 – 95,6	

Fig. 5 Cluster 1 characteristcs. Tool used to create the chart was Microsoft Analysis Services [16] [10].

Variables	Values	Probability
Home place	Urban	
Situation	Repproved	
Situation_ING	Dropout	
Type of home school	Public state	
Living with	Parents	
Gender	Male	
Ethnicity	Brown	
Family income	Up to 1 min. wage	
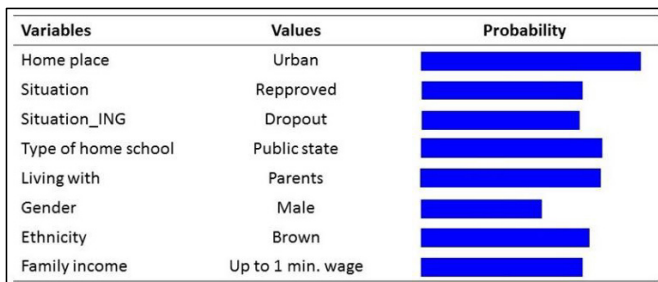
Fig. 6 Cluster 5 characteristcs. Tool used to create the chart was Microsoft Analysis Services [16] [10].

5   Results and Conclusion

Based on the obtained results show that the dropout rate at Natal-Central campus is quite high, above 16% for the years after 2010. Another finding, very important, that until then, no one had noticed, is the index registrations canceled the courses. If we add the dropout index with the index of canceled registrations, we will have an index above 25%. If we observe that, the IFRN has around 5,000 students, 25% of 5,000 = 1,250 students who dropped out or canceled their registrations annually.

Analyzing the graphics obtained by the data mining algorithms, at first, one can trace a profile for school dropout as being: students from state schools, with family income up to one minimum wage, living with parents consequently, they are unemployed or are minors, of mixed race, with the final and very low yield coefficient. It is known in practice that students entering the public schools come IFRN, arrive with knowledge far from desired in basic subjects such as mathematics and portuguese, which are fundamental to have a good performance in those courses. These students face many difficulties to subjects that contain logic, advanced abstraction and or mathematics such as the technical disciplines of technological area.

Based on this layout profile, one can suggest that the IFRN, Natal-Central campus, adopt some preventive measures to minimize both tax dropout, as school failure. Among them, one can cite:

- The result of the analysis should be shared with all staff of the IFRN, so everyone has knowledge of the actual situation;
- Propose the development of outreach projects, to work with the new students the basic knowledge of portuguese and mathematics;
- Making an analysis of the data of the selection tests in order to predict the actual situation of students in the target disciplines (mathematics and portuguese), to have real numbers that lag in these disciplines and thus make plans and goals to create booster classes in matters in which the incoming students have more difficulties.

These are just some of the goals that will be proposed this preliminary study, however, will be continued in the analysis of the academic system data and certainly more knowledge will emerge, and these

managers IFRN will be passed, so that action can be taken that, will reduce the problem of dropout in our school.

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PHABRIKA: teaching financial techniques to sell through Serious game

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Abstract. Starting in the 50's, aiming to empower financial executives, the games have evolved to help in-company teaching. The need to empower employees to carry out their tasks and teaches them about the company's culture has made several corporate universities adopt this methodology. In this context is presented a serious game in order to allow the sales executive to experiences a financially management of a company. It facilitates learning how to sell using financial techniques in a dynamic way. This sales philosophy is a gap in a globalized world where the high added value solution suppliers can differentiate themselves from the competitors. To provide this result phabrika simulate a corporation where the executive go through different management situations in a controlled environment without businesses risk. The game is based on theoretical concepts of games, simulations and accounting, assuming game evolution and corporate universities history. Throughout the game and its conclusion the participants will be able to learn and improve their sales skills.

Keywords: Phabrika, Serious game, financial techniques to sell, business games

1 Introduction

From the 80's corporate universities have been widely adopted by companies as fast and efficient teaching method. The concern of companies to develop and coach their employees as well as disseminate information at all levels resulted into the usage of a learning environment abroad schools and universities.

Epistemological games is one of the tools used by universities. Begun around 1924 [9] had its origin as an evolution of education based on the industrial revolution. This game category combines entertainment with educational values [22], being able to disseminate knowledge and develop skills [11].

One of the areas addressed by the business games is accounting, responsible for generating information for decision making. This valuable information is to be used by sales executives, when financial sales techniques used, thereby addressing the maximization of profit and the reduction of taxes [16].

The key role in the success of any business is sales that's why is also in the focus of enterprises to be trained, improved and developed skills in this area [8]. Essential features for sales executives must be worked by the companies, however

these techniques are known and widely applied. The sales executive must be able to understand your customer in all aspects including financial, for the manner in which the sale takes place will influence customer profitability [16].

Considering these aspects the PHABRIKA game is presented as a serious game to facilitate Sales Executive to learn financial techniques sell. The purpose of this article is to describe the theoretical foundations that formed the basis for the development of the game.

2   Corporate University

The need for training and development of personnel brought about, in the 19th century, a movement of creation of training programmes. At this point, focused on recently-hired young on themes such as optimization of business results. In the same century, with the advent of the railroads, the first training centres came to being [4].

The evolution of these training centres gave way to corporate universities. They were created to improve professional competencies and cover the existing deficit from a faulty traditional educational system [4].

Aiming to be a centre for training, improvement and development, corporate universities are responsible for teaching professional routines and procedures to each and every employee. However, it is not limited to technical aspects, as it also teaches the culture and the values of the company [4]. Corporate university does not only include internal training, as extension courses may be offered to the market through seminars or other platforms [4].

Within this context of professional teaching and corporate universities, usually different teaching methodologies apply, such as Celemi international consultants, who offers courses aimed to turning ordinary students into business people.

There are also simulations in metaphorical contexts (different companies or factories) to avoid the participant use technical or industrial know-how, so they do not stray away from the main focus of learning [2].

Based upon this concept, the book "The Accounting Game" [17] creates a specific learning experience for the teaching of concepts in basic accounting. Information is imparted through a fun and relaxing game, which allows the reader to interact and discover everything in a simple way. The book offers the reader the experience of managing a lemonade stand. Making use of a game, it teaches the basic language of business and specific concepts.

3   Digital games and education

The existence of over 2300 classified serious games shows the growth of this kind of game, with 60% of these ranked Business Games to attest for the importance of this niche [7]. The adoption of these serious games by companies show the constant search for the development of their professionals [1].

Many of these are focused on the evolution of the old management model, considered outdated for not being efficient, where top management has other following their strategic command [21]. Always taking into consideration that the growth of organizations rely on the retention and development of staff on all organizational levels.

These games are based on theoretical currents that seek to understand the various educational methodologies. Some focus on studies of teaching for the business environment, while others focus on the teaching of new professionals. It may be summarized and analyzed in light of the various theoretical approaches that seek to explain the teaching and learning processes in companies and other environments.

3.1   Business Games

Games that aim to enhance managerial abilities or evaluate the performance of the player are called Business Games. In a risk-free environment, it allows for learning in practice [2], avoiding costly financial losses due to a bad decision [1].

Business games are simplified mathematical abstractions of a situation related to the business world [19]. These games may also be regarded as simulations as they present an environment similar to the original one [7, 13].

These simulations are functional representations of reality, in an abstract, simplified or accelerated way in the process, yet still offering a behaviour similar to the original system's [7]. As they are copies of elements of reality, they may be based on dynamic and creative models, becoming more effective and offering accelerated learning [2].

The participants in business games are involved - individually or in groups - to run a fictitious company or a part of it, through sequences of decisions [3]. The high level of realism encourages the player to reflect upon his or her actions, allowing for the improvement of his or her abilities to communicate, decision-making, etc [10].

The main aims of these simulations are to hone leadership skills, decision-making, communication, work and risk analyses during crises [10], preparing leaders to take on new challenges. However, they may be used with other aims, as games help during the learning process [2].

To keep the student focused on his or her development, there must be a system of continuous feedback focused on the development of the learning of pre-established objectives [19]. This bilateral communication system stimulates the student and shows improvements in the learning process. Immediate feedback may be offered [11], with a view to influence following decisions, or at the end of the process [18].

Feedback at the end of every stage or at the end of the game, through a feedback session, improves the learning experience of the student [7]. Through this session the student gets an opportunity to consolidate the experiences and show the value of the theory acquired relating it to the practice of the experience. At this time it is possible to share feelings and impressions between participants

and instructor, directing results towards the desired aims [10]. This consolidation, which may be an oral or a written summary, allows the player to reflect upon their own actions and feelings [11].

At this stage there must be a breaking down of the facts, to let go of steam, tensions, perceptions and attitudes of the participants during the experience. After decompression, there must be a review of what has been learnt, allowing the player to understand what he or she has achieved, consolidating and integrating the content [11].

At the end of the game there must be an analysis and conclusion of learning, establishing relationships between learnt content and the game, creating reflections and conclusions on the experienced shared. When the game is related to reality, there must be caution as oversimplification of the model may lead to a greater distancing from reality and, therefore, from the desired conclusion [11].

3.2   Serious games

Business games are a kind of serious games. These are games, adapted to modern times, where there is an environment to think outside the box to take education to different levels, as they are epistemological [9]. These games allow the players to face dilemmas and develop skills [22]. The main attributes of the serious game are challenge, feedback, and immersion [18]

Many educational games are simulations where players are challenged with situations that become games. Serious games are based on simulations of the themes and problems to be covered, allowing an innovative approach and the search for solutions [22].

Games are fictitious, hypothetical situations based on rules, aiming to train. Simulations are based on real models [3], simplified models of a representation of reality. The boundary between games and simulations is blurred. When there is a combination of features of the games with reality elements in simulations, then they are called simulation games. These present the features of games based on reality models [11]. These are either simplified models of reality or hypothetical, where the player performs competitively or cooperatively, based on rules and actions [11].

However simulation rules must be clear to be understood by all participants. Therefore visual aids must be employed throughout the simulation [6]. So, satisfactory results may be obtained with the use of serious games in the training of seasoned sales staff [9]. Part of the fun in games is to play by the rules, even if in some cases rules tend to be more complex and demanding than the rules and practices of a job [22].

Many professionals carry out tasks that are hard to standardise and continuously meet challenges beyond their scope. These challenges may not be exactly the same twice, therefore the methodology for resolution will not necessarily follow the same steps and procedures. So, at a globalized time, with professionals action on a global scale, professional training games may help players to think, speak, and work outside the box [22].

In Sales, innovation may be a decisive point in the closing of a deal. The sales person, other than being a technical consultant, must also be a financial advisor, thinking through sales financial solutions [16]. A serious game, in order to teach financial solutions, must offer players an innovative way of looking at reality as it is.

3.3   Adaptive games

Decision-making is the essence of many games. In strategy games, for example, you must be aware of the expected result at every move. However, when all variables are known, some decisions become vital, but not catchy [1].

For this scaling, artificial versions of human abilities must be used. Therefore, Artificial Intelligence (AI) methods may be employed. However, it is not necessary to use cutting edge AI technology for the game to be catchy - it is possible to create this environment without the implementation of AI [5].

Nonetheless, the adoption of AI seeks to offer pleasant challenges to the player, and not just help him or her increasing the fun factor. As a result, there is a game cut out for the player [12].

Adaptability may be achieved simply with the addition of random elements, rendering impossible a wholly integrated strategy [1]. Games without a random element to them tend to not vary much. However, such necessary variation may occur with the introduction of different scenarios or autonomous agents - NPC: Non-Player Character [7].

Among different AI techniques used in games, the decision tree model is quite effective. Through binary responses, it is capable of choosing the subsequent action [15]. Through a compact architecture, it allows simplicity in the interpretation and editing of logic [5].

Although traditional Logic is only capable of processing binary values, there are situations where intermediate values are needed, a state of "maybe" [15]. With the added value of offering a grey area between black and white, Fuzzy Logic may be adopted [5]. When properly employed, it demonstrates very human-like decision-making [5].

One application where human expertise does not follow a linear logic is the financial market. With decisions based on various indexes and rates, several logics are used to simulate the market. Most information is based on financial indexes calculated according to the balance sheet of each company.

4   The company's financial structure - The Balance Sheet

The balance sheet is the financial control of a company [17]. With it is possible to measure the "financial health" of a company, through control of the asset situation of the company during a period of time [14]. However, it reflects only a specific period in time [23, 20]. Understanding the influence of every financial aspect of the company on profit, as well as the cycle of the money, has its place

6   PHABRIKA: teaching financial techniques to sell through serious game

[17], as accounting information of a company seek to, through the wealth of information provided, aid the decision-making process [23].

The balance sheet is the representation of the financial situation of a company at a given time [17]. It aims to show the asset situation of the company considering certain evaluation criteria [14].

For a better analysis and standards for comparison, they usually feature over a year's revenue in parallel columns [20]. On the left hand side of the balance sheet, by convention, there are the assets [17], that is, goods and rights expressed in values [14, 20]. These are the items responsible for the generation of wealth [23].

Fixed assets are purchased assets unlikely to be converted quickly into cash. They are used in the maintenance of the company, or merely for the existence of the business. Examples of fixed assets include buildings, equipment, cars, machinery, production lines, etc. [14].

Many times these assets have a limited shelf life and may, therefore, be sold for a different amount than they were purchased. In cases where the sell goes for a value superior to the asset's, there is a proportional reduction in the assets and an increase in net worth, due to this profit [14]. When the sale is carried out for amounts smaller than what was invested in its acquisition, there is a reduction in assets, and this value is added to the cashflow or accounts receivable [14].

When the asset stays with the company for a longer period of time, the invested value, in accounting, is split throughout its estimated shelf life, instead of just being accounted for during acquisition, doing away with the instant expense. This procedure is known as depreciation, which is the transformation of part of the acquired value into expense. This procedure must be adopted because usually the asset will not be sold for the same amount it was acquired. This procedure exists to reduce the value of the asset in accordance with estimated usage and obsolescence [17].

Depreciation is an expense without expenditure of cash [17], as it transforms the money invested in the acquisition of an asset in expenses in installments. The number of installments is calculated according to the estimated life span and the residual value that may be fetched with its future sale. However this calculation is an estimate, as its actual productive life span may differ from the asset's durability [14].

On the right hand side of the balance sheet, by convention, there is the liability [17]. These represent a company's financial obligations [23]. In a simplified way, these are Accounts Payable, Suppliers, Payroll, Taxes, Loans [14, 20].

Both sides of the balance sheet must be evened out [17]. Difference between assets and liability is called net equity [14]. This calculation maintains the basic principle of accounting, where the value of the assets equals the sum of liabilities and net worth [23].

Revenue is value added to asset that refers to either a service rendered or the sale of merchandise. In some situations revenue may happen either with the reduction of liabilities [14], or the rentability of a financial investment [23].

Acquisition of material lowers the amount of cash at the company's disposal. However, it may be acquired over time, in which case it is counted as liability, keeping both sides of the balance sheet evened out without alteration of the cash value [14].

In Brazil, the transfer of merchandise is subject to taxation. Among them, ICMS taxes the buying and selling of products, being integrated in the final selling price of the product. At the end of the fiscal period, companies pay the Treasury the difference in taxes over trade. All taxes paid upon the acquisition of goods that are recoverable upon final sale (PIS, COFINS, IPI in some instances) are accounted the same way [14].

Analysis of the balance sheet shows in a simplified manner the general state of the company. When a deeper analysis is required different aspects of the business must be observed. Although some financial indicators in a single balance sheet may yield interesting data. Analyzed data allow for a comparison between companies' performances over time [23]. However, the use of financial indicators are only one way of analyzing and following the financial health of a company.

5   Phabrika

The universal language of business in decision-making must be used by the sales force. To sell successfully, you must speak about the total cost of the property, return of investment, financial pay-off, analysis of value for money and contribution to profit [16]. However you must have experience and knowledge of the entire scope of the client to approach these subjects.

Considering the importance of financial techniques in sales [16], based on the theory presented thus far, the aim of this game is to turn finances and financial techniques user friendly for the sales force.

With the elaboration of a serious game that allows the sales person to live the financial experience of a company, simulating various different managerial positions (financial, production, sales, purchasing), adopting a role according to the problems to be tackle by each one of them [6].

So there is the PHABRIKA game, a dynamic and interactive teaching proposal of financial sales techniques. Set in a virtual environment (Fig. 1) , developed in Game Maker, it presents a simulation of the realities of a company, aiding in the association between game and the work environment. In this game, players are challenged to a series of decision-making, in a simplified way, on all levels of an organization. Playing the role of a recently hired manager, the player must take decisions in different areas in the company, such as production planning, raw material purchase, production and storage of the final product, as well as sales.

The game is made up of two levels, each featuring the same main routines. Each level takes five years, where the player must take decisions with a view to future results. On the first level the player will have a fixed sales margin and will not face any outside competition, only so he or she can learn the basics of

8   PHABRIKA: teaching financial techniques to sell through serious game
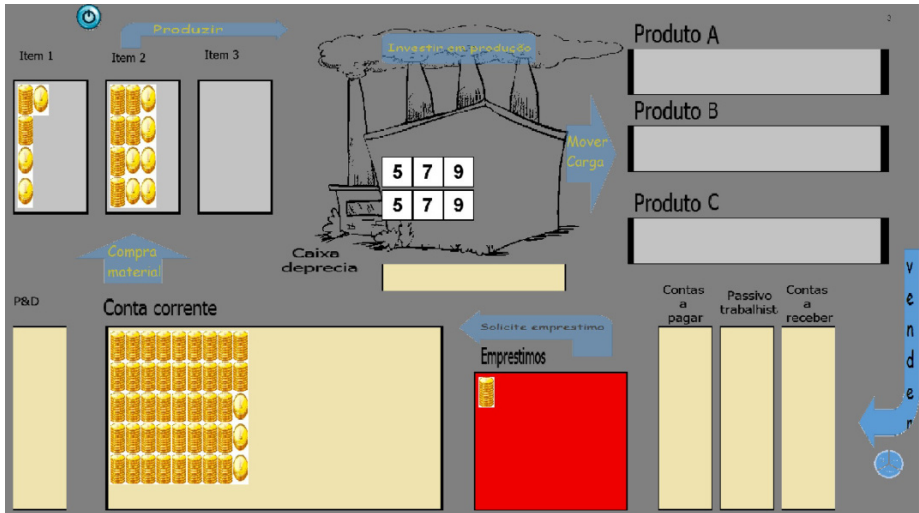
Fig. 1. PHABRIKA's board

the game and its routines. On the second level sales margins will not be fixed, with competition generated by NPC.

Routines are divided into early in the year, quarters and end of the year. Early in the year the player must carry out the financial planning of the company, and may ask for a loan from the bank. The bank may grant total, partial or no loan, giving the client feedback on their decision. Then the player may invest in a new production line, either for a new product or to increase capacity.

Quarterly routines are repeated four times throughout the year. They begin with the movement of the final stages of production for storage of the finished product, followed by the player going to the shop where he or she can purchase raw material. Finally there is production, simulated by the addition to the products of production costs. Production is a monthly routine.

At the end of each year the end of the year routines are carried out, beginning with payment of interest over loans, followed by the option of paying up the debt totally or partially. Then production lines are depreciated.

With a view to simulating Brazilian taxation, the player must pay the government a third of his or her profits. Finally the player takes over the financial role of the company, carrying out the accounting. At this stage the player understands the impact every investment has on profit, as well as learns basic financial concepts and their jargon.

On the second level the player is presented with the customer needs and their yearly costs. These requests are selected by a specialist system based on a graph of demand for products available to the player. However, these products are also available to their NPC competitors.

PHABRIKA: teaching financial techniques to sell through Serious game   9

If the NPC wins the bid, the player may choose a different bid. If the player fails to deliver the expected quantity, he or she is subject to a contractual fine. This fine will be calculated at the end of the year, alongside delivery of the products.

At the end of five years the player gets an assessment report on his or her performance against previously established results by different players. This report aims to aid the wrapping of the activity. There will also be a grade awarded according to financial indexes considered.

With the purpose of assess the method proposed an observation model was used with a sales team of four. Prior to the experience was conducted with the attendees a questionnaire to measure the knowledge of the group about the subject. After it was conducted a session of 2 hours included an explanation, playing the game and after game conclusion. A week after was conducted another questionnaire to compare the evolution of the knowledge of the group. The group was divided in two pairs to be possible a comparison between them. In the conclusion part was consolidated the content and collected the feedback of the game an asked for their feedback.

6 Conclusion

The game aims to provide the player with experience in financial aspects of the company, providing information and consolidating opinions, in a practical way, allowing for a later group discussion. The series of decision-making the player is exposed to makes him or her responsible for their own learning, catering for a motivational environment.

To take full advantage of the game, a later discussion with participants on the decisions taken and actions that influenced profit positively and negatively, in the short and long term. This consolidation is of the utmost importance, as the main objective of any company is to maximize net profit, and not increase revenue [16].

During the game, decisions may be taken that may lead to major losses and subsequent bankruptcy of the simulated company. However these mistakes must be seen as learning steps, as they were made in a safe environment, avoiding their recurrence outside of the simulation.

This consolidation aims to facilitate the building of concepts of financial sales techniques, so they are rooted in each and every sales person, to allow them to act routinely as business consultants, rather than traditional sales people.

The experience allows the sales executive an understanding of how production costs, the weight of investments in production lines and their relationship with profit, also outlining the differences between sales of products and services.

The observation make possible the validation of the model and the feedback of the players help to improve the playability. The game jointly with the feedback improve substantially the knowledge level of the players.

10   PHABRIKA: teaching financial techniques to sell through serious game

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Education challenges in a hyperconnected society based on the national survey #ConnectedYouthBrazil

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Abstract. This paper presents in its introduction, considerations regarding the strong contrasts and the huge necessity of human values reconfiguration in all activities due to the hyperconnected contemporary society. Both authors are part of School of the Future – USP Research Laboratory. Considerations regarding students self-perception and their comprehension on teacher's digital literacies are shown based on a previous research they conducted, entitled "#ConnectedYouthBrazil Research". The study mixed quantitative and qualitative methods, which included survey, Internet monitoring (E-Meter), in-depth interviews and focus groups. The results here presented help to keep the discussion about the reshaping of education in Brazil in the agenda to enlighten its future.

Keywords: Digital Literacies, Education Challenges, Students, Teachers, #ConnectedYouthBrazil Research, School of the Future – USP Research Laboratory.

Introduction

It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us, we were all going direct to heaven, we were all going direct the other way - in short, the period was so far like the present period, that some of its noisiest authorities insisted on its being received, for good or for evil, in the superlative degree of comparison only. (Dickens, 1985, p. 35) [1]

The words of Charles Dickens regarding the 18th century revolutionary period in France were used to describe the moment we are living now, the spring of the digital age, by Prof. Waldomiro Vergueiro in his foreword in the "Handbook of Research on Comparative Approaches to the Digital Age Revolution in Europe and the Americas". According to the author, it is a time of marvelous promises, but it is also a time of vailed threats [8]. What will happen to freedom of thought? What will happen to

privacy? What will happen to dialogue in the digital environment? (Vergueiro, 2015, p.xxii).

Prof. Dr. Fredric Micahel Litto, Emmeritus Professor at School of Communications and Arts, a seminal American / Brazilian researcher on Information and Communication Technology (ICT) in Education and founder and president of ABED – Association of Brazilian Distance Education also considers technology as a controversial development as he states:

[8]…It cannot be denied that the advent of the computer, and the digital processing it requires, was one of the most important conquests made by humans—the first machine capable of executing more than one type of task, and, in its present stage of development, whether it is sitting on a table, held in the hand, used on the body, or even adhering to one's skin—conflating, as it does, the operations of a typewriter, a calculator, a telephone, a television, a phonograph, a modem, and a Global Positioning System (GPS). It supports one's work, study, entertainment and social communication, and it is increasingly ubiquitous. But, for all that, like many phenomena in the complex contemporary world, it brings with it both benefits and drawbacks. Seen principally in its manifestation allowing the operation of the World Wide Web, considered by many as a major public good, the critics of the web decry it as an "ecosystem" which falsely promises greater democracy. While applauded for increasing an "open culture" (see, for example, www.openculture.org), with considerable potential for the redistribution of power in society, digital culture, its detractors complain, tends increasingly to be closed and to concentrate power and wealth in the hands of a few, not necessarily the same persons who repeatedly, in times past, were the most benefitted (Litto, 2015, p.xxvi).

On the other hand, we may find some authors that recognize the revolutionary Internet DNA and the centrality that digital technology plays in contemporary life, considering its recent developments as Internet of Things (IoT) and Big Data to name a few. Researcher and philosopher Luciano Floridi, Director of Research and Professor of Philosophy and Ethics of Information at the Oxford Internet Institute considers the influence ICTs are having on our world [2,4] and he poses questions as: who are we, and how do we relate to each other? Hence Floridi proposes that technology constitutes the fourth revolution drawn by Alan Touring's work following those led by Copernicus (geocentrism), Darwin (evolution of species), and Freud (psychoanalysis) [3]. He has also coined the concept of "Onlife" stating that it makes no sense anymore to consider "offline" once the majority of the occidental culture is wired and this connection defines the way we shop, work, learn, care for our health, entertain ourselves, conduct our relationships, interact with the worlds of law, finance, and politics, and conduct war in a hyperconnected society.

Another major effort dealing with the reconfiguration of human life and activities due to the digital technology and the Internet is United Nations Educational, Scientific and Cultural Organization (UNESCO)[1] proposal of MIL - Media and Information Literacy to embrace every shape of media and other information providers as libraries, archives and museums [15]. Media literacy and Information literacy are traditionally seen as distinct fields, but UNESCO joined both together, consolidating a

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[1]   UNESCO.   Available   in   http://www.unesco.org/new/en/communication-and-information/media-development/media-literacy/mil-as-composite-concept/.

set of vital competences (knowledge, skills and attitudes). These literacies (regarding information and media) are a fundamental condition to freedom of expression, once it enables citizens to understand mass media function and other information providers, in order to critically evaluate contents and make decisions as users and content producers. Therefore, UNESCO is disseminating the urge to introduce MIL as part of curricula of both formal and non-formal education, in all levels to initial years to university. Special attention should be devoted to develop guidelines for teacher qualification, to allow the interaction among literacies, learning procedures and new pedagogic methods and curricula.

2. School of the Future Research Laboratory – USP (EF–USP)

School of the Future Research Laboratory[2] (EF–USP) at the University of São Paulo – Brazil, was founded in 1989, committed to contribute to the improvement of education in Brazil through the better understanding of ICTs impacts in formal and non-formal learning and teaching environments. EF–USP has developed a partnership model involving university, society and different research funding agencies and government spheres to fund action - research projects. To better understand the complexity of the contemporary hyperconnected society and the strong asymmetries on the distribution and access to the digital technology, in 2007 the Digital Culture Observatory was established. Emerging concepts as MIL focusing on literacy as a set of social practices [10]; the empowerment of connected actors to behave differently and act both as consumers and producers of knowledge; and the experience of new forms of authorship and protagonism in today's connected society [9,11,12,13].

3#ConnectedYouthBrazil: Methods and Main #Education Findings

#ConnectedYouthBrazil Research [5] was developed by three institutional actors: funded by Telefonica Foundation and developed by Brazilian Institute of Opinion and Statistics (IBOPE) responsible for the national data survey and EF–USP for the analysis and final report. #ConnectedYouthBrazil Research aimed to investigate four dimensions regarding: social behavior, education, activism and entrepreneurship. In order to do so, main players decided to adopt a blend of quantitative and qualitative methods as:
• A survey interviewing 1,400 respondents aging between 16 and 24 years old and from different social backgrounds in the whole country;
• Internet monitoring (E-Meter – an IBOPE E-Commerce solution) authorized by ten users during 30 days. Installed on their computers, E-meter allowed to map Internet user navigation patterns along the day. After the Internet monitoring period, the participants were interviewed online in order to identify the reasons behind the mapped behavior;
• Six focus groups, three online and three "face-to-face" with seven to nine participants. Conducted by a moderator and a previous quest discussion intended to go beyond the survey's first results analysis;

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[2] More information about School of the Future Research Laboratory at the University of São Paulo – Brazil available in http://futuro.usp.br/.

• Individual in-depth interview with eight content specialists aiming at recognizing their points of view, based on quantitative data collected in the present study.

This paper explores the education main results of the original research and some tables are presented, followed by our analysis.

3.1 #Education: Internet Uses at Schools

Considering the most recent data on Internet devices at Brazilian schools as ICT Education 2014[3], there is stability in the proportion of Internet access among public and private schools in urban areas [6]; reaching 93% and this fact helps to explain the intense utilization of Internet among Brazilian youth.
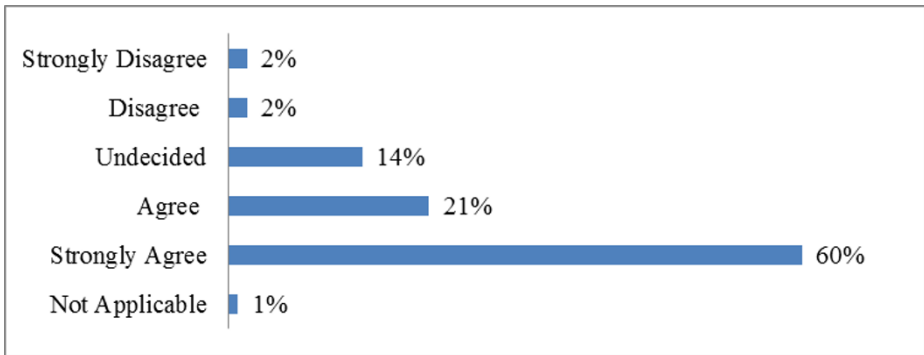
Fig. 1. Internet Access Makes Homework Easier. Source: #ConnectedYouthBrazil Research.

For 81% of respondents it is easier to do homework using Internet. Only 4% disagree and strongly disagree about this facility.
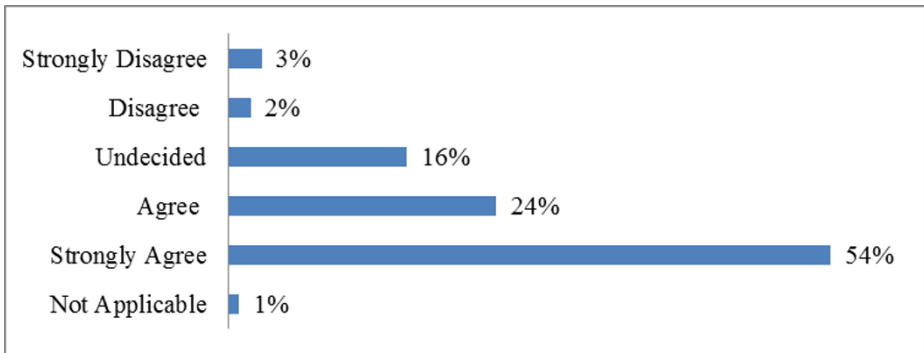
Fig. 2. Internet Improves Performance on Tests and Self-Evaluation (Public Tender, University Admission and Others). Source: #ConnectedYouthBrazil Research.

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[3] ICT Education 2014 Research is conducted since 2010 by Brazilian Internet Steering Committee (CGI.br). Available in http://cetic.br/pesquisa/educacao.

Almost 80% of the respondents believe that Internet also allows them to better perform and self-evaluate for exams and tests.
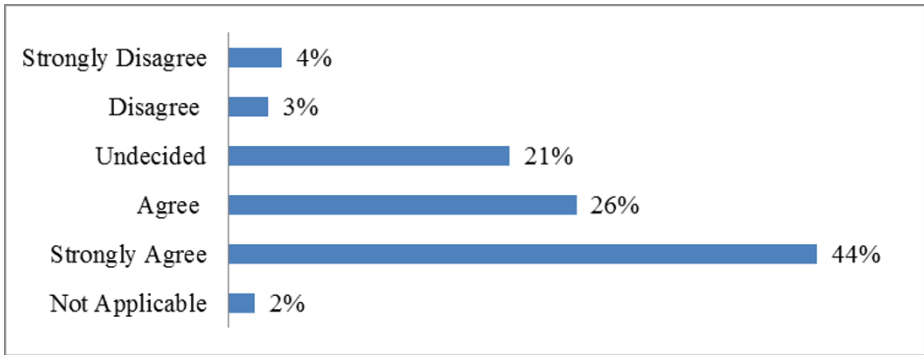
Fig. 3. Internet provides learning according to my rhythm and is more suitable for place and time. Source: #ConnectedYouthBrazil Research.

For 70% of respondents, Internet provides access to learning according to the student's needs. On the other hand, for almost 30% of them it is not the case.
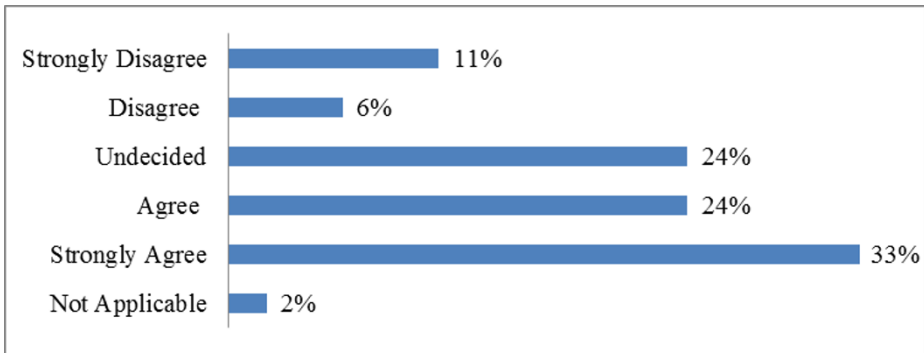
Fig. 4. Internet disrupts learning. Source: #ConnectedYouthBrazil Research.

It is interesting to note that, at the same time the majority states it is easier to do homework using Internet, 57% of respondents agree or strongly agree that Internet disrupts learning, when students face distraction caused by social networks and games. Although there are very positive aspects about technology use for learning, contradictions have been also noted, such as illustrated by the next graphs.
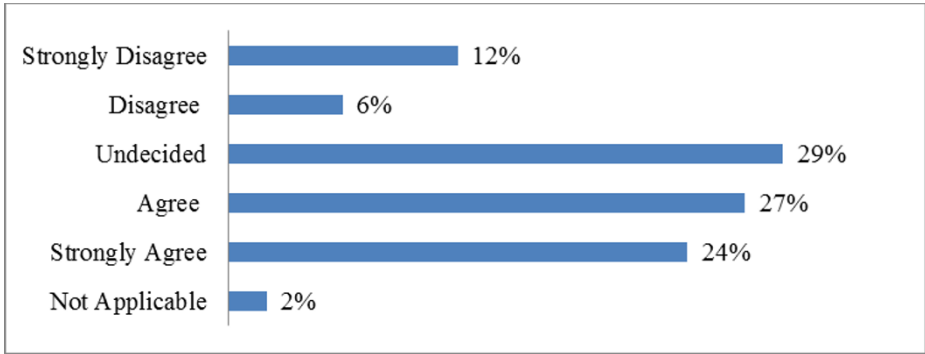
Fig. 5. Internet has too much information and hampers best content selection. Source: #ConnectedYouthBrazil Research.

Slightly more than half of respondents (51%) agree or strongly agree that Internet has too much information and the excess makes the process of selecting best content more difficult. We can not deny there is also almost the same amount of respondents that disagree with this statement.
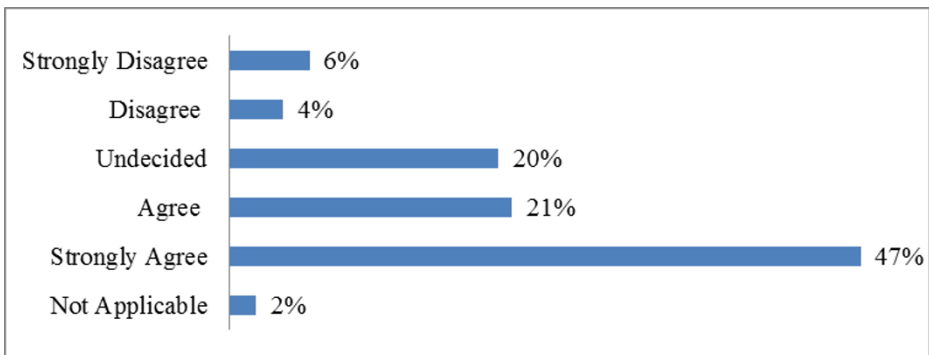
Fig. 6. Young people learn more with traditional classes than with distance education. Source: #ConnectedYouthBrazil Research.

For 68% of respondents, they learn better in traditional education than through distance education. Such data so far reveal their self-perception of advantages and challenges. On the other hand we can notice that, besides using Internet for educational purposes, they still want to have their traditional face to face contacts with teachers.
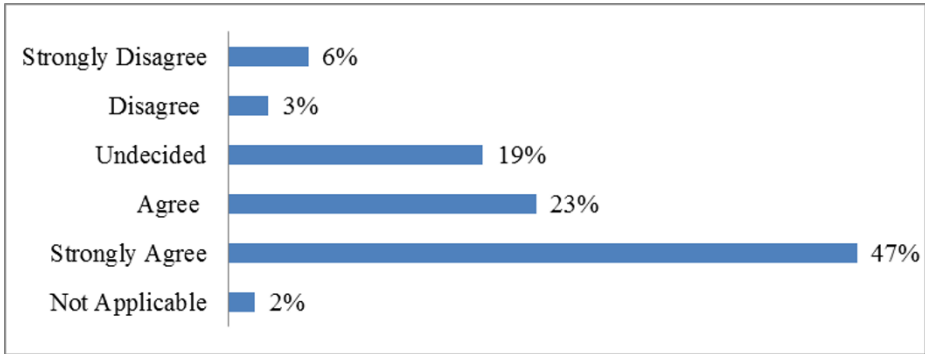
Fig. 7. A good teacher knows how to use the Internet and ICTs to help students learning. Source: #ConnectedYouthBrazil Research.

#ConnectedYouthBrazil Research also included the youth perception on teachers' competence regarding MIL. Many respondents valued the teacher's knowledge regarding technology tools. For 70% a good teacher knows how to use the Internet and ICTs to help student learning.
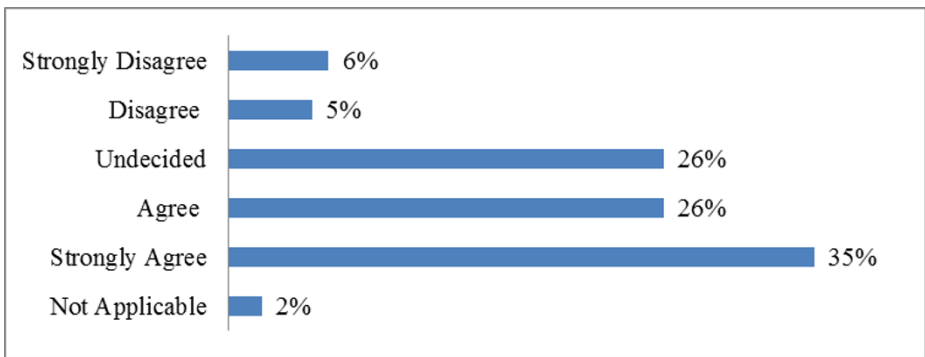
Fig. 8. Internet improves the relationship between students and teachers. Source: #ConnectedYouthBrazil Research.

Internet, especially social media, is capable of interfering in the relationship between students and teachers. Curious to note that 26% is undecided, the same number (26%) agree that Internet improves the relationship between students and teachers. And 35% of respondents strongly agree with this issue.
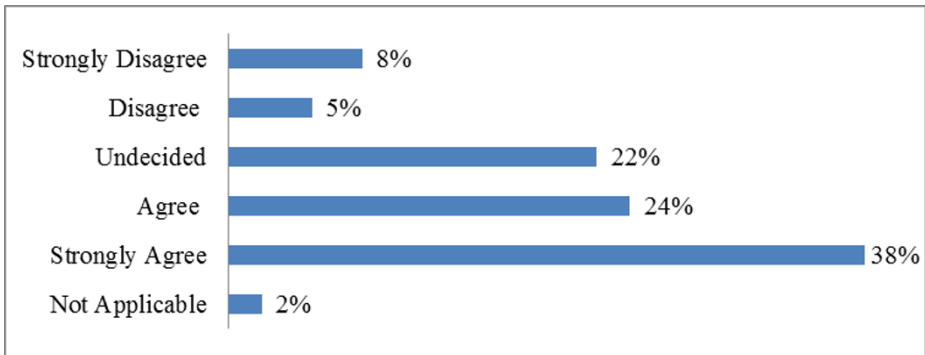
Fig. 9. In the future, with the Internet, teacher will be more a guide to studies. Source: #ConnectedYouthBrazil Research.

More than half of respondents (62%) agree or strongly agree that, with the Internet, teacher will be more "a guide on the side than a sage on the stage". In fact, the teacher's role has been debated facing the technological advancement. In his book "Grown up digital", Don Tapscott points out that young people are remaking every institution of modern life, from politics to education [14]. The author lists some of the ways in which it is occurring, but it is noteworthy to observe that, in education, youth is "forcing a change in the model of pedagogy, from a teacher-focused approach based on instruction to a student-focused model based on collaboration" (2009, p. 11).

That is why most of respondents believe a good teacher knows how to use the Internet and ICTs to help students' learning and he is online taking part in social media, through an Internet that can improve the relationship between students and teachers. The transition from a teacher-focused approach based on instruction to a student-focused model based on collaboration reveals a shift in both students and teachers roles.

4   Final Considerations

This paper aimed to present Brazilian youth perception both on themselves as Internet users and their perception on teacher's competence regarding MIL. According to the results here presented, youngest people believe that Internet access makes homework easier; enhance their performance and self-evaluation for tests (public tender, university admission and others); it provides learning according to their rhythm and it is more suitable for place and time. But, at the same time, Internet disrupts learning and has too much information and hampers best content selection. Furthermore, young people learn more in "face-to-face" classes than in online classes.

Regarding youths' perception on teacher's competence on MIL they consider these skills as very important and they believe in new roles for students and teachers.

#ConnectedYouthBrazil Research also shows that there is still a huge asymmetry regarding the ownership of notebooks and computers throughout the country in comparison with mobile phones. It can be said that mobile phones (even the less sophisticated ones) are the real device to overcome digital divide in Brazil, mostly in

the North and Northeast regions, where the access to Internet is made only through them. Brazil is a continental country with immense challenges and contrasts between North and South. This scenario turns national public policies into a guessing game as can be seen in Prof. Dr. Litto statement:

[7] Brazil's ambitions of boosting its importance on the international scenario run the risk of being rendered unfeasible due to its workforce, whose qualification level and numbers are below global standards. Distance learning had its implementation in higher education in Brazil delayed by the conservativism of the academic community, generations of bureaucrats who were not education-oriented, and the National Congress. The criticism leveled in Brazil against distance learning is the result of a lack of knowledge regarding the achievements it has attained abroad, and because of myths which prevent it from being fully used so as to enable a more democratic access to advanced studies and their accreditation. New digital tools, such as Learning Objects, Open Educational Resources, and Massive Open Online Courses, certainly provide the path towards making the teaching/learning process more dynamic in general, and making independent learning possible (Litto, 2013 – 2014, p. 58).

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TTATI - Three-dimensional Technological Approach to Teaching Innovation: prospects for successful teaching and learning

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Abstract. Projects for implementing Information Technology in Teaching (ITE) do not achieve the expected success because they concentrate all the effort on specific elements, not focusing on a systemic view that enables to enhance the use of that technology. The goal of this paper is to propose a systemic approach that covers multiple dimensions and enables a successful implementation of information and communication technologies in educational scenario. By combining emerging teaching technologies to coherent didactic strategies, having an appropriate technological infrastructure as support, we will create the necessary lócus to perform a meaningful learning experience. The necessity of attributing meaning to educational innovation, beyond the simple instrumental training, reinforces the dimensional interdependence proposed in this paper.

Keywords: TTATI; ICTs; Infrastructure; Emerging Technologies; Didactic-pedagogical.

1   Introduction

Learning process in digital era cannot disregard factors related to technological infrastructure, emerging technologies and didactic-pedagogical elements. Projects for implementing Information Technology in Teaching (ITE) do not achieve the expected success because they concentrate all the effort on specific elements, not focusing on a systemic view that enables to enhance the use of that technology. Looking at the routine of educational institutions it is common to observe that teachers and students use traditional teaching and learning practices, using technology as the only innovative feature [1]. In this sense, instead of using a book, they use the computer; instead of the black board, they use a projector; instead of pencils, keyboard; instead of library, the web. Therefore, same teaching practices are reproduced and old problems are repeated.

On the other hand, when one think of acting from an innovative perspective, he/she is not quite sure what does that mean. Thus, usually he/she adopts the method of trial and error, seeking a more appropriate way of teaching that goes beyond the traditional model and responds to the aspirations of the information era. Considering this, it is common to notice teachers' reports stating that they do not know which subject, which resource, how, where, when and why making use of such tool that may effect the training needs of students [2]. Those questions arise due to reasons that ultimately fall on one of the dimensions considered by the systemic approach we are proposing in this paper, that is, the three-dimensional approach. This approach comprehends the following dimensions: infrastructure, emerging technologies and didactic-pedagogical aspects. Furthermore, this approach is closely linked to teaching innovation. The goal of this paper is to propose a systemic approach that covers multiple dimensions and enables a successful implementation of information and communication technologies in educational scenario. We propose the "TTATI" approach, acronym of *Three-dimensional Technological Approach to Teaching Innovation*.

In this context, we intend to clarify the general aspects of such approach, as well as to define the terms "innovation", "technological innovation", and "educational innovation", in order to achieve a qualified manner of teaching innovation.

2   Innovation

The term innovation is considered polysemous, plural and complex. It is worth to go back to the Latin origin of the word innovation, which is *innovatìo*, meaning renewal. Besides trying to find a concept to the term, innovations have been helping to transform humanity's history. From the first artifacts to stem cells therapies, a vast set of products and processes have permanently changed people's lives.

The dissemination of information and knowledge has been advancing at an accelerated and unprecedented rate [3]. This fact rises primarily from the emergency of information and communication technologies - ICTs, associated with their resulting innovations, considering that a substantial part of many people's lives is either immersed in knowledge-based activities or enabled by high technological content. As a direct impact, a considerable amount of the world economy is rooted on technological-content-based activities, that is, this type of knowledge-based activities.

When we specifically deal with innovations of technological nature, we notice that this kind of innovation corresponds to meaningful technological implementation or improvements in products and processes. Innovation, on the other hand, is what promotes the transformation. Such innovations can include completely new technologies, or can result from the combination of previous technologies applied to new usages, or can derive from the use of new knowledge.

2.1 Educational Innovation

The term educational innovation was defined by Pedró [4] as any dynamic change that aims at adding value to educational processes that promote measurable results. Based on Cunha's work [5], and in order to more precisely indicate the criteria and looks for innovative teaching experiences, we point out their characteristic conditions. Educational innovation requires: a rupture of traditional teaching and learning practices; a participatory management in which the subjects of the innovative process participate of the experience from its origin to the analysis of its results; a reconfiguration of knowledges in which merely dualistic stratifications are abandoned; a reorganization in which the comprehension of the relation theory-practice or practice-theory constitutes a foundational axis of paradigmatic innovation; an organic perspective for the conception, development and evaluation process of the developed experience; a mediation that includes socio-affective relations as meaningful learning conditions; and finally a leading role, since it is noticeable that both students and teachers are subjects of pedagogical practice and even playing different roles, they act as active subjects for their learning practices.
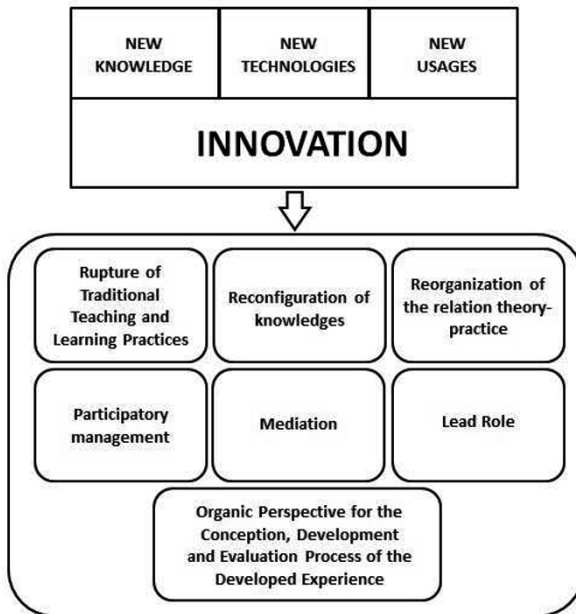
Fig. 1. Educational Innovation - innovative teaching experiences (source: the autor)

In an objective way, Figure 1 shows the key elements that should guide an innovative teaching experience. However, in order to incorporate those elements to educational practice, it is necessary to have a macro understanding of teaching and learning process in its various aspects and demands [6]. In this sense, we present below a systemic approach that, from our point of view, congregates necessary aspects towards achieving effectively innovative teaching on technological and pedagogical basis.

3 TTATI – A systemic approach

The goal of this paper is to propose a systemic approach that covers multiple dimensions and enables a successful implementation of information and communication technologies in educational scenario. We propose the "TTATI" approach, acronym of *Three-dimensional Technological Approach to Teaching Innovation*, an approach that aims at analyzing different dimensions that directly influence the application of ICT's in innovative teaching. The dimensions listed in this approach are infrastructure, emerging technologies and didactic-pedagogical contributions.
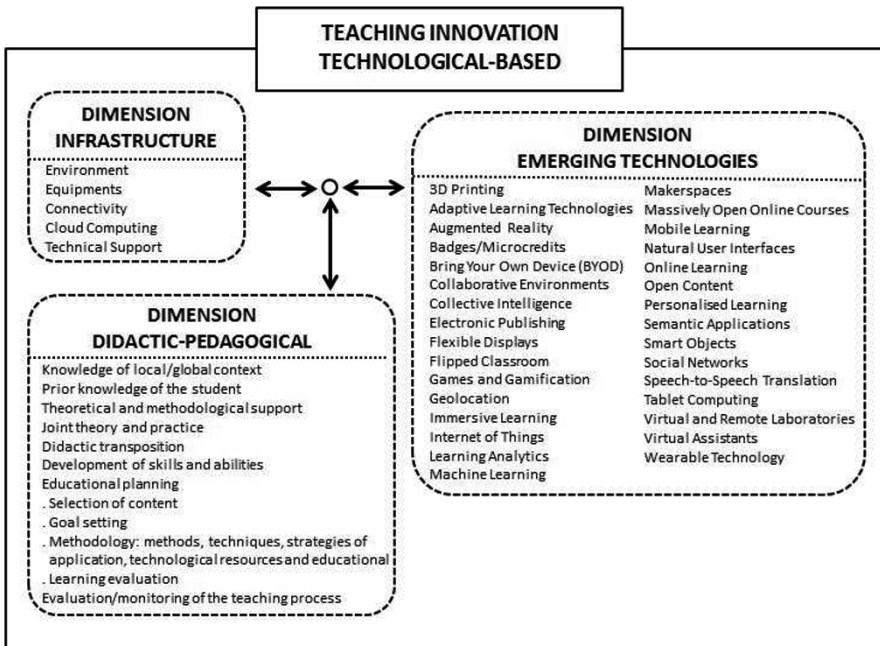
Fig. 2. Three-dimensional Technological Approach to Educational Innovation (source: the autor)

TTATI creates an interdependent relationship among the dimensions in which certain parameters influence the choice of other parameters from the same dimension or from different ones. In choosing a subject to teach, for instance, there is a relationship between some type of emerging technology [7] and the infrastructure available at the school. In case Internet connection is a decisive or limiting aspect, parameters for choosing technologies and the didactic-pedagogical dimension will be readjusted. For example, the choice for a technology such as *Mobile Learning* in an environment with limited or impaired connectivity will be an obstacle to the dynamics of teaching and learning process. Thus, the interdependence among the dimensions outlines a common thread that provides the development and execution of teaching and learning process from technological and didactic-pedagogical basis.

Next, we will present a summarized analysis embracing the dimensions addressed in this paper, using daily problem situations as examples.

In relation to the dimension of available infrastructure, we can notice that Internet connection at schools is one of the main factors that makes the systemic teaching approach implementation difficult. This fact becomes more severe when we refer to those schools that are furthest away from great urban centers and end up having limited or no Internet connectivity. Besides, for several schools that have broadband connection (2 to 5 Mbps), such connection is no longer appropriate to deal with some of the technological resources. Even faster connections are being required: ultra-broadband connection – 100 Mbps, for example.

When we look at the dimension of emerging technologies, we notice that these are usually implemented to solve specific problems and just after some time they are applied to teaching practices. Examples of that, among others, are: *3D Printing*, *Electronic Publishing*, *Games and Gamification*, *Geolocation*, *Internet of Things*, *Machine Learning*, *Smart Objects*, *Social Networks*. These informational systems derived to be used in classroom but they were not conceived, *a priori*, to be used in teaching practice.

Both dimensions, infrastructural and technological, are vital to make the technological-based innovative teaching effective [8]. However, these two dimensions need to be closely linked to the didactic-pedagogical dimension. By stating this, we seek to emphasize that a physically and virtually well structured environment needs to be well designed in order to have an efficient process. In this sense, it is necessary that teachers are willing to get continuing education enabling them to acquire knowledge of both environment and technological resources. Furthermore, it is important to plan the educational process seeking, from the selection of contents, the definition of clear objectives, choosing methods, techniques, strategies and technological resources in consonance with such objectives. Teachers should make sure they know from where to start and where they intend to go, that is, which competences and learning skills they expect to help the students to develop and in order to do so, teachers should consider the background and the local/global context of their students. Underlying to that, there should be students learning assessment and the monitoring of the whole process. Thus, in order to

perform a meaningful learning experience [9], that goes beyond a mere resource replacement, it is important to conduct a didactic transposition and an articulation between theory and practice. Those elements can be added to the teaching and learning process by adopting the TTATI, whose core lays on the supply of necessary conditions to cause a rupture of traditional teaching practice, moving towards not only a technological-based education but also an essentially (trans)formative and viscerally innovative one.

4 Conclusion

Innovative educational practices embrace multiple knowledge and especially require from the subjects of the teaching and learning process a reconfiguration of attitudes. The necessity of attributing meaning to educational innovation, beyond the simple instrumental training, reinforces the dimensional interdependence proposed in this paper.

By combining emerging teaching technologies to coherent didactic strategies, having an appropriate technological infrastructure as support, we will create the necessary *lócus* to perform a meaningful learning experience, fostered by a synergic conjecture that does not dispense creativity, dynamism and innovation.

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Systematic Review of Literature: the contributions to the learning process by digital technologies and pedagogical architectures

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Abstract. This article presents how the interactions between digital technologies and learning processes have been studied in the last years. Using the Systematic Review of Literature it was possible to identify and analyze the studies involved with this subject since the first registered publication until the most recent. This way, it was clear to comprehend what information there is about it, and what still can be explored with new studies. It was discovered that there is still a lot to be studied about the possible contributions of digital technologies and pedagogical architectures on learning processes.

Keywords: digital technologies, pedagogical architectures, systematic review, learning.

1   Introduction

The technological advances are transforming the way how the human being interacts with the world. The communication happens in many ways, therefore people are always sending and receiving information. With a great variety of devices on sale, and being some of them considered essential nowadays for the most users, it is almost impossible that there is not any interference on how people learn.

In the last decades, the inclusion of computers and digital devices in schools have been a growing effort, even by governmental initiatives, hoping to promote the digital inclusion of the students as well as promote a teaching method more connected with the extra class experiences of the students [1]. However, there is still some difficulty to employ digital technologies in favor of pedagogical processes, because of a lack of interest or prepare of the teachers and tutors, even though these technologies are recognized as a beneficial factor of innovation in education. Vallejo [2] says that the use of digital tools offer independence of time and place, as well as of learning rhythm, becoming a great resource once it adapts to the individual needs.

Thus, this study seeks to comprehend, by using the Systematic Review of Literature (SRL), how digital technologies contribute and relate with pedagogical architectures, and which are the effects of this relationship on learning processes. Find this

understanding is possible by identifying and analyzing studies that address this matter, since the oldest to the most recent publication.

2   Systematic Review of Literature (SRL)

The Systematic Review of Literature is a research technique, considered replicable, because it follows a standard process in its execution, and transparent, because the steps taken should be specified contributing to the replicability of the method. The main goal of this methodology is to provide an overview about the chosen topic. The SRL revels how the chosen subject has been addressed since the first occurrence in a publication. This is useful to build a base of knowledge about the matter, because it is possible to identify how many times it has been approached and what is the need of more studies about it.

Freire [3] states that the "SRL is a data collection process where stringent reviews of academic publications are required" in order to find evidences about a subject or topic in a particular area. Another SRL important characteristic is the obstruction of bias, once the author cannot freely choose the analyzed data.

A systematic review does not produce new outcomes or a straight answer to an initial question, but it does point what was already studied and what require more studies about a certain question approached by the systematic review. [4]

2.1   Producing a Systematic Review of Literature

2.1.1   Drafting the Research Question

The first step to produce a SRL is to formulate a research question, which is going to be the starting point to search studies related to this question. The goal is to characterize the scenario in which the question is being asked. The question needs to be well elaborated to clearly expose what is wanted to comprehend, and with the required boundaries of the subject.

2.1.2   Choosing the Database and Inclusion and Exclusion Criteria

Having prepared the research question, it is necessary to define which database is going to be used to gather the publications related with the question. It is also important to define the criteria that establish which studies are relevant to the research: the inclusion and exclusion criteria applied to the studies found in the database.

2.1.3   Chosen Studies' Critical Analysis

At this stage, the information provided by the studies requires an analysis in order to identify those which are closer with the context of the research question. This analysis

can be quantitative, qualitative, about the theory, or a combination of all this options. In some cases, specialized software can be used to execute this analysis.

2.1.4 Chosen Studies' Analysis and Synthesis

Having found the studies more related with the research question, a deep analysis is required, in order to present a synthesis about them. There are many methods to produce this synthesis, but the most common is the narrative method that allows an abstract about the study in question.

3   Systematic Review's Outcomes

This work consists in an exploratory descriptive research with a quantitative approach, using bibliographic data and statistic descriptive methods. The SRL was chosen to execute an investigation about digital technology in education and pedagogical architectures. The intention was to discover when the research about this matter had begun, and how it has been developed as the time goes by, seeking to answer the research question about "which are the scientific publication's tendencies and origins about how digital technologies and pedagogical architectures have contributed in learning processes?"

The database chosen was the international database SCOPUS. On September 2nd, 2015 the research was executed employing a sequential filtering system reaching the final amount of 29 (twenty-nine) articles that supposedly had some relation with digital technologies and pedagogical architectures. The filtering system was made in the following way:

Table 1. Filter applied to the reserch at SCOPUS

Sequency	Filter	Result
1st	Education AND Technolog*	117.513 articles found
2nd	Digital	19.766 articles found
3rd	Pedagogical	2.999 articles found
4th	"Digital Technolog*"	414 articles found
5th	Pedagogical Architectures	29 articles found

After the filtering, the exclusion criteria was defined, excluding books, books chapters and conference reviews. The included ones were articles and papers. It is important to point that the each work had their own classification in SCOPUS database, and they were included or excluded accordingly with the respectively SCOPUS classification. This way, 9 (nine) studies were dismissed, now reaching the amount of 20

(twenty) studies having the following distribution: papers represent 40% of the total and articles represent 60% of the total.

   Turns out that the articles aimed to this subject are recent, being the first publication dated from 2001. The publication's apex occurred in 2008 with 5 (five) published articles, representing 25% of the total, as showed in figure 1.
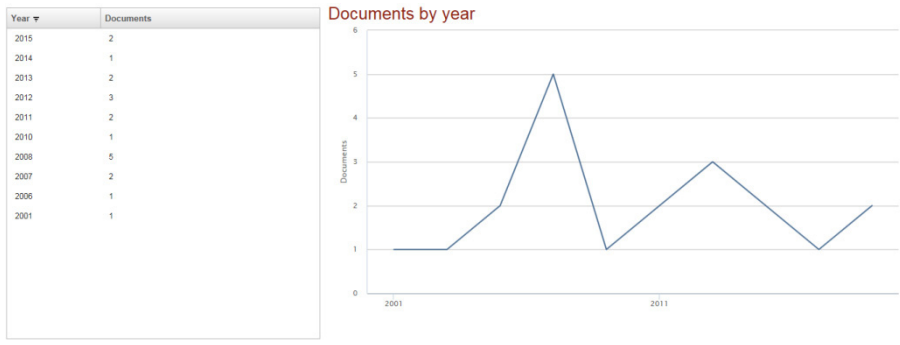
Fig. 1. Documents published by year

   Another relevant aspect is that there is not more than one article published by the same author, as figure 2 shows.

Fig. 2. Documents published by author

   The following figure 3 represents the amount of articles by country. It can be observed that there are contributions of many countries of different continents. The USA was the location where most presented publication with this subject, contributing with 6 (six) documents. In the second place is the United Kingdom presenting 4 (four) publications, followed by Germany and Australia both with 2 (two) publications. The other countries have published 1 (one) document each.
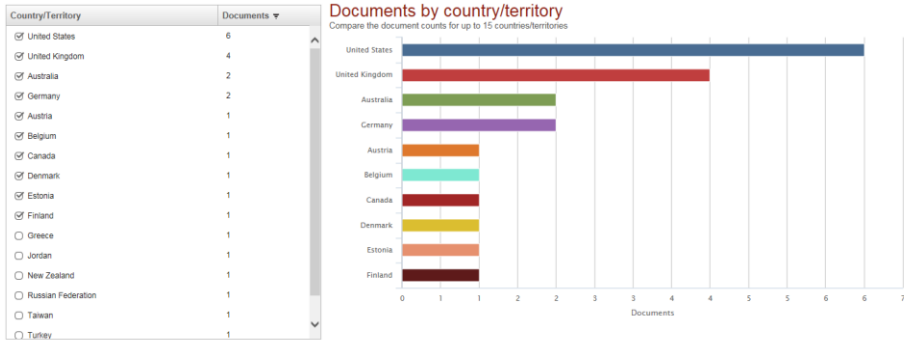
Fig. 3. Documents published by country

With regard to the field of study, the documents fit within 7 (seven) distinct fields. It was discovered that the majority would fit within more than one field of study, what characterize the subject as multidisciplinary. Figure 4 shows the percentage of studies by separated fields, remembering that many of them fit within more than one field of study, which characterizes them, therefore, as interdisciplinary. The field which most contribute with documents was Computer Science, followed by Social Sciences and Engineering.
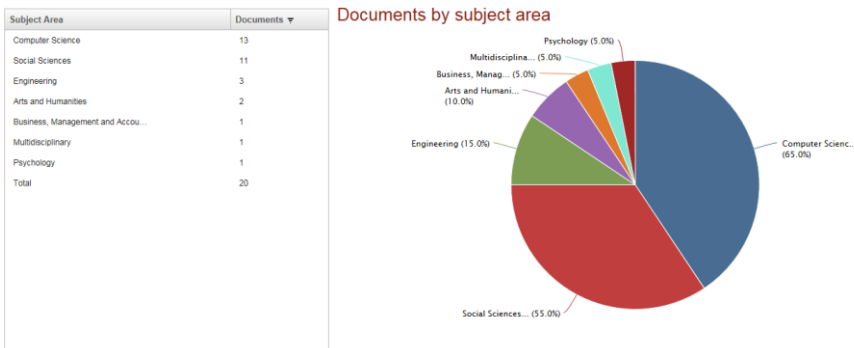
Fig. 4. Documents published by field of study

The next step was to analyze all abstracts, in order to comprehend the subject and goal of each study, to identify the ones that were more related with the initial subject of this work. Many of the studies were focused in teaching fields more specific, as certain university courses, what is out of this research's boundaries, which seeks to comprehend about teaching methods with digital technologies in a general way, especially in elementary and high school. Therefore, only 5 (five) of the 20 (twenty) initial studies were selected to be analyzed deeper by observing the following criteria:

- their adaptability in different educational contexts;
- the studies' offer of practical examples;

3.1   Chosen Articles' Overview

The SRL about the studies in inclinations and origins' field, relating with digital tech-
nologies and pedagogical architectures and its contributions in learning processes,
revealed a recent and undeveloped area. In this context, this stage's goal is getting to
know which scopes and outcomes are presented in the publications, field of study and
authors selected by this research.

Table 2. Chosen Articles

Order	Article's title	Author	Publication's Location
1º	Digital Technology: Building Pedagogical Bridges Between Secondary and Higher Education with a Focus on Architectural Engineering Technology	James E. Fuller	American Society for Engineering Education Annual Conference and Exposition
2º	Examining the impact of off-task multi-tasking with technology on real-time classroom learning	Eileen Wood. Et al.	Computers and Education
3º	Scripted Collaboration to Guide de Pedagogy and Architecture of Digital Learning Games	Stravos Demetriadis, Thrasyvoulos Tsiatsos, Anastasios Karakostas	Proceedings of the 6th European Conference on Games Based Learning
4°	Technology and Reform-Based Science Education	Danielle E. Dani, Kathleen M. Koenig	Theory Into Practice
5°	Conceptualising Teachers' Professional Learning with Web 2.0	Kevin John Burden	Campus-Wide Information Systems

The first article results from the author's research, dialog and collaboration with a
local school district. First, he support that technology in education can be found in
three different ways: it can supplement the traditional curriculum, it can improve the
traditional curriculum or a specific curriculum can be developed for technology driv-
en teaching.

After presenting these initial concepts, he argues that it is necessary to build links
between K-12 (elementary and high school) and higher education to smooth the stu-
dents' transition and connect teachers and students of both levels. The author was a
technology committee member, created by the local school district superintendent and
formed by parents, educators, technologists and administrators. The committee's goal
was to evaluate and find solutions for some questions involving K-12 education.

In the author's opinion it is necessary that the students comprehend the technology's role in society, and not only present technology as a learning tool. By achieving this it would be possible to develop long-range curriculum and pedagogy. He states that this would be truthful students' education for technology, and not only a training of how to use it. The author also argues that the courses offered on grades 11-12 should be preparing the students for the transition to higher education, reinforcing technologic aspects.

The authors' goal in the second article was to analyze the impact of off task multitasking with digital technology while in a real-time classroom university lecture. It was performed an experiment with 145 students. It was assign a task for each participant in order to repeat it for three consecutive lectures.

Table 3. Distribution of tasks

Task	Amount of participants
Facebook^TM	21 students
Texting using cellphone	21 students
Word-processing note-taking	21 students
Paper-and-pencil note-taking	21 students
MSN messaging	20 students
Emailing	20 students
Natural use of technology condition	21 students

By the end of each lecture the students answered a 15 item quiz about the content presentend by the professor in the lecture, and also filled a survey in order to mesure the students' fidelity in doing the assigned task.

The authors had three hypotheses: a) students in off task multitasking would have a poorer performance; b) it is possible for students in off task multitasking improve their performance once they get more practice over the three lessons; c) it was expected that students might engage in more tasks than it was assigned to them, and that is why they filled the fidelity measure survey.

The examination tests were analyzed, and brought the conclusion that students multitasking with Facebook^TM and MSN messaging had worse performance than the ones who used paper-and-pencil note-taking. This outcome partially supports the first authors' hypotheses.

The second analysis was about the performance in each lecture. The outcomes indicated that the best general performance occurred in the second session, while the general performance in the first and in third sessions were practically equal. This fact showed that there was no enhancement in students' performances even acquiring more practice in multitasking, what disagrees with the second hypothesis.

The analysis of the fidelity test measure revealed that on average 57% of the students reported had truly followed the given instructions over the three lessons. The

rest of them vary between practicing more tasks than it was asked, not attending to any multitask when it was asked for.

In general the students who did not use any technology during class had significant better performance than the students who used it. It was concluded that the Facebook^{TM} and MSN are the most harmful tools for learning. It is very important to highlight that at any time in this study it was proposed an educative use of technology, but only as an entertainment, having no relation with the lectures' content.

In the third article, the authors investigate and present a framework to use digital learning games through a collaborative method between peers of students, where the instructor uses scripts to guide the participants.

The main idea is the application of the Computer-Supported Collaborative Learning (CSCL), which consists in a variety of educational practices where the peer interaction is the key factor for learning, as well with the technologic tools support for the interactions to happen, once they could be remote (online) or physical interaction. Research point that this system use to fail when students does not have any orientation usually because they does not engage in productive learning interaction by themselves. As a possible solution, the teacher would guide the students using didactic scenarios (scripts) what would lead the students to engage in the collaborative tasks and would facilitate learning interactions. The scripts should offer specific instructions to small groups, such as what to do and, when to do and who may do.

The authors also suggest that a script component should be added in digital learning games environment as a tool, in order to the scripts collaboration learning system occurs almost automatically, depending only of the instructors definitions applied to the game.

In the fourth publication the authors present practical examples of how digital technologies can contribute in science teaching. Different options of techniques and tools are presented:

- Models: virtual environments that facilitate dynamic or static representation of scientific concepts, phenomena, system or complex or abstract processes. The models motivate the students and make possible the study of a given subject in a more practical way. There is also the possibility of the students to build their own models.
- Tutorials: virtual environments that allow scientific representation of a specific subject through programmed instructions. They are interactives, have immediate feedback and can be adjusted accordingly the needs of each student. It is a great option to reinforcement of students with learning problems.
- Electronic voting machines: small devices that allow the students' interaction in the lecture by given their opinion/answer. Usually questions are displayed in presentations in the class and the students pick an option and vote on it using the voting machine. Another device receives the answers and after the voting, an histogram of all responses is displayed. It is a great option to clear up concepts and knowledge failures.
- Simulations: similar with the models, simulations are recommended to practice impossible, extremely difficult or too long experiments. It develops analysis, problem solving and decision making skills. Simulations are also applied

to teach students how to do something, for example teach anatomy and dissect procedures.

- Probeware: educational software composed by hardware with sensors that are able to collect, analyze and organize data almost in real time.
- Virtual learning communities: virtual environment where users of different places can present, discuss and update topics.

The fifth article aims to provide a framework to conceptualize how the technologic characteristics of Web 2.0 can contribute to the teachers' professional learning. The authors relate the learning process with experience, reflection and construction, and they affirm that these factors depend on context, collaboration and mediation.

The authors identify as Web 2.0 characteristics: publication; collaboration, participation and sharing; re-purposing; multi-literacies (extended concept of literacy, adding multimedia content); inquiry and research.

The Web 2.0 characteristics offer some contribution in learning, although they were not meant specifically for educational purposes. This way, the authors highlight three types of technology and how they can contribute to teachers' professional learning:

- Knowledge construction and teacher learning: wikis
  Wiki is a type of website where users can edit collaborative content. The construction of wiki websites gives teachers the freedom to build and share their knowledge while other teachers also interact with the content.
- Teacher learning through reflection and collaboration: VoiceThread
  VoiceThread is described as a tool to produce conversation surrounded by medias. It allow writing conversation as well as allows conversation with many kinds of multimedia, what offers the teachers learning with multi-literacies. VoiceThread also develop critical reflection based on the special context that this software provides.
- Teacher learning through experience and construction: 3D worlds
  3D environments offer to the users many experiences such as explore, build and manipulate 3D objects. The learning process in 3D environments is highly experimental, since it allows the users to assume a role in the 3D world accordingly with the purpose and context.

4   Conclusions

This article, guided by the SRL method, presented an analysis about the usage of digital technologies in teaching and listed the main studies published so far about this matter. The outcomes revealed that there is a lack of investigations in this field, especially with respect to the possible contributions of the digital technologies usage in elementary and high school, since the higher education has been the main target in analysis about the good or bad effects of digital technologies in teaching. Nevertheless, it was possible to comprehend that when it is used in an organized and teaching orientated way, digital technologies are a powerful instrument to rise the learning quality. The studies selected brought many examples of how digital technologies can

interact and contribute with learning processes, demonstrating many options of approaches to insert technology in education.

The performed analysis confirm that the increase of interest in this matter is a global trend, once there are contributions of several countries and even if the studies are very recent. However, Brazil is still far from this movement, what configures itself a gap to be filled with new studies about digital technologies and pedagogical architectures and its contributions to learning processes.

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Exercise composition: from environment properties to composed problems

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Abstract It is well known that (1) problems have a structure, (2) often this structure comes from its input, output or internal objects, (3) this structure organizes the problem resolution. Decomposition of a problem by its structure is a typical path in problem resolution.

In this article we will do the inverse: composition of simple problems using structure-builder operators.

We will start by (1) discuss problem structures, (2) select a set of important structure-builder operators, (3) study their properties, (4) apply them to a simple math case-study.

1   Introduction

Problems have a structure, usually connected with its input, output or internal objects.

With different names and flavors, problem decomposition was recognized as a crucial step in mathematics, physics and philosophy since the ancient times.

One incredible 4000 years old Egyptian papyrus[1] claimed that (many) problems can be seen as composition of "chip's part problems", "aha problems"[2] or "Pefsu problems"[3]. Greeks discussed problem composition in very different domains. Descartes included this subject in the second principle of *Discourse on the Method*.

Today it continues to be a rather challenging task in a wide number of areas.

The study of the problem structures plays a central role in mathematics and computer science areas [3,7].

Some problems can be described as (1) pairs, triples, tuples of problems – (p1,p2,p3), (2) functional composition – p3(p2(p1())), (3) systems of equation problems – (union of constraints), (4) inductive problems – (sequences, trees), and that internal structure can be used to decompose them in smaller problems. We will discuss some common problem structures in next section.

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[1] See Wikipedia, *Moscow Mathematical Papyrus*
[2] Aha stands for a variable – x in modern math notation.
[3] A *pefsu* measures the strength of the beer made from a *heqat* of grain.

Problem structures and exercise generation –

Studying the problem structure is a very important subject because: (1) it helps in problem resolution, (*a*) we can decompose the problem – divide and conquer approaches, (*b*) we are able to transform the problem into a description where reusable patterns are easier to see; (2) it helps in problem understanding.

In a complementary way, problem structure can be used to assist in problem composition and exercise generation[1,9]. Beside the main problem text, in the area of exercise generation it is necessary to produce the exercise resolution, the suggestions, the results, the verification functions [5], metadata, etc. Problem decomposition and problem structure may guide in the construction of the exercise components. For example, sub-problems: (1) can be used as sub-questions; (2) may organize the generation of resolutions; (3) are crucial in the generation of suggestions; (4) can be used to organize problem recommendation.

Problem structure and didactic strategy –

Problem structure may also be used to systematically present different didactic choices to apply to different kinds of students or different situations. Example:

– ask for sub-problems before asking for the full problem,
– ask for the full problem and suggest sub-problems if necessary,
– incremental strategy.

A simple example –

The following example is presented to briefly illustrates some of the notions previously presented.

Problem 1: Consider figure bellow. Calculate the area of a rectangle measuring $5\,m$ by $10\,m$ with a circular hole with diameter $3\,m$.
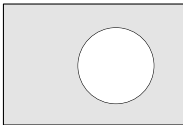

```
prop1 :: area = area(rect) - area(circ)
prop2 :: area(rect) = 5 × 10 m
prop3 :: area(circ) = π × (3/2)
```

$$p1 = \boxed{prop2 :: a, b \rightarrow area(rect)}$$

$$p2 = \boxed{prop3 :: diameter \rightarrow area(circ)}$$

$$p3 = \boxed{prop1 :: area(rect), area(circ) \rightarrow area(gray)}$$

$$p4 = \boxed{p3 \circ (p1, p2) :: a, b, diameter \rightarrow area(gray)}$$

Problem structure: p1(p2,p3).
Sub-problem order: (p2 before p1); (p3 before p1).
Suggestions that can be provided to students:

1. tips to help in the problem decomposition: "start by calculate area(rect)" or "start by calculate area(circ)";

2. suggestion coming from the sub-problems (problem p2, p3 suggestions).

Example of an alternative way of asking the exercise:

Problem 1a: Consider figure with a rectangle measuring $5\,m$ by $10\,m$ with a circular hole with diameter $3\,m$.

1. Calculate the area of the circle. (problem p3)
2. Calculate the area of the external rectangle. (problem p2)
3. Calculate the area of the gray area (rectangle with the hole). (problem p1)

In this article... We are concerned with problem composition. Using problem-structure based approach we propose:

– from a (mathematical) scenario write the existing properties;
– from each property write the elementary problems;
– from the elementary problems calculate more complex problems and exercises, using the proper problem structures;
– using the usual forward-chaining like approach [6], calculate reasonable exercise item chains.

Our goal is to see how far we can go in *recognizing and organizing the underlying exercises hidden in a (simple) scenario*.

Next section we will start by describing some common problem structure. Following, we will center in a case-study (a geometry scenario) and follow the previously stated steps.

2 Common problem structures

We will start by discussing a set of common problem structures.

Tuples: – pairs, triples, tuples of problems – (p1,p2,p3). Example:

> *Problem* Given the side of a square, calculate its area and perimeter.

$$p : side \to (area, perimeter)$$

> is decomposable in a pair of problems

$$(p_1 : side \to area, p_2 : side \to perimeter)$$

Functional composition: – p3(p2(p1())). Example:

> *Problem* Given the perimeter of a square, calculate its area.

$$p : perimeter \to area$$

> is a functional composition of

$$(p_2 : side \to area) \circ (p_1 : perimeter \to side)$$

System of equation problems: – union of constraints. Example:

Problem Given the perimeter and area of a rectangle calculate its dimensions.

$$p : perimeter, area \rightarrow a, b$$

is a system of equations of two undetermined problems

$$\begin{cases} p_1 : perimeter, a \rightarrow b \\ p_2 : area, b \rightarrow a \end{cases}$$

Inductive problems: – (sequences, trees). Example:

Problem Given the first 3 numbers of an arithmetic progression calculate the general term.

Specific decomposition problems: In most situations the decomposition strategy is problem specific. For example, "given a polynomial function, find its roots" relies on polynomial factorization.

Composition of problems: In most common situations we want to decompose complex problems in order to solve them. The strategies presented in this section are going to be used in the opposite direction.

In this article we will focus in problems directly derived from a mathematical scenario. Given a mathematical scenario, we want to calculate the problems that we can derive from it: *a*) each elementary problem is originated by a property of the scenario; *b*) the composition of elementary problems will allow us to obtain more complex problems.

Each environment property involving variables $x_1, x_2, ...x_n$, entails n elementary problems that given $\{x_i | i \neq k\}$ asks for x_k.

3   Exercise generation by problem composition

In this section we will introduce a mathematical case-study, define its properties, calculate its elementary problems and discuss the most important composition structures.

Problem scenario: Consider the $\Delta[ABC]$, with right angle at B and let $[BD]$ be the height in relation to its hypotenuse, as suggested by the figure.
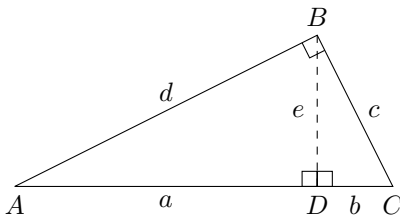
Also consider that $f = \overline{AC}$.

3.1 Scenario properties

The observation of this mathematical scenario allows us to establish some relations between the lengths of the sides of the different triangles. Thus, we can establish 10 different mathematical relations:

- as $f = \overline{AC}$, we have one addition relation:

$$f = a + b \quad S;$$

- as $\Delta[ABC]$, $\Delta[ABD]$ and $\Delta[BDC]$ are right-angle triangles, we have three Pythagorean theorems:

$$c^2 + d^2 = f^2 \, Pyt_1 \qquad b^2 + e^2 = c^2 \, Pyt_2 \qquad a^2 + e^2 = d^2 \, Pyt_3$$

- as $\Delta[ABD]$ and $\Delta[BDC]$ are similar to each other and similar to $\Delta[ABC]$, we can establish nine similarity relations:

$$\frac{c}{d} = \frac{b}{e} = \frac{e}{a} Sim_a \qquad \frac{d}{f} = \frac{e}{c} = \frac{a}{d} Sim_b \qquad \frac{c}{f} = \frac{b}{c} = \frac{e}{d} Sim_c$$

which corresponds to the following six equations:

$$c \times e = b \times d \; Sim_{a1} \qquad\qquad c \times d = e \times f \; Sim_{b1}$$
$$a \times c = d \times e \; Sim_{a2} \qquad\qquad d^2 = a \times f \; Sim_{b2}$$
$$a \times b = e^2 \quad\;\; Sim_{a3} \qquad\qquad c^2 = b \times f \; Sim_{c1} \,.$$

3.2 Elementary problems and their composition

After we establish the mathematical relations of the scenario, we can analyze which exercises can be generated by them.

Using only one of these 10 mathematical relations each time, we can generate 33 problems of different difficulty levels. We will name them *elementary problems*. In each one of this problems we are using one scenario property, and we ask for one unknown variable, given two or three instantiated variables.

After the relations are established and the elementary problems generated, we can go further on, composing them to create more complex exercises.

When we compose problems, we may want to guarantee that:

- the problem has a solution;
- there's an increasing of the difficulty level (from the easier one to the harder), to motivate the student;
- we visited at least one item of each mathematical concept, in order to include all the themes we want to cover;
- question items are in the correct order: question items are not dependent of of the following ones.

To automatically proceed with the composition of elementary problems, we will use the operators:

- *tuples* (from a certain set of given values, we will obtain the unknown values, using elementary problems not related to each other);
- *functional composition* (from a certain set of given values, we will obtain one of the unknown values using elementary problems, and knowing this new value, we will obtain the remain unknown value);
- *system* (to obtain any of the unknown values, we mandatory need the other unknown value).

We will essentially use these operators, as its applicability can easily be seen by the analysis of the elementary problem signatures.

Attending to the scenario presented, we can generate 375 different problems by composition of two elementary problems. From these cases, we will privilege the situations in which all the data defined in the beginning of the exercise is needed, although in some cases, part of the data may not be needed in an earlier stage of the resolution [4].

3.3   Tuples

When we compose two elementary problems using tuple structure, we are generating an exercise with two independent question items, that are commutable: we can safely change the order of the questions.

Composing elementary problems using tuples structure is outlined in figure:
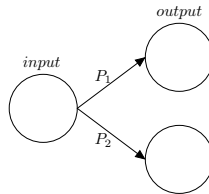
Note that both the input and output set of the composed problem are the union of, respectively, the input and output sets of the elementary problems. Also, the output set of each elementary problem and the input set of the other elementary problem should be disjoint.

Given P_1 and P_2 elementary problems, with input data I_1 and I_2, and output data O_1 and O_2, respectively, a problem composed using tuples (P_1, P_2) is:

$$P_1 = \boxed{T_1 :: I_1 \rightarrow O_1}$$
$$P_2 = \boxed{T_2 :: I_2 \rightarrow O_2}$$

$$(P_1, P_2) = \boxed{T_1, T_2 :: I \rightarrow O}$$

where the precondition is: $O_1 \cap (I_1 \cup I_2) = \emptyset \bigwedge O_2 \cap (I_1 \cup I_2) = \emptyset$
and the postcondition is: $I = (I_1 \cup I_2) \bigwedge O = (O_1 \cup O_2)$.

   Example: Consider the elementary problems P_1 e P_2:

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[4] Some exercise authors like to give extra data, in order to stimulate the creativity and to develop the critical capacity of the student to select of the information needed, but this aspect will be out of scope of this article.

Problem P_1: Given b and e, obtain a.
Problem P_2: Given b and e, obtain c.
The problem P is given by $P = (P_1, P_2)$.
Problem P: Given b and e, obtain a and c.

3.4 Functional composition

The figure outlines the composing of elementary problems using functional composition.
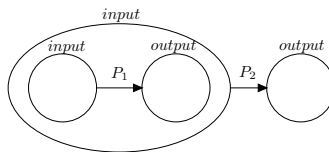
When we compose two elementary problems using functional composition, we generate an exercise with two question items that are sequential: the second item depends on the first – we can not change the order we pose the questions. Furthermore, we can ask only the second question item, increasing the difficulty level and training the student to use the capacity of subdividing a problem in two problems.

The input set of the composed problem is the union of the input sets of the elementary problems excluding the output set of the second elementary problem, and the output set of the composed problem is the union of output set of both elementary problems. In order to have functional composition, the input set of the second elementary problem must contain the output set of the first elementary problem.

Given P_1 and P_2 elementary problems, a problem composed using functional composition $P_2 \circ P_1$ is:

$$P_1 = \boxed{T_1 :: I_1 \to O_1} \qquad\qquad P_2 \circ P_1 = \boxed{T_1, T_2 :: I \to O}$$
$$P_2 = \boxed{T_2 :: I_2 \to O_2}$$

where the precondition is: $O_1 \cap I_2 \neq \emptyset \bigwedge O_2 \cap (I_1 \cup I_2) = \emptyset$
and the postcondition is: $I = (I_1 \cup I_2) \setminus O_1 \bigwedge O = (O_1 \cup O_2)$.

Example: Consider the elementary problems P_1 e P_2:
Problem P_1: Given b and e, obtain a.
Problem P_2: Given a and e, obtain d.
The problem P is given by $P = P_2(P_1)$.
Problem P: Given b and e, obtain a and d.

3.5 Systems of equations

Composing problems using systems of equations structure is outlined in figure.
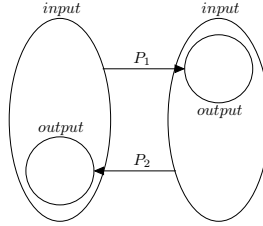
When we compose two elementary problems using systems of equations structure, we are generating one exercise with a single question item, because the two elementary problems are dependent of each other. Besides, we just need to ask for one of the unknown values, increasing the difficulty level, as the student needs to calculate both unknown values.

Some of these composed problems can go beyond the technical capacity of the students so, using certain techniques, such as Gröbner bases ([2,4,10]), can help the creator of the exercise to exclude some situations (inconsistent systems or dependent ones) [8].

Note that the output set of the composed problem is the union of output set of both elementary problems. The input set of the composed problem is the union of the input set of both elementary problems minus their output sets.

Given P_1 and P_2 elementary problems, a problem composed using a system of equations $\begin{cases} P_1 \\ P_2 \end{cases}$ is:

$$P_1 = \boxed{T_1 :: I_1 \to O_1}$$
$$P_2 = \boxed{T_2 :: I_2 \to O_2}$$
$$\begin{cases} P_1 \\ P_2 \end{cases} = \boxed{T_1, T_2 :: I \to O}$$

where the precondition is: $O_1 \cap I_2 \neq \emptyset \bigwedge O_2 \cap I_1 \neq \emptyset$
and the postcondition is: $I = (I_1 \cup I_2) \setminus (O_1 \cup O_2) \bigwedge O = (O_1 \cup O_2)$.
and the obtained system of equations should be independent and consistent.

Example: Consider the elementary problems P_1 e P_2:

Problem P_1: Given a and e, obtain d.

Problem P_2: Given d and f, obtain a.

The *problem P* : Given e and f, obtain a and d.
is given by

$$P = \begin{cases} P_1 \\ P_2 \end{cases}.$$

3.6 Multi composition

Consider the previous *Problem P*: "Given e and f, obtain a and d."

Analyzing this example, we can easily see that we can expand it to P_f: "Given e and f, obtain all the other variables". At first sight, this seems an unsolvable problem. But, giving a clue (for instance, "use a system of equations to obtain the values of a and d"), the student is able to solve the problem. Note that considering the elementary problems:

P_3: Given a and e, obtain b,
P_4: Given d, e and f, obtain c,
we have $P_f = (P_3(P), P_4(P))$.

Reordering it in a compact way, we can summarize the process to:

Given e and f,

$p1 = \boxed{Pyt_3 :: e, a \rightarrow d}$ $p5 = \boxed{(p4 \circ p3) :: e, f \rightarrow a, d, b}$

$p2 = \boxed{Sim_{b2} :: f, d \rightarrow a}$ $p6 = \boxed{Sim_{b1} :: d, e, f \rightarrow c}$

$p3 = \boxed{\begin{cases} p1 \\ p2 \end{cases} :: e, f \rightarrow a, d}$ $p7 = \boxed{(p6 \circ p3) :: e, f \rightarrow a, d, c}$

$pf = \boxed{(p5, p7) :: e, f \rightarrow a, d, b, c}$

$p4 = \boxed{Sim_{a3} :: a, e \rightarrow b}$

(it is possible to follow other alternative paths).

Studying the process of composition/decomposition of the exercises gives us something more than just the final result. It ends up to give us some clues about the scholar themes involved in the exercises and, if we associate a name to the properties of the problem, we can present some suggestions to the student (guiding him to the resolution of the problem) and we can automatically generate the resolution of the exercise proposed.

For instance, considering the example presented for functional composition ("Given b and e, obtain a and d"), as P_1 is an elementary problem involving a similarity relation and P_2 is an elementary problem involving a Pythagorean theorem, we can guide the student, generating some clues such as:"Note that a, b and e are in a similarity relation" or "Note that a, d and e are related by a Pythagorean theorem".

Also, we can generate the problem resolution, obtaining:

"As a, b and e are in a similarity relation, we have $a \times b = e^2$. Replacing the values of b and e we obtain a.

As a, d and e are related by a Pythagorean theorem, we have $a^2 + e^2 = d^2$. Replacing the values of a and e we obtain d".

4 Conclusions

Studying, understanding and training problem decomposition, problem structures, problem composition is a very relevant area. Studying the set of exercises derivable from a scenario, is a very time-consuming task.

Starting from a scenario with explicit stated properties, we can automatically derive a set elementary problems. From these problems, and using only signature constraints rules, we can do a forward-chaining composition of the problems, obtaining a large set of (muti-item) Exercise candidates. The decision about the applicability of the composition operators is exclusively based on the signature of the problem (input and output). These automatically generated exercises are

a rich resource: they carry the annotations about its building process (the set of properties used, the involved composition structures, possible suggestions, item order constraints) making them a good base for Exercise-generation activities. Using operators to compose problems, allows us, not only to obtain new and more complex problems, but also to generate suggestions (that can help the student in its resolution), resolutions, metadata (for instance, the themes involved in the new problem) and verification processes.

In some experimental situation some of the generated exercises included interesting cases that escaped human author analysis.

Work is being done to improve: (1) detection of equivalent exercise item chains, (2) compressing of partially equivalent exercises, and exercise sets.

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Digital Games for Math Literacy: A systematic literature mapping on Brazilian publications

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Abstract. This work surveys the Brazilian scientific production regarding Digital Games (DG) for Math Literacy. Math literacy is divided into three stages: fundamental, numbering and operations. Through a systematic literature mapping, 16.483 papers from all the main events and journals in the computing and informatics in education areas over the last decade were analyzed. Among the few (7) DG found all comply to the features of a Serious Game (SG); most focused on the four basic operations, especially on the multiplication operation; none focused on the fundamentals or numbering; they were meant for children of the first cycle of elementary school; the participation of educators occurred in 5 but in only 2 of them the participation occurred in the designing phase of the game. The majority of SG were evaluated against usability issues rather than learning aspects. The results indicate that Brazilian research on DG for Math Literacy is yet to mature and there is a remarkable absence of SG developments for the initial stages of Math Literacy by the Brazilian scientific community.

Keywords: Educational Games, Serious Games, Numeracy, Math Literacy, Systematic Literature Mapping.

1 Introduction

A video game is a playful activity that consists of actions and player decisions that generate a final result [1]. These actions and decisions are limited by a set of rules and by a space which is, in the case of Digital Games (DG), a computer program [1]. DG are teaching resources with features that can bring benefits to the learning process [2], such as motivation, development of cognitive skills and learning by discovery. According to Abt (1987 *apud* [3]) games that have educational purpose designed from the very beginning and not designed exclusively for fun, i.e. those that were created with the intention of teaching something to the player, are considered SG. "There is an increasing number of Serious Games (SG) addressing the curriculum objectives which could be used for achieving the curricular pedagogical goals in an efficient manner" [4].

Math Literacy is a phenomenon that comes from understanding, interpretating and communicating mathematical contents and are the baseline for the mathematical

knowledge [5]. Mathematics is important to the child's development as it allows its transformation into a critical citizen, developing autonomy and increasing their ability to solve problems [6]. Math Literacy is composed of several stages and levels of difficulty, the following is a description of the components of each stages:

1) Fundamental stage:

i.   Hierarchical inclusion is the ability to realize that one is included in two; and two is in the three and; so on (Piaget, 1976 *apud* [6]). For instance, present two kinds of animals to a child and ask her to tell you how many animals that set make up;

ii.   Classification is the function of separating objects, personel, facts or ideas in sets [6]. For instance, present various geometric figures of different colors and sizes to kids and ask them to classify the pictures;

iii. Serialization is the process of comparing objects to establish their differences, placing them in order. [6]. For instance, present several sticks of different sizes to a child and ask her to order them;

iv.   Biunivocal correspondence, or correspondence one to one, is the connection of sets, where a set A has only one correspondent in B set (Piaget, 1975 *apud* [6]) as in a memory game, where one of the cards contains a numeral and another card pairs up with an amount of drawings correspondent to that numeral;

v.   Conservation is the action to realize that the amount of things does not change, despite changing their disposal [6]. For instance, the amount of liquid in two plastic bottles with identical capacities: one is large and short, the other thin and tall;

2) Numbering stage:

i.   Decimal System lets you represent numbers with few characters [7]. For instance, acknowledging the numbers and meaning of some quantity;

ii.   Positional Value is presented according to the position that the characters has in a number indicating if it is unity, tenths, hundreds and, so on [7]. For instance, understanding that the number "1" within the number "51" is the unit and the number "5" is the tenth.

3) Operations stage: Addition, subtraction, division and multiplication. It is at this stage that one learns the meaning and procedures to perform the four basic mathematical operations.

Games can be used in the classroom for teaching mathematics as a technological resource at various moments of learning and proved to be an effective tool in the mathematics teaching-learning process [8]. "Game Based Learning (GBL) aims at making the learning activities more enjoyable and engaging by using the potential of games mechanics for achieving the (curricular) learning objectives" [4]. "Despite a higher use of repurposed games in mathematics, pre-service teachers showed a preference for using existing Serious Games (SG) designed specifically for the primary education curricular objectives" [4]. Math Literacy has been elected a key area for a Brazilian Ministry of Education program. This program called, PNAIC (National Pact for Literacy at the proper Age), aims to promote both reading and writing literacy as well as math literacy at the right age [9]. EG and SG are two types of DG that can be used to promoting math literacy. If DG have pedagogical potential for learning math, it becomes important to identify how the brazilian scientific community has been approaching this relationship. This is the aim of this paper.

This paper is organized as follows: section 2 presents the systematic literature mapping. Section 3 discusses the research data. Section 4 is a discussion of the data generated by the survey. Finally, in section 5 is the conclusion of this work.

2   Systematic literature mapping of digital games for Math Literacy

Systematic review is a methodology that performs a review of existing literature, and this process takes place in an organized and systematic way, allowing its execution through steps defined and providing great reliability and a solid theoretical basis [10], so it enables a broader view of the primary studies to identify the available evidence in a research area [11]. The present mapping was produced following the procedure described by [11]. The proposed research questions are:

RQ1 – How to characterize DG for math literacy?

RQ2 – What is the focus on math literacy are covered by DG?

RQ3 – What age range are the DG intended to?

RQ4 – What kind of help educators give to develop DG?

RQ5 – What kind of assessment is being carried on these games?

RQ6 – What kind of audience they target?

Thirty-two data sources were screened. Table 1 lists these sources and the amount of papers found at each one considering the last 10 years of publications. These sources were chosen because they cover all major Latin American scientific publications media in the area of 'informatics in education' and 'mathematics education'.

Table 1. Events and Journals and their respective amount of papers

Events			
Acronym – Description	**Qty**	**Acronym – Description**	**Qty**
SBIE – Brazilian Symposium on Informatics in Education	858	IHC – Brazilian Symposium on Human Factors in Computer Systems	201
WIE – Workshop in Informatics in Education	426	WRVA – Workshop on Virtual and Augmented Reality	363
TISE – International Congress on Computers in Education	409	SJEEC – Workshop on Electronic Games, Education and Communication	176
SBGAMES – Brazilian Symposium on Computer Games and Digital Entertainment	629	WAVE – Workshop on Virtual Environments in Education	18
SVR – Symposium on Virtual and Augmented Reality	274	WEI – Workshop on Informatics Teaching	304
Journals			
Acronym – Description	**Qty**	**Acronym – Description**	**Qty**

RIED – Iberoamerican Journal of Distance Education	175	RENOTE – Journal of New Trends in Education	1142
IEEERITA – Iberoamerican Journal of Learning Technologies	182	RBCA – Brazilian Journal of Applied Computing	94
RITA – Journal of Theoretical and Applied Informatics	149	RIA – Applied Informatics Journal	107
RBIE – Journal of Informatics in Education	201	IETP – Journal of Informatics in Education: Theory and Practice	220
Bolema. Mathematics Education Bulletin (UNESP. Rio Claro)	178	Research Notes (Carlos Chagas Foundation. Printed)	380
Journal of Physics Teaching	734	ComCiência (Unicamp)	715
Proceedings of the Brazilian Academy of Sciences	942	Mathematics Education Research	253
Notes In Public Health (ENSP)	2360	Journal of Pedagogical Studies	314
Science and Public Health	1619	Journal of History of Mathematics	126
Brazilian Journal of Medical Education	617	Journal of Public Health	1260
Brazilian Physics Teaching Notes	287	Health and Society (USP)	770
Total		**16483**	

Inclusion Criteria (IC) applied over the papers were:
- IC1 – Papers available for free download in full;
- IC2 – Papers classified as complete or full.

Table 2 shows the total publications per year, considering the Inclusion Criteria, which resulted in 16.483 papers.

Table 2. Total publications analyzed per year

Types\Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Events	192	292	248	341	309	431	403	422	488	532	**3658**
Journals	803	883	1031	1278	1436	1374	1437	1488	1572	1523	**12825**
Totals	995	1175	1279	1619	1745	1805	1840	1910	2060	2055	**16483**

In Table 2, the annual production can be observed, for the past 10 years. It can be observed that the amount of paper produced is growing steadily over the last decade.

To the exclusion of papers that do not meet the objective of this literature mapping three Exclusion Criteria (EC) were applied. Due to the absence of a single search engine to cover all these sources, an exhaustive manual search by reading all the titles was made necessary, and in many cases the abstract of the papers was read as well is order to be certain of the paper contribution.

The first criterion, EC1, defines the need of the word "mathematics" in the title or abstract. The remaining papers after EC1 are presented in Table 3.

Table 3. Papers on mathematics

Types\Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Events	10	7	4	11	18	14	14	17	15	18	**128**
Journals	16	7	3	7	14	10	8	10	15	5	**95**
Totals	26	14	7	18	32	24	22	27	30	23	**223**

As for EC2, it was decided that the paper should report the use of the games as part of a classroom activity. The remaining items after EC2 totaled 38 papers, and are presented in Table 4:

Table 4. Papers about games and mathematics

Types\Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Events	2	1	2	1	4	1	3	4	4	7	**29**
Journals	2	0	0	1	2	0	1	1	2	0	**9**
Totals	4	1	2	2	6	1	4	5	6	7	**38**

For EC3, it was decided that the game needed to be aiming for math literacy. After applying the filter EC3, just a few papers stood out, as shown in Table 5:

Table 5. Papers on games developed for Math Literacy used in the classroom

Types\Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Events	0	0	1	0	0	0	0	1	2	2	**6**
Journals	0	0	0	1	1	0	0	0	0	0	**2**
Totals	0	0	1	1	1	0	0	1	2	2	**8**

As it can be seen, a total of eight papers remained after the application of all criteria and these games will be described in section 3. These 8 papers refer to 7 different games. These references can be found at the reference list marked with a "*"at the beginning.

3   Results

To answer the Research Questions, six characteristics were analysed. The first characteristic observed concerns the games' nature: six authors classify their games as an EG and only one as a SG. As SG definition is not yet so widspreated, it may have influenced the authors while classifying their games as EG rather than SG. Taking the above, all games comply to the definition and can be called SG.

The second characteristic is their focus on the issue of Math Literacy: all games found are used for teaching one or more basic mathematical operations and not for fundamentals stage of literacy (classification, serialization, ordering) or numbering stage (decimal system and positional value). The most frequent operation in the games was multiplication. Graph 1 shows the number of games that deal with each specific operator (notice that a game can deal with more than one operation). The numbers on each slice indicate the amount of games that deals with that item.

The third characteristic is the age targeted: 5 games were indicated for the elementary school-first cycle (ESFC), one for elementary school-second cycle (ESSC) and another for Youths and Adults Education (Y&A) (see Graph 2).
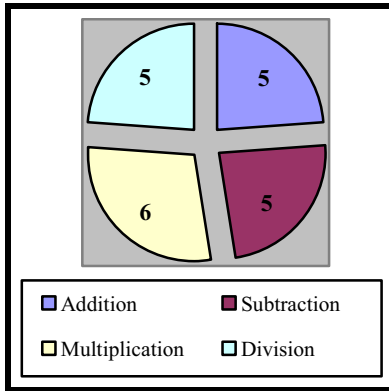
Graph 1 – Math Operators in Games   Graph 2 – Age Group
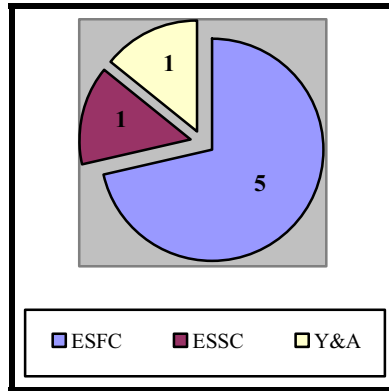
The fourth characteristic relates to the participation of educators at some stage of the game development, from design to evaluation. Some games did not have the participation of teachers at any stage which is weird considering that they are supposed to be EG/SG. Those who have participated, have done so at the development phase or at the evaluation phase of the game development. Graph 3 shows the results.

The fifth characteristic concerns the type of assessment that was carried out by game developers. In this case the criteria used are varied. However, one can see a predominance of usability assessment compared with players' performance. These data can be seen in Graph 4. The assessment process was performed through pre and post-test with mathematical problems to be solved (three out of seven games) and by observing the behavior and motivation of the players while using the game (four out of seven games). Graph 4 also presents the distribution of evaluation methods because the amounts coincide with the distribution of the type of evaluation.
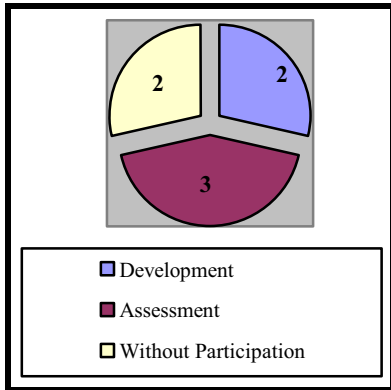
Graph 3 – Educators involvement
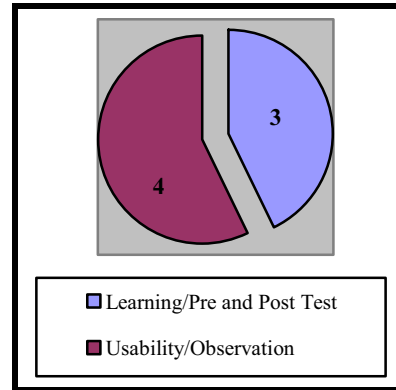
Graph 4 – Types and methods of assessment

The sixth characteristic identified analyses if the game was developed to meet special needed audience. In this case, only one out of the seven games was developed for people with visual impairment.

4 Discussion

The largest number of papers on the use of games for Math Literacy has been published in scientific events. The work presented in a journal is a master thesis project with two published papers which complement each other and tackle one game. As can be seen in Table 3, only 223 out of the 16,483 papers were found with "games" and "mathematics" terms in their titles. Both journals and events have published papers on Math Literacy, but just a few focused the classroom. Most of the games found were presented at SBIE (Brazilian Symposium of Informatics in Education), all presented in the last two years of the event. Among the journals surveyed, only RENOTE (Journal of New Trends in Education) presented a paper describing the development of a game for Math Literacy.

It can be seen in Graph 1 that the production of games for Math Literacy is small and variable, but shows a slight upward trend in recent years. Most papers initially selected were eventually discarded because showed no details on the development or no use of the games. They were mostly papers describing the use of virtual environments for teaching other subjects along with mathematics or addressed other subjects of mathematics discipline such as training undergrad mathematics teachers.

The answer to RQ1 is that all the games found use basic operations but are not concerned with the sound foundations for Math Literacy. Few games were found and they are mostly incomplete, since they are concerned only with the use of operations and not on how to get to use them. Graph 1, shows that multiplication is the operation most present among the games found (answering RQ2).

To answer RQ3 suffices to analyze Graph 2 where it is possible to identify that most games found are meant for children of the first cycle of elementary school, so

the age group is children from 6 to 10 years old. The participation of teachers in the development of games is there, which can be seen in Graph 3 and answer yes to RQ4, but the amount of games that have been found that do not have this participation is almost equal and worrying.

As for RQ5, it can be answered by looking at Graph 4, where the types of assessments that have been conducted are shown. It can be observed that most of the games demonstrate concerns with usability rather than with its effectiveness for Math Literacy. Only one of the games is intended for an audience considered special, answering RQ6 to yes, and it was done only to the visually impaired.

Due to the lack of a single repository that provides all the proceedings and journals in Table 1, this literature mapping has become more difficult than expected because it took many searches on the internet to get all publications. It demanded reading large amounts of texts and consequently lengthened the search time which was from Dec / 2014 to May / 2015.

Some authors advocate that Serious Games should include subject matter expert (SME) from the very beginning phases of designing and that, by definition, they are required to have a clear purpose beyond entertainment. To that end we understand that all games found comply to the definition although SMEs were not clearly reported. But we also infer that some of the authors might as well be math educators and failed to mention it.

5   Conclusion

Through a systematic mapping, six research questions about digital games for Math Literacy were answered. After analyzing 16.483 papers only 7 games used in classroom were found. Although the number of the games is not statistically meaningful, some observations can be drawn. For instance, the complete absence of games targeting the first stages of Math Literacy indicates a challenge and an opportunity: A challenge in order to design an effective Serious Games (SG) for such so important subject; An opportunity because such initiative is so needed.

The main focus of the games found was the four basic operations and the majority of the games are for a specific age group (from 6 to 10 years old). The participation of educators was found in 5 out of 7 of these games and only 2 have occurred in the development phase. The games have been mainly evaluated for their usability and not for their capability to promoting learning. The vast majority of games were developed for the general public and only one game was developed for a specific audience (visually impaired).

Although the amount of initial studies was big (223) just a few (7) targeted the use of digital games for Math Literacy and were actually used in classroom. We conclude that the scientific community in Brazil is yet to mature on the use of SG for math teaching and this need to be done fast in order to gather information to convince teachers to use games as a valuable instrument for their craft.

As future work, a literature review on the games found in this systematic mapping is necessary to identify how they are addressing the issues of mathematical teaching within the game and the public being benefited by this initiative.

Acknowledgment

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An approach that support multiple linked representations within an intelligent tutoring system for helping students to develop skills on designing digital circuits

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Abstract. This paper proposes an approach that allows an exploration of three linked representations within a tutoring system for helping students in problem solving situations to develop skills on designing digital logic circuits. Specifically, we provide a learning environment by considering situations that essentially consist of mapping a logic expression into another equivalent. This environment can work on two basic situations: (i) the students are asked to solve problems, having the possibility to receive personalized assistance or (ii) the tutoring system resolves problems asked by students. The problems and solutions have to be specified in two symbolic representations: Boolean algebra or Propositional Logic, having each expression automatically mapped into its equivalent expression displayed in gate logic language. The tutoring system architecture is presented, as well as its aspects of implementation. The proposed and implemented approach to the tutoring system was evaluated through scenarios of problems with adequate coverage, demonstrating its feasibility.

Keywords: Personalized educational systems, Intelligent Tutoring Systems, multiple representations, Digital Circuits.

1   Introduction

Typically an Intelligent Tutoring System (ITS) [1] focuses on providing personalized support to students engaged in educational interactions in a particular domain knowledge. Recently, some studies have worked on multiple representations for a given domain knowledge.

Educators have recognized the importance of providing multiple representations, of a given domain, as a pedagogical strategy for achieving rich understanding and improving learning. In fact, in a broad sense, some studies have presented arguments in favor of the use of multiple representations of a given domain knowledge,

considering its potential to cause positive effects on the learning process [2]. Additionally, they state that during the learning process, switching among different methods may cause more effective learning [3]. Particularly, this importance is relevant when we deal at the same time with abstract and concrete views on the same domain. Here, one important question is on how approximate abstract and concrete approaches in order to help the students to have a unified view between these two abstraction levels.

In this paper we propose a pedagogical approach that allows an exploration of three linked representations within a tutoring system for helping students in problem solving situations to develop skills on designing digital logic circuits. This domain has been worked on designing circuits with the use of approaches, such as Boolean algebra and Logic, as in Gregg [4]. Specifically, we provide a problem-based learning environment by considering situations that essentially consist of mapping a logic expression into another equivalent, for example, the task of simplifying digital circuits that could refer to a specific real problem, like how to the design of logic digital circuit to control the use of seat belt in automobile system designed to sound an alarm under certain conditions.

The proposed learning environment contains an Intelligent Tutoring System [4] with modules responsible for problem solving, evaluation and diagnose, pedagogical planning, as well as, student modeling. Essentially, it works on two basic situations in an available problem space: (i) the students are asked to solve problems, having to each posed problem the possibility to receive personalized assistance from the system, providing them with pedagogical resources according to the needs identified in the evaluation of their student's solutions or even on some doubts from students or (ii) the tutoring system resolves problems asked by students, presenting the solutions step by step, with all the associated justifications. The problems and solutions have to be specified in one of two symbolic representations: Boolean algebra or Propositional Logic, having each expression automatically mapped into its equivalent expression displayed in gate logic language. In this approach, the system permits students to make connections between these three representations, but they have to choice just one symbolic representation to work in each moment.

We present the system architecture and its functionality, as well as its implementation aspects. The proposed and implemented approach to support three representations within the tutoring system was evaluated through scenarios of problems with adequate coverage, demonstrating its feasibility.

2   Related Work

Learning environments with support to multiple representations have been the focus of some studies in the literature. Part of them concentrate on examining the potential benefits of supporting multiple representations by analyzing the main influences on learning process. In particular, Steiner, and M. Stoecklin [5] showed that learners acquire a deep understanding only if they are able to link multiple representations of the same concept and to coordinate between them. The work proposed by Rau, Aleven and Rummel [6] shows an ITS that uses multiple graphical representations as

support to teaching mathematical fractions, just focusing on exploring concepts. In this sense, the authors propose that students use self-explanation, aiming to improve the students' comprehension about the relation between the different graphical representations and the symbolic representation. However, this approach uses multiple representations with support only to visualization to illustrate the involved concepts, but it does not offer a proposition where the student can solve a problem based on the two considered representations. On the other hand, our own past work in Costa et al. [7] shows an ITS for classical logic with focus on solving problems related to check the validity of a given argument. Then, this work is closely related to the present work in terms of its basic design and supporting problem-based learning.

The work proposed by Lukins, Levicki and Burg [8] shows an ITS to teach students basic concepts of propositional logic and theorem-proving techniques. However, one limitation in this work is that it offers just one representation of this domain. Our approach differs from this, mainly on dealing with multiple representations on the knowledge domain and on problem solving learning as a pedagogical approach.

3 Proposed Approach

In what follows, we describe the approach here proposed, presenting aspects concerning the target knowledge domain used in the tutoring system, considering three distinct representations: two symbolic and one visual. In addition, we present the architecture of the tutoring system and its dynamic.

3.1 Multiple representations and Curriculum Structure

As previously stated, the digital circuit subdomain here considered can be interpreted by different approaches, such as Boolean algebra or equivalently by the representations via logic gates or sentences of propositional logic, as illustrated by one example in Figure 1. A digital circuit problem in the proposed system has been addressed by the two symbolic approaches: Boolean algebra and propositional logic, but each generated sentence is automatically translated to one equivalent sentence expressed in logic gates as one visual representation.
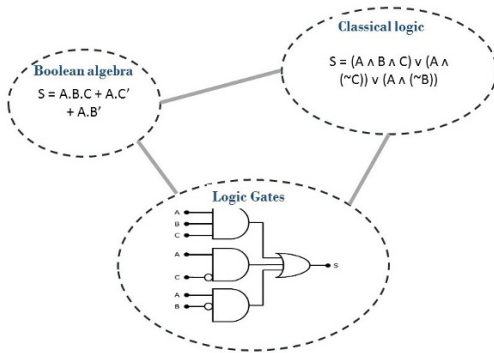
Fig.1. Expression described in three different languages.

A curriculum, as in Figure 2, is characterized by three interconnected graph structures: one to specify the topics or pedagogical units, other structure to specify problems that are associated with topics, and another to identify educational resources that lend themselves to knowledge support to help students in problem-solving activities. Then, a curriculum is composed by a set of topics (T). Each topic is associated to a set of problems (P). To each problem we have multiple possible solutions (S) for a particular problem P and a set of Knowledge Support (KS) as a kind of pedagogical resources, for example video, hints. Notice that, in Figure 2, we have expressed the notion of cardinality, characterizing two types of relationships: "one-to-many (1 to n)" and "many-to-many (n to n)." Each one of the three representation languages adopted in our work has an associated curriculum structure. That is, one for Boolean algebra, one to logic, and another to logic gates. To illustrate this structure, let us suppose that we have the following topics for Boolean Algebra: OR Relations, AND Relations, DeMorgan's Laws, Distributive Law, Identity Law, among others.
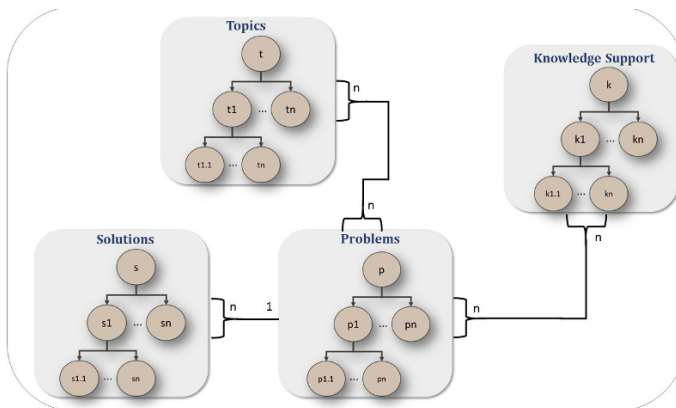
Fig.2. Curriculum Structure for the Domain.

3.2. Tutoring System Architecture

The architecture of the proposed system, as shown in Figure 3, consists of the following modules: an Expert Module, a Pedagogical Module, a Student Model, Domain Model, and an Interface. The Expert Module is composed of 3 rule-based systems: (1) a Problem Solver that is responsible for solving problem posed by the students, (2) Evaluator that is responsible for evaluating the solutions presented by the student, (3) Diagnoser that is responsible to find the possible cause of a certain error in the solution presented by the student, trying to infer an error from a knowledge base with mal-rules. Each one of these 3 rule-based systems contains a rule base, an inference engine, and an explanation module. In addition, the Expert Module has a Student Modeler component that is responsible for maintaining the student knowledge concerning topics and problems and then updates his profile in the student model. The Pedagogical Module is also a rule-based system that is responsible for the management of the student-tutor interaction, including different roles, such as: (i) task sequencing over the curriculum structure, allowing a personalized navigation, and (ii) a knowledge-based assistant responsible for providing pedagogical support to the student, giving him access to the knowledge support, such as hints, videos. Domain module stores the curriculum structure to be processed by the pedagogical module, as well as, the rule-bases to be used by the expert module. To implement all the involved rule-based mechanisms in this tutoring system, we have used the Inabit expert system shell [9].
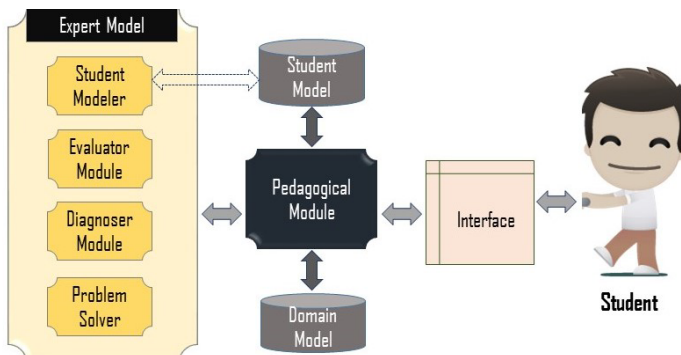
Fig.3. Tutoring System Architecture.

3.3. Functional View of the Architecture

To summarize a functional view of the proposed tutoring system, we illustrate the main interactions between the student and the tutoring system, as in Figure 4. In one way, an interaction session starts with the tutor selecting a problem taking into account the information about this student in terms of curriculum structure and student model, and then asks the student to solve the selected problem. In this case,

the student is required to explicit his problem-solving steps, showing each step and the corresponding justification. Then, the student can present a full solution to the posed problem or ask for some hint or even other kind of supporting. If the student presents a full solution, the system will evaluate it and inform the result. In case of correct solution, the student modeler updates the student model and then the pedagogical module decides the next action. If the solution is just partial, the tutor evaluates it and provides some adequate assistance. If the solution is not correct, the diagnoser is requested to find the possible error, exploring its mal-rules and then send the result to pedagogical model to provide the next action, for instance, giving some hint or other kind of assistance to the student. Here, it important to emphasize that during the interaction session, the tutor maintains the information about the context of the interaction student-tutor, and then update the student model. In another way, we have a situation where the student ask the tutor to solve a given problem and then the tutor via Problem Solver module solves the problem, presenting the solution step by step, as well as, presenting justification to each step. To each step, the system displays in particular window, a view on logic gates by showing to the current expression, a correspondent expression in a visual way in terms of logic gates. Alternatively, the student can choice another symbolic representation to check the solution expressed on it.
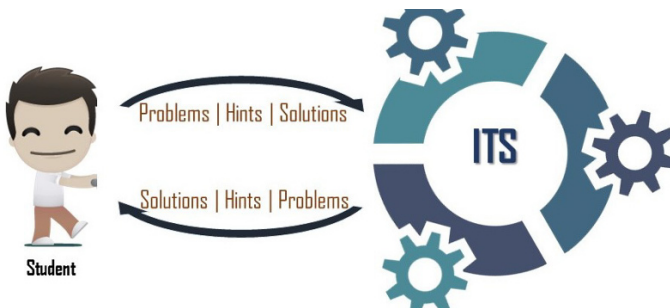
Fig.4. Interaction Student and Intelligent Tutoring System.

4   Evaluation of the Proposed Approach

The purpose of this section is to evaluate the proposed approach as concept proof, adopting different problem scenarios, aiming to cover the use of the functionalities associated to the defined architecture, emphasizing the components: Problem Solver, Evaluator and Diagnoser. These scenarios cover the tasks for problem solving, evaluation, and diagnosing, working as a kind of test cases used to analyze the system behavior.

4.1. The Contexts of Evaluation and Diagnosing

In this scenario is described a situation where the students are requested to solve

problems as selected by the system, providing steps involved in their proposed solution. Then the system starts an evaluation process via Evaluator Module that in case of existing some step not validated, it calls the Diagnoser Module to try to identify the cause of the supposed error. Hence, let us consider the following example related to a real problem, as illustrated in the three screenshots below, associated to the Figures 5, 6, and 7, concerning the design of a logic digital circuit to control the use of seat belt in automobile system designed to sound an alarm under certain conditions.
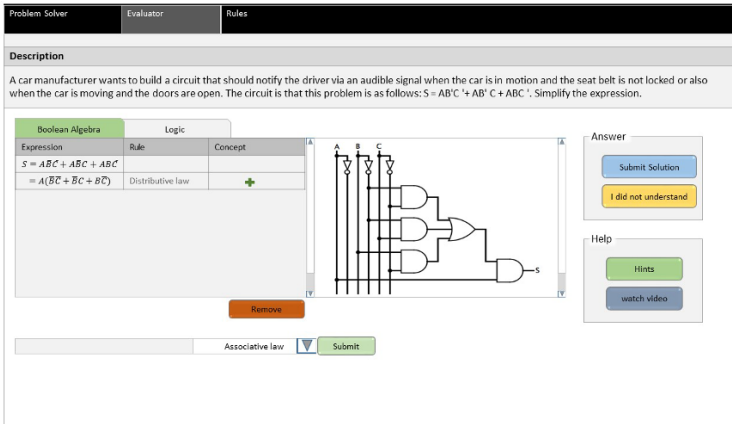
Fig.5. Screenshot: Student solving the problem: Step 1.

Fig.6. Screenshot: Student solving the problem: Step 2.

Fig.7. Screenshot: Student solving the problem, providing a step with an error.

The three screenshots showed above represent the main screenshots of the tutoring system, where we can see the following options:

1- Problem solver, Evaluator (and Diagnoser that is hidden) e Rules (laws and properties);

2- Problem Description area;

3- Workspace, where is displayed solution steps. In this part are shown: the expressions in the selected representation, each step used in the solution with the respective used rule, as well as, some assistance resource. This assistance may occur as follows: i) a green cross that indicates the correct application of the rule by the student; or ii) a red X indicating that the expression or application of the rule is incorrect. If something is incorrect, the student can get more details by blue balloon that appears next to the X;

4- Expression Edition: area reserved for the choice of the rule and sending option to partial solution;

5- Circuit: area where the system displays the correspondent circuit as the student will solving the expression using the selected symbolic representation;

6- Answer: area composed by a submit button of the complete solution or even a button with the option "I did not understand", where the student can tell the system that he did not understand the problem;

7- Help: in this area there are two buttons, where the student can seek help system asking for a hint or even watching a video.

4.2. The Context of Problem Solving

In the context of this scenario we describe a situation where the student requests the tutoring system to solve a given problem for him. This problem is adequate to

illustrate the system behavior when the system provides the student with a solution step by step, as well as, the justification linked to each step. Hence, let us consider the following example. The screen of the system contains the following resources:

1- System Options: Problem solver, Evaluator and Rules;

2- Input Expression: area where the student can enter the expression in logic or Boolean algebra and submit for the system to solve;

3- Workspace: Window where the student can observe each step of problem solution, according to the selected representation approach: Boolean algebra or Logic, having the correspondent used rules;

4- Circuit: area where the system displays the correspondent circuit as the student will solving the expression using the selected symbolic representation.

Fig.8. Screenshot – The Problem Solver module solving a Problem step by step.

5 Conclusions and Future Work

In this paper, an approach to explore multiple linked representations within an intelligent tutoring system on digital circuits domain, has been introduced. This system has been designed for helping students in problem solving situations to develop skills on designing digital logic circuits, taking into account a problem-based learning approach, focusing on logic expressions problem solving, dealing with symbolic and visual representations. The preliminary results using this tutoring system are positive, mainly with regard to its feasibility. Therefore, this work set out to answer the following question: "How to provide multiple representations for digital logic domain", having personalized assistance mechanisms to help students in problem solving in the domain of logic digital circuits. For immediate future work, we will invest in performing experiments in a regular digital logic course, in both technical and undergraduate courses.

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Open Course Ware (OCW) as support to the Social and Collaborative Learning

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Abstract. The Web 2.0 technologies have significantly increased the access and use of contents on the websites, in the field of Education OCW provide students, faculties and self-learners the opportunity to access the prestigious Universities in the world. The aim of this study is to propose the integration of social technologies in the cycle of production and publishing of OCW in order to enhance the social and collaborative learning. The proposal is based on the analysis of literature review and application of quantitative and qualitative methods in a case study, the level of acceptance and expectations of integrating social technologies in Open Educational Resources (REA). The obtained results are a social and collaborative production cycle (REACS) complemented by social technologies implemented to Educommons platform to promote access, use and collaboration of this kind of resources.

Keywords: Education, Technology, resources, OCW, collective intelligence, collaborative learning, social web, social networks.

1 Introduction

The introduction of the social web in education assumes that student learning processes have a social, personal and dynamic character; knowledge will be explicitly acquired and interactive within a continuous process; and education will be more creative, participatory and socializing [1]. With exponential advances in technology occurring at a faster pace than social adaptation, educational challenges will be evolving in parallel to make possible adjustments between technology and society [2].

Open Educational Resources (OER) were defined at the 2002 UNESCO Forum, as follows: "[…] the digital materials that are offered open-source for educators, students and autodidacts for their use and reuse in education, learning and research" [3]. Although OER and OCW promote access to education, social networks are booming technologies that can provide tools for social learning. We believe that an integration of the stronger aspects of the web within a reference framework that is applicable to OCW sites will multiply its benefits, such as knowledge and content accessibility, education globalization and student satisfaction. The reference framework includes a

methodology that is oriented to the social and collaborative production of OCW resources, and it also include a tool that supports the methodology (production cycle) in its implementation phase.

1.1 Technologies for Learning

Learning technologies are the outcome of information and communication technologies (ICT) applied in education. Through collaborative technologies, knowledge is constructed and new spaces for learning are promoted. Educational institutions are increasingly adopting tools and technologies that allow for improved collaboration between teachers and students. Social networks and cloud-based tools are changing the methods by which teachers communicate. Open resources, wikis, and Google 'Apps' are tools that enable the free interchange of ideas and interesting and rapid discussions between teachers and students. As a result, there are greater opportunities for collaboration and an increasing perception of positive change in the dynamics of the teacher-student relationship [4]. The New Media Consortium has stated that the open technological trend has occupied a primary position for short-term (less than a year) and higher education [5] release of content and publication of open resources for transparency and ease of access to data and information.

1.2 Open Course Ware

According to the OCWC, OCW consists of a free digital publication that is open and contains high-quality educational material at the university level. The OCWC is currently composed of more than 289 organizations belonging to 40 countries whose production of OCW courses is at approximately 30000. However, each institution has a specific production process, which can it can be observed in section 2.5

1.3 OCW Production and Platforms

In the production of OER, the needs of the teaching and student communities have to be considered. OER must be delimited within their own action field, meaning that they must be integrated as a project where persons and organizations participate. These organizations have to be experienced in pedagogy and the didactics applied to educational material design. The resulting product has to be attractive for the user, and the existing platforms in the market must be reviewed.

1.4 Design of Learning Models

Open educative design corresponds to the use of instructional design techniques that include the analysis, design, development, usage and resource evaluation that provide the source of the design. These techniques document different elements considered during the process, from the principles, techniques or applied theories to the final

artefacts with which the apprentices interact and their usage data [3]. Additionally, in OCW design, one has to consider the elements that are used in an online course design, described in [6]. Learning theories: theories of how a person learns, including the following: a) Pedagogical models, b)Educational system, c) Hypermedia tools.

1.4.1 Instructional Design Models

Open educative design corresponds to the use of instructional design techniques that include the analysis, design, development, usage and resource evaluation that provide the source of the design. The creation of an instructional design model becomes complex according to [7]. In contrast to what can be performed during in-person education, under a distance mode, it is necessary to perform the courses in a structured manner, employing strategies, methodologies, and tools to modify the learning process. With the aim of students obtaining real knowledge, he/she becomes the main object of study because the success of their education is evaluated according to their constant participation. There are many models for instructional design. However, in the analysis Table 1, we have selected the most frequently used model based on the analysis performed by [8]:

Table 1. Comparison of Instructional Design Models

Model	Strengths	Weaknesses
ASSURE	Develop a characteristic environment for each student.	The teacher might design the course incompletely or with inappropriate material
DICK AND CAREY	Organization objectives and analysis, specification of the processes that are used to meet the goals.	Each process has a sequence, where if one fails, the entire process stops, causing an increase in the scheduled time.
JONASSEN	To develop critical thinking in each student.	Rigorous teacher preparation that better suits the material used.
ADDIE	Instructional design model commonly used and represented by a workflow that allows each phase to be interconnected with each other, where the result of each phase is the beginning of the next [9].	Closed System

1.5 OCW Production

The study by [10] concerning OCW initiatives and their platforms analyzed 176 universities worldwide and used the OCWC, Spain and Universia for the data source and data analysis. The study identified the most used platforms in the world as EduCommons 37% and Moodle 25%, followed by other platforms (own university developments) at 25%.

2 Problem statement of reasons

Social and collaborative learning, learning technologies, OER and OCW have broad potential to enable access to knowledge; however, they have not been developed to their full potential, which is shown by the following:

- [11] suggest that there is a wide range of OER for virtually all disciplines. The basic infrastructure for searching and finding is well organized. However, the use of OER in the actual educational practice lags behind the expectations.
- [12] argues that social learning is a key element within the tectonic movements observed in the educational landscape, where the OER correspond to an important feature. However, in the absence of quality interactions around OER, their potential to enhance or even transform learning is greatly reduced.

However, [13] in their book The New Social Learning, provide a good contextualization of the possible solution: "social media is the technology used to join three or more persons, and social learning is participating with others to make sense of new ideas. What is new is how hard you work together."

In a review of methods for OER creation, [14] conclude that there are few systematic methods for the creation and acceptance of appropriate OER. In addition, they suggest that little attention has been provided to the adoption of technologies, such as the Web 2.0 and the Semantic, even after being considered in [15] and despite the great potential of these technologies to effectively contribute to the development, publication and search for OER. In [16] suggested that the creation and use of digital content in the open educational movement within Latin American networks still require work on the collaborative culture and resource sharing, analysis of technologies for the production and publication of educational resources, impact of using these resources at different educational levels and long-term sustainability of an open education project.

To influence this approach, it is necessary to analyze the production cycles of the most important institutional OCW sites. Initiatives such as the Degree Directory categorize the OCW sites, performing a ranking of OCW courses and areas of expertise. Similarly, the Unit of Scientific Culture and Promotion of Research at the Universidad de Murcia ranks the OCW sites only by the number of courses offered at the institutional OCW site. However, these categories are limited to just one variable or indicator. Therefore, this paper has provided a categorization based on various indicators to determine the relevance of OCW sites based on the parameters in [17] which have been updated in [18]. These are detailed in Table 2.

Table 2. Correlation of indicators for OCW site ranking.

Indicators	Indicators proposed in (Webometrics, 2014)
N° of visits	Visibility (external links)
N° of results in searches on Google sites	
	Altametrics
N° of resources	Size in N° of pages
	Rich Archives
N° of citations in indexed databases	Google Scholar

The proposed indicators are consistent with the nature of the OCW sites and can detect maturity in the diffusion process and investigation of OCW sites. The proposed indicators are described below.

- **Number of visits**: This parameter is known as the traffic rank; it determines the popularity of a website based on the number of visitors [19]. This was obtained of the number of monthly visits average was obtained for each site using the traffic estimate tool.

- **Number of sites returned with a Google search**: The results obtained on the following search sites are considered to demonstrate the visibility of the OCW sites, Google site search indicator, the direct observation technique for data collection was used, and it corresponds to a technique where the researcher takes data directly from the population without questionnaires and interviewers. According to [20] the participation and observations of researchers in virtual environments develop with more dynamism and interaction.

- **Number of resources**: This parameter is used to determine the number of published courses, and it checks whether there is a process for the publication of the OCW courses within the institution. These data have been obtained using the technique of direct observation. It should be noted that there are sites that indicate the total number of published OCW and others where the total number of courses had to be counted.

- **Number of citations in scientific databases**: This parameter allows for the demonstration of the scientific quality of research undertaken and therefore the corresponding visibility in research related to OCW. The remaining sites correspond to OCW sites appearing with greater citations in indexed databases.

A comparative study has been conducted by collecting data from institutional OCW sites. This information is stored in a format that allows for building comparative tables according to the established indicators. Table 3 describes the assigned weights for the proposed indicators in Table 2. The weights are consistent with the weights given in [18]

Table 3. Parameters proposed for RSOCW

PROPOSED PARAMETERS			PROPOSED PARAMETERS IN (Webometrics, 2014)	
INDICATORS	WEIGHT (%)	ARGUMENT	INDICATORS	WEIGHT (%)
N° of visits	10	Website popularity	Visibility (external links)	25
N° of results for Google site searches	40	Visibility of the OCW site	Altametrics	25
N° of resources	20	Greater number of resources that a OCW has. Shows that a structure from the OCW creation could exist. Therefore, it is possible that it has been developed following a standard process	Rich Archives	10
N° of citations	30	Quality of the research	Google Scholar	30

in indexed databases	works around OCW. The quality is associated with a sequential process.

The following metric was defined to determine the relevance of the OCW sites:

$$RSOCW= p1(P1) + p2(P2) + p3(P3)+ p4(P4)$$

Where:

P=Number of visits	p=10%
P2=Number of results in Google sites	p2=40%
P3=Number of resources	p3=20%
P4=Number of citations in indexed databases	p4=30%

The results obtained by applying the metrics are shown in Figure 1.

	MIT	OUUK	OUNL	UPM	TU DELFT	JHBSPH	UTAH STATE	TUFTS	UC3M	OPEN YALE
N° DE VISITAS (10%)	10,00	1,70	0,19	0,91	0,73	0,27	0,71	0,91	0,01	2,90
N° DE CURSOS (20%)	20,00	5,95	4,86	1,43	1,17	1,02	0,74	0,49	1,90	0,38
BÚSQUEDAS SITIO GOOGLE (40%)	40,00	10,00	10,00	30,00	40,00	30,00	30,00	40,00	40,00	30,00
N° DE CITAS (%30)	30,00	2,86	1,43	8,57	1,43	1,43	4,29	1,43	2,86	4,29
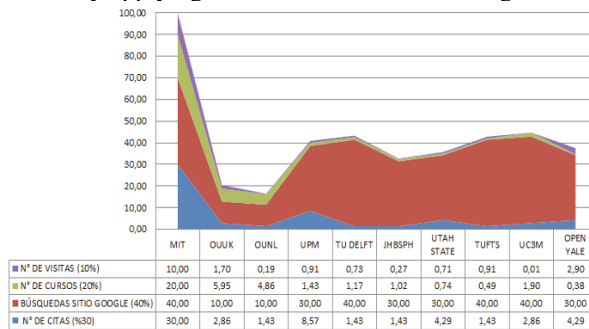
Fig. 1. Relevance of OCW sites

Based on the results in Figure 1, we have selected the five institutional OCW sites that have a higher score. These will be the targets of the methodology analysis for building OCW. In addition, the Technical University of Loja is also included because it is the site where the proposal described in Chapter 3 is going to be implemented. The analysis of each OCW site for the process of creating OCW will then be performed. It is evident that there is no standard methodology, with each OCW site adapting a methodology in accordance with its institutional policies; this is shown in Table 4:

Table 4. Production methodologies for OCW and utilized platforms

OCW sites	Methodologies for Instructional Design	Platform
Massachusetts Institute of Technology (http://ocw.mit.edu/)	Own Model	MIT OCW
Universidad Politécnica de Madrid (http://ocw.upm.es/)	Shared Model	EduCommon
Universidad Carlos III (http://ocw.uc3 m.es/)	Own Model	EduCommon
Delft University of Technology (TUDelft) (http://ocw.tudelft.nl/)	Own Model	Typo

| TUFS University (http://ocw.tufts.edu/) | Own Model | |
| Universidad Técnica Particular de Loja (http://ocw.utpl.edu.ec) | Own Model | EduCommon |

From the previous analysis, we conclude that there is no standardized process of creating an OCW. Thus, it is unclear what processes are used by institutions and/or associations in the production of OCW courses. The objective is to propose a standard process that includes best practices for creating educational resources that compose OCW.

3 Solution proposal

The importance of social technologies lies in the widespread growth of access and use. [21] Garcia (2012) suggests that "social technologies have been introduced recently in the lives of many people who were previously outside the Internet phenomenon... The extraordinary ability of networks to bring together people has caused many to use them with very different purposes." Education and the production and implementation of OER cannot remain oblivious to such social phenomena.

The integration of potential access to and use of social networks in the context of OCW-OER has been analyzed formally [11] and informally [22] (with results and contributions.

This work focuses on the integration of social technologies in the production and implementation phases of OER/OCW to promote social and collaborative learning through a framework composed of the following:

- A production methodology called the production cycle of OER with social components (REACS), which integrates social tools at every production stage of OER/OCW.
- Social technologies that support the implementation of the proposed methodology by integrating social functionalities into the platform where OCW are published.

The next sections describe each of these components:

3.1 Production Cycle for OER with Social Components

The REACS production cycle includes social components in its process for each of the phases. This contributes to a collaborative work among the staff.

The production cycle proposed in [23], shown in Figure 2 is focused on providing flexibility and a continuous improvement of resources; thus, it should be possible to identify an opportunity at any phase. The REACS production cycle is based on the ADDIE instructional model design. In each of the phases, social components have been incorporated that contribute to the social and collaborative learning among students and teachers.
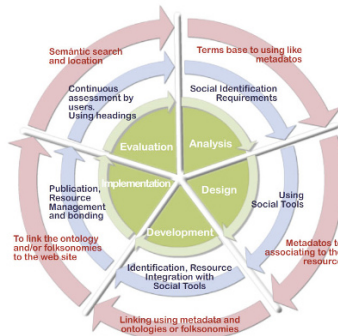
Fig. 2. Production cycle with social and semantic components **[23]**

Next, we describe on Table 5 all the components an REACS should have in each of its cycle phases, its contribution to social and collaborative learning and expected results.

Table 5. Phases of REACS with its contribution to social and collaborative learning and expected results

Analysis: To identify the needs of the user to be met by the OCW and answer the following questions: What do we need to produce? What is the learning problem? It should be noted that teachers and students are considered as users at this stage.	
Contribution to social and collaborative learning:	**Expected Results**
- Social and collaborative collection of the course requirements using tools such as social networks, micro blogging, blogs and wikis and considering users as a source. - Analysis of the learning requirements in a collaborative manner using tools such as wikis, blogs and Google Docs.	- Implementation of social tools, such as blogs, wikis, social network, etc. - Requirements of the course students. - Suggestions of aspects to consider for the course design. - Definition of general metadata.
Design: To define the structure of a course by incorporating objectives, content, categorization, metadata, policies, licenses and user profiles.	
- Definition of objectives, basic content, structure, categorization and metadata publishing policies through social tools (wikis, blogs, Google Docs) to enable effective participation of designers, experts, educators, academic peers, students and staff. - Provide spaces and periods of social feedback to raised definitions using social tools.	- Structure and components of the course. - Resources that are identified and categorized. - Base taxonomy with the general, specific and social metadata. Management strategy for metadata.
Development: To produce the resources according to the structure defined in the design phase.	
- Reuse available OER social structure with social tools considering quality criteria, such as the evaluation associated with each resource, comments, number of views and	- Selection of OER applying quality criteria. - Integration of OER developed and reused from social tools.

ranking.

- Use socially defined metadata to identify OER.

- Develop new OER according to the characteristics defined in the design.

Implementation: Publication of the new OCW on the OCW institutional site.	
- Disseminate new OCW publications using social tools, such as microblogging, social networking and RSS. - Provide new OCW with reputation systems, version control and feedback tracking. - Use the socially defined metadata in the analysis and design phases. - Use tools for monitoring and managing the new OCW	- OCW courses published in the OCW website of the institution. - RSS linking related OER with the new OCW. - Dissemination of the new course through social tools. - OCW tracking tools.
Evaluation: To monitor, control and improve the resource.	
- Monitor the acceptance of the OCW based on assessment received in social tools. - Identify potential improvements applicable to OCW	- Feedback from users of the OCW to enable decision making on the quality and serve as input for the next iteration of the production cycle. - Versioning of documents from the design phase shared in Google docs. - Reports of OCW monitoring tools.

3.2 Social Functionalities for OCW Platforms

To complement the proposed OER production cycle, we have developed and implemented social features for the EduCommons platform where the OCW are published. Thus, the OER production cycle can be implemented successfully and enhance the social and collaborative learning.

To identify the functionalities to implement, we have utilized the UTPL as a case study and have adapted the approaches in [24] regarding the high use of SNS and [11] on the low level of use of OCW. The results were as follows: 96% of students use SNS. The most used SNS are 29% Facebook, 27% Twitter, 18% and 14% Google+ LinkedIn. 67% report a SNS usage time of 2-8 hours per week. 81% believe that it is "very important and important" to incorporate social networking features in OCW. The features considered most relevant are the ability to leave assessments, comments, post contents and posts on other social networks. Only 28% know, use or have used an OCW site. From the results obtained in the study, we have identified the social features suggested as relevant. These must be implemented and are described in Table 5: Having identified the requirements to be implemented, the OCW for this platform is selected. We considered several OCW sites as the most representative (see Table 4), which were selected through direct observation. We then identified the platforms being utilized.

Because the EduCommons platform is the most used [10] and is used by the UTPL, it will be the platform used for development and implementation. EduCommons was developed in the CMS Plone on top of the Zope architecture with a Zope Object Database (ZODB). Prior to development, we performed a systematic

review to identify functionalities available to EduCommons, Plone and Zope. The development of the missing functionalities was performed using Plone Buildouts logic and OpenBD Products. These are integrated, which is feasible because they correspond to a CMS open source template. Table 6 summarizes the development and customization of products made to meet the requirements.

Table 6. Utilized platforms in OCW

Requirement	Develop	Reuse Code
REQ01: Assess I like button		x
REQ02: Share Information	x	
REQ03: Comments		x
REQ04: Link to social networks		x
REQ05: Social Widgets		x
REQ06: Social Tagging	x	
REQ07: OCW Activity		x

The implementation has been performed for OCW-UTPL on a local server. Figure 3 shows a screenshot of the implemented social features.

Fig. 3. OCW with social functionalities.

Finally, the validation phase was oriented to verify the implemented features. The level of acceptance was measured using two types of tests. The functional testing aimed to identify deficiencies in the functions for which they were created. Communication errors were found for Google+ and Twitter, as well as security checks, in certain developed products. These errors were resolved prior to the following tests. We observed user tests with 0% error and 98% acceptance.

4. Conclusions

The literature review emphasizes that the features, benefits, uses and applications of

OCW evidence that even though they are not the latest evolution of the REA, they represent a challenge for research and application of IT in education because of their potential to democratize access to knowledge of the universities.

This paper presents a development cycle of REA, called REACS, which pretends to substitute the absence of a standard process in the OER development in institutions. The use of REACS aims to standardize the development of content for OCW. At the moment, it has been tested successfully in developing new courses for the OCW of UTPL.

The implementation of the REACS production cycle at UTPL makes it possible to reduce the processing time of production and publication of new OCW in a 50%, which constitutes another contribution of REACS cycle for OCW initiatives.

The production cycle proposed was complemented by social and collaborative components, since it was detected that the use of SNS is quite high in other OCW environments; for that reason, it was concluded that its introduction in the OCW is a benefit, because it promotes social and collaborative learning by incorporating the reuse of existing resources and the collective intelligence which is product of the participation of teachers and students.

The use of this method for producing OCW courses makes emphasis on the usage of collaborative tools that drive university teachers to be part of this type of projects that help both, people as well as students who use them.

5. Future Work

Implementation of the proposal through case study.
Implementation of security in social tools used in the production cycle REACS

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A Hypermedia-based Online Educational System for Assisting Accounting Students in Systems and Information Technology Course

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Abstract. There has been observed, after a questionnaire applied to accounting science students in a public university, a significant lack of motivation of them with respect to the discipline of Systems and Information Technology, as part of the solid formation in this undergraduate course. In addition, it was also observed that there were many different specific interests among the students concerning accounting profession specializations. To mitigate this problem regarding motivation and diversity aspects, we propose an approach using a hypermedia-based online educational system for improving teaching and learning processes in the mentioned discipline for accounting science. This paper gives an overview of our approach with the current system, discussing its design and implementation aspects concerning its main components: adaptive model, student model, and domain model. We evaluated this approach with respect to its associated system and preliminary results indicated that it is feasible concerning its potential for adaptively assisting its users.

Keywords: Online educational systems, Adaptivity, Systems and Information Technology.

1   Introduction

Some studies report the growing disinterest and lack of motivation of undergraduate students with respect to traditional design and the execution of a standard course in the classroom concerning the discipline of Systems and Information Technology. Particularly, in the earlier work [8] data were collected from accounting science students to obtain their opinions about motivations and to know about their

professional interests aspects, including specializations, such as Managerial Accounting, Cost Accounting, and Auditing. Hence, a questionnaire was applied to these students in a public university, then diagnosing a significant lack of motivation of these students with respect to the discipline of Systems and Information Technology, as one of the fundamentals in terms of a solid formation in this area. In addition, we also observed that there were many different interests among these students concerning professional specializations.

From this problematic scenario, we set out the following particular research question: How to design an appropriate educational technology to effectively meet the diverse professional interests of students and also to address the lack of motivation in the context of the mentioned discipline for the course of Accounting Science at the mentioned University? Overall, to mitigate this problem in a previous work [8] was presented evidence that suggested that adaptive hypermedia technology is suitable to provide customized pedagogical resources for students and its adequation to deal with the diversity of students' interests in terms of professional specialization. Then, we follow this track by presenting an adaptive approach using hypermedia-based online educational system for assisting students to accomplish their particular activities, allowing them flexible access to the digital resources they need to know in the mentioned discipline, as well as, recommending appropriate actions during the interaction process. The main idea is still to provide such system to serve as complement of the work in the regular classroom, helping teacher and students in the learning processes, for instance, firstly linking content structure to professional interests. We focus here in extending the system in the mentioned earlier work, taking into account an analysis on the previous system in an experiment involving 94 undergraduate students from the mentioned discipline, investigating some limitations in such system. Hence, we discuss the current system in terms of design and implementation aspects concerning its main components: student model to represent students' profile, domain model to represent the subject matter and domain knowledge, and adaptive model, offering intelligent and adaptive tools to assist the student to interact with the learning environment associated to the educational system.

We evaluated this approach with respect to its associated adaptive system with the rule-based mechanisms added to earlier system, involving its main components, and preliminary results indicated that it is feasible concerning its main purpose in adaptively assisting students and teachers.

The rest of this paper is organized as follows. Section 2 presents some background knowledge, giving basic concepts related to the main modules commonly found in an adaptive hypermedia system. Section 3 describes the proposed approach with its adaptive system involving its main requirements, its overall architecture, and its main functionality and interactions among the modules. Section 4 presents an evaluation of the proposed approach, focusing on the current system and offering comments on the preliminary results. Finally, in section 5 we present some conclusions and discuss some future work.

2   Some Background Knowledge

Adaptive technology [6] has been widely used in several areas, including education with, for example, the fields of adaptive hypermedia and Intelligent Tutoring Systems [9]. Particularly, a typical adaptive hypermedia system can be characterized by its aim to offer personalised tools by considering some relevant differences among users and that different individuals are different at different times, therefore taking into account the user's goals, preferences and knowledge [2]. Therefore, such a system usually offers adaptive presentation, providing the different content for users with different knowledge, goals, and background. Furthermore, it also offers adaptive navigation support for guiding the users by providing orientations regarding the exploration of contents. To this aim, the adaptive hypermedia architecture is composed of three models, usefull in educational settings: the user model, the domain model, and the interaction model [3].

The user model is a crucial module in the adaptive hypermedia system that maintains a representation of the user's knowledge state and his preferences [4]. It includes user's (which may be an individual or even a group of people) goals, background knowledge, preferences and needs, which may eventually change overtime. Among several different approaches to student modelling [7] is that where the knowledge for the user model can be acquired implicitly by making inferences about users from their interaction with the system, by carrying out some form of test, or by assigning users generic user categories usually called 'stereotypes' [1].

The domain model defines the knowledge aspects of the application, which includes educational content associated to the concepts, exercises, and other entities of the domain. However, essentially, the primary purpose of this model is to provide a structure for the representation of the domain knowledge.

The interaction (adaptation) model is responsible for providing students with educational resources based on the relationships that exist between the representation of the user model and the representation of the domain model. Therefore, it contains everything, which is concerned with the relationships, which exist between the representation of the users (the user model) and the representation of the application (the domain model) [1].

3 Approach and System Description

Our approach consists of methods and mechanisms to provide a customized educational experience that meets the professional interests and needs specific to each student. The system here described extends a previous work that was designed as a supplement to regular classroom, therefore having the teacher with an active role, participating in the adaptive interaction process. The overall aim is to present content structure in hypermedia module wih a hyperspace and then provides interactions tailored to the students based on their characteristics and domain knowledge,

considering the customization of individual (or group) branches through the contents from the hyperspace, taking into account learning activities. Towards this end, we developed a prototype for the online system by focusing on the adaptive mechanisms. In what follows, we describe the approach here proposed, focusing on the aspects concerning the principal elements of the adopted adaptive educational system with a hypermedia module containg a hyperspace.

The conceptual structure for this system follows the reference model presented in Section 2, adapting it to educational purposes, as illustrated in Figure 1, which essentially consists of three models: the student model, the domain model and the adaptive model. But, before discussing the system in itself, we present some comments about the initial phase of this research work to better understand the problem and to influence its solution with the choice of the adaptive educational system.

3.1 Preliminaries

As a starting point in the design phase in a mentioned earlier work, one conducted a survey of 94 students aiming at identifying in advance characteristics of the students with respect to their preferred professional interests in terms of specialization in accounting science, including specializations, such as Managerial Accounting, Cost Accounting, and Auditing. This enabled the definition of course with different paths to follow in the interaction process as in [8], providing possibilities for content adaptation considering different professional interests and needs. It can facilitate the course design to be tailored to each student, taking into account his starting level, where different options for navigating through the content structures of the course are available from domain model as defined in Section 3.2.

The current adaptive hypermedia educational system extends previous work, mainly by investing in improving the adaptive interactions between student-system, but also helping the teacher in some situations. In addition, we have also considered some ideas from an adaptive learning environment that integrated two technologies: Intelligent Tutoring System and Hypertext [5].Then, we have worked on the main components from an adaptive hypermedia system, as in the architecture discussed in Section 2, investing in each one of the main components, as well as, in the interactions between these components.
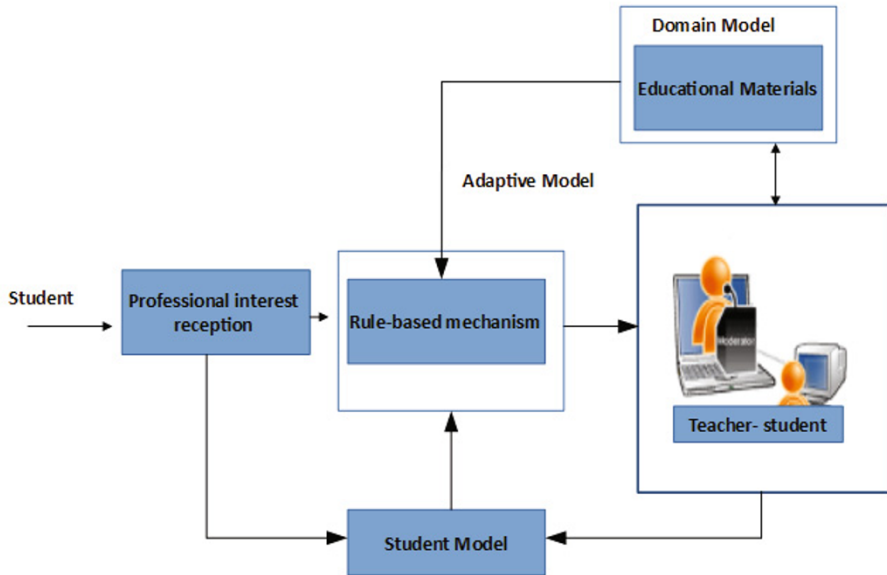
Fig 1. Conceptual Adaptive Educational System Architecture.

3.2 Domain Model

As previously stated, the Domain Model describes the structure of the knowledge content, representing the domain knowledge, containing a collection of topics with several concepts related to the content and learning objectives of the system, serving to be explored by the students. Associated to each topic also there are activities used to evaluate knowledge acquisition by the student, as well as, there is project as a special kind of activity used to promote the general evaluation covering all the topics. Basically, there two types of activities: open questions or multiple choice questions. In what follows, in Figure 2, is our proposal to the knowledge structure of the target subject, focusing on information system part, which has been used in our application domain from the mentioned course. It includes all the concepts that are going to be presented to the students, as well as, all exercises associated to these concepts. This model uses a hypermedia module with a hyperspace containing a collection of hyperdocuments and a navigation control. Each topic corresponds to one of these hyperdoduments.

The purpose of this model is to structure the knowledge or information contained in the system to be displayed depending on the professional interests of the student and his needs in terms of contents from the domain.

Design and structure knowledge space in Information System course for Accountants
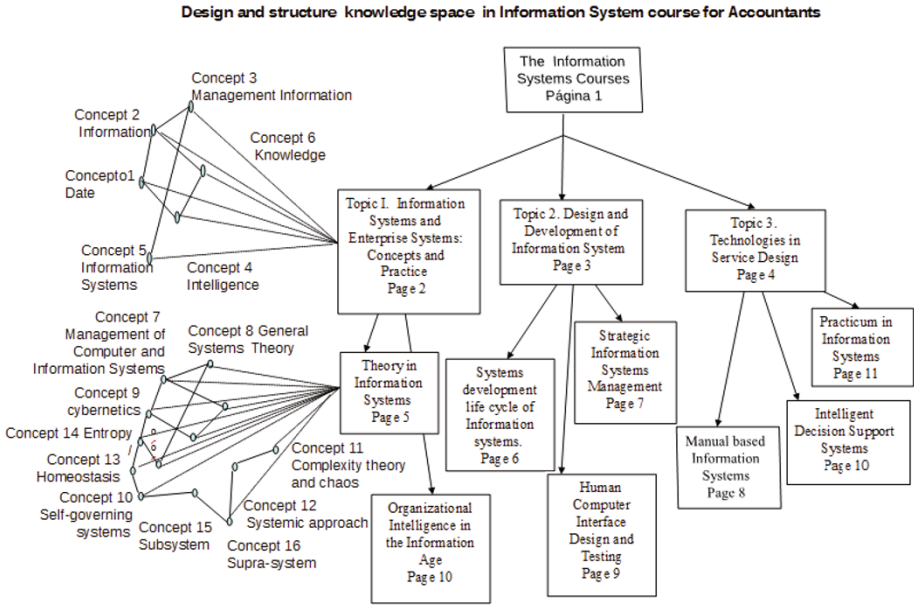
Fig. 2. Domain Model with the structure knowledge space in Information System course for Accounting.

The general goal is the adaptation of content, which involves generating real-time learning activities, by assembling atomic resources consistent learning activities based on student cognitive requirements.

3.3 Student Model

This module stores information about the student, as a kind of internal representation of the student, taking into account static and dynamic information. Static information is primarily obtained when the student starts a course and informs through a questionnaire his professional interests in terms of specialization related to accounting area, including: Managerial Accounting, Cost Accounting, and Auditing. Dynamic information is captured, by a dynamic student modeling module, according to the performance obtained by the student in activity-solving on the topics, during the course. Therefore, besides the static part, this module contains an evolving descritpion of what the student knows about the subject domain, specifically the concepts and topics from the knowledge domain. To each student in the course, there is a student model associated to him, but we also provide group model to put together students with similar profiles.

This model is an internal representation of the student, stored, maintained and accessed by the system and by the teacher, in order to adapt to each student, providing navigation and presentation of the information according to student needs and

professional interests. Hence, in our proposal, we defined a student model to have three kinds of information in related table structures containing: student's professional interest, domain knowledge concerning the mastering of topics and concepts, and activity-solving performance.

3.4 Adaptive Model

This module is responsible for helping the teacher and the system to adapt the content and the navigation on the hyperspace to each student according to his particular characteristics based on static and dynamic information as stored in the student model. Then, the adaptive navigation mechanism helps students to find their paths into hyperspace, adapting the way to present the links. The same link can lead to different students at different hyperdocuments. The navigation control module is responsible for managing the hyperspace in hypermedia module from domain model and its interaction with the student. In this case, the system can provide navigational support tailored to student, using decision rules to select which concepts should be presented in the hyperspace structure. To this adaptive end, this module uses its navigation control mechanism and information from the student model and from the domain model with its structure containing relationships among the concepts. Therefore, the implementation of this module is also based on a rule-based mechanism. However, as a startpoint a particular mechanism first executes a matching operation that maps the student professional interest to an appropriate content structure from the hyperspace in the domain model. After, during the learning process, another rule-based mechanism helps the teacher to select content feedback to be recommended to be explored by the student, as the student needs, as a consequence of his work on some activity or on a given project. Particularly, when a student makes a mistake with an incorrect answer for a given activity the system notify the teacher informing that an error occurs and then he provides a pedagogical intervention for helping the student.

3.5. Student-System Interactions

As illustrated in Figure 1, firstly the student begins in a first session by logging into the system and then he needs to fill in a form, where, among other things, he is requested to state his professional interests to be stored in student model associated to him. After this introductory part, there is a first adaptive action, where the system uses a matching operation that maps the student interest to into an appropriate content structure path from the hyperspace in the domain model. From now on, the student interacts with the teacher and with the system through the selected content path, where student enters in a kind of activity-based learning approach to be worked individually or in group together other students with similar interests. During this learning process, each student is allowed to freely explore the content available in the

hyperspace from the domain model, as well as, he can also explore the content in a guided way where the system offers personalised assistance. Each activity to be solved is associated to topics from domain and it has a defined time slice to be completed. Moreover, student is allowed to request a help in any stage of activity-solving process and in this case, the system displays a resource associated with the skill tested by the activity. After submitting a solution, the student receives one evaluation, any pedagogical recommendation and this evaluation is stored in the student model, updating it. If the student answers incorrectly, or requests help, the system notifies the teacher and then an assistance is provided the teacher. The rule-based mechanism adapts its behavior to student and to teacher based on data from the student model and from the domain model.

4 Evaluation Study and Results

This approach with an earlier hypermedia system was partially evaluated by focusing on the aspects of performance, satisfaction, and motivation, considering data collected from an experiment conducted in a regularly scheduled class sessions, where students interacted with a hypermedia module integrated to the Moodle platform, involving third-year undergraduate students from a large public university. In this context, the assessment of the academic performance gains for the students was based on data from measures on activities and project performed by the students. Overall, the analysis for performance revealed an important increasing. These performance gains suggest that the proposed approach seems interesting. Concerning satisfaction aspect, an activity was accomplished to measure the levels of student satisfactions regarding adaptations of activities taking into account their professional interests. The analysis for satisfaction revealed 28 students from 42 consider their satisfaction level as high. Nevertheless, even with these positive results, the system implemented in the Moodle platform associated with this approach in the mentioned experiment, practically did not offer automatic services to the users. This fact is not interesting neither to teacher nor to students. Therefore, we decided to go further by extending this system to include automatic and adaptive mechanisms based on if-then production rules, as discussed in Section 3, where we provided a presentation related to the main three models: student model, domain model, and adaptive, as well, the interaction protocol among theses models.

The brief evaluation regarding the current system with respect to its adaptive mechanisms to automate part of the personalised student support indicated that they are feasible, they work in the sense all the input-output tests accomplished, the results were positive. This part of the system was tested by two teachers aiming to check its functionality in different scenarios to cover situations where students needed support. Nevertheless, these functionality tests were accomplished with these mechanisms working isolately, but in the future we need to test them integrated to the system as whole and then being used in real courses.

5 Conclusions and Future Work

In this paper, we have presented some of the key aspects of an adaptive approach for hypermedia online system aimed at assisting accounting students in a personalized way to appropriately interact with the digital resources that are part of material of the discipline of Systems and Information Technology. The personalized interaction solution is achieved by the system when it uses static and dynamic information from the student to recommend educational actions to follow in the course or digital resources within the domain. We then designed our customized solution for the main modules in a hypermedia adaptive system, defining a static and dynamic solution for the student model, defining a domain knowledge model, and finally the adaptation model to provide an effective way of navigating on the content associated to domain knowledge, taking into account particular characteristics of each student, including his professional interests that are captured in advance.

Based on the evaluation conducted and results presented in Section 4, concerning previous work, the main conclusions with our approach can be summarized as follows: the students accepted our approach, gaining with it more active participation and satisfaction in the learning process, and increasing in their academic performance. With these positive results, we then extends the earlier system to have automatic mechanisms for adaptively helping students and teachers in educationally exploring content resources from hyperspace in domain model.

As a future work, we need to conduct more experiments with other classes, this time with the proposed extension, as well as, to experiment the approach with the current system applied to similar domains.

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Part III
Information Technologies
in Radiocommunications

A Sum-Rate Maximization Scheme for Ultra-Dense Network[1]

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Abstract. This paper considers the power allocation to maximize the sum-rate of the users when the total allocated power is limited in the ultra-dense network (UDN). In the paper, we first regard the interference caused by the specified base station (BS) to the other mobile station (MS) as a constant, and obtain the expression of the allocated power of each BS. However, it is not a closed-form solution, we apply the classic water-filling algorithm to get the optimum power allocation by some times of iterations. Finally, the simulation results show that the power allocation scheme can greatly improve the sum-rate of the users compared to the average power allocation.

Keywords: ultra-dense network, water filling algorithm, sum-rate maximization

1   Introduction

The rapid expansion of the data traffic and the mobile users has proposed some challenging requirements for the future 5G wireless network in terms of the capacity, spectral efficiency, energy efficiency, and so on [1]. Ultra-dense network is expected

to be an effective method to fulfill these requirements. It brings BS closer to the MS, which make the interference much more complicated [2]. Therefore, some effective methods of resource management should be adopted to alleviate the interference and get the greater capacity.

There have been many researches of the UDN. [3] [4] and [5] analyze the effect of BS density to the network spectrum efficiency (SE). Other researches concentrate on the interference management of ultra-dense network. And nowadays, much attention has been paid to the green communication, so increasing the network throughput with the limited power is necessary in both academic and engineering. [6] gives a strategy to decide the number of BSs to switch off to maximize the energy saving, while maintaining coverage, capacity and quality of service. [7] draws attention to the area throughput and the energy efficiency (EE). The classical water-filling based power allocation is often used in Orthogonal Frequency Division Multiplexing (OFDM) systems [8].

The remainder of the paper is organized as follows. In section 2, the system model is described, and the problem is formulated. Then the water-filling based power allocation is detailed in section 3. Section 4 gives the simulation results of achievable sum rate of all the MS in the specified area. Finally, conclusions are drawn in section 5.

2   System Model

We consider a downlink transmission in ultra-dense network, many low-power BS and MS uniformly and randomly distribute in the area, and the number of BS is much larger than the number of MS. Each MS chose the best BS as its serving BS according to the reference signal receiving power (RSRP). In this paper, we assume that each user chooses only one BS as its serving BS, and each BS serves only one MS. Then the redundant BS are closed to avoid the energy consumption and the interference.

2.1   Signal Model

Suppose the system consists of M BS and K MS $M > K$. For convenience, denote g_{kk} as the channel gain of the MS k and its serving BS,

$g_{ik} (k = 1, 2, \cdots, K \quad i \neq k)$ as the channel gain of the MS k and the serving BS of the

MS i, which is regarded as interference for MS k, and denote s_k and p_k as the

transmitting signal and the allocated power of the serving BS of the MS k. Then the

received signal of MS k is

$$y_k = \sqrt{p_k g_{kk}} s_k + \sum_{i=1, i \neq k}^{K} \sqrt{p_i g_{ik}} s_i + n_k \tag{1}$$

Where n_k is the additional white Gaussian noise with distribution $\mathcal{CN}(0, \sigma^2)$.

It is obvious that the three parts in the right side of the equation (1) are the desired

signal, interference signals and the noise of the MS k, respectively. And then we can

easily obtain the received signal to interference plus noise ratio (SINR) of MS k

$$\text{SINR}_k = \frac{g_{kk} p_k}{\sum_{i \neq k}^{K} g_{ik} p_i + \sigma_k^2} \tag{2}$$

According to Shannon capacity formula [9], the achievable rate of MS k can be

expressed as

$$R_k = B_k \log_2 (1 + \text{SINR}_k) = B_k \log_2 \frac{\sum_{i=1}^{K} g_{ik} p_i + \sigma_k^2}{\sum_{i \neq k}^{K} g_{ik} p_i + \sigma_k^2} \tag{3}$$

2.2   Problem Formulation

This paper aims to maximize the downlink sum rate under the limited total power constraint,

since each BS is allocate the equal bandwidth, that is $B_k = B (k = 1, 2, \cdots, K)$, we can omit the

bandwidth B, and easily denote the objective function as following

$$\max \quad B \sum_{k=1}^{K} \log_2 \frac{\sum_{i=1}^{K} g_{ik} p_i + \sigma_k^2}{\sum_{i \neq k}^{K} g_{ik} p_i + \sigma_k^2} \tag{4}$$

$$st. \quad \sum_{k=1}^{K} p_k \leq P_{\max}$$

where $P_{\max}$ is the total available power. It is not easy to prove the convexity of the

objective function. However, the problem can be much easier when regard the

interferences of the MS as constants, and then the problem is transformed into a convex constrained optimization. Applying our assumption into the problem to get the convex optimization problem, the Lagrangian Multiplier method can be adopted to solve the optimum power allocation [10]. Define the Lagrangian function as

$$L(p_k, \lambda) = B \sum_{k=1}^{K} \log_2 \frac{\sum_{i=1}^{K} g_{ik} p_i + \sigma_k^2}{\sum_{i \neq k}^{K} g_{ik} p_i + \sigma_k^2} + \lambda \left(P_{\max} - \sum_{k=1}^{K} p_k \right) \tag{5}$$

where λ is the Lagrangian multiplier for the total power constraint. Take the partial derivative with respect to p_k, we can obtain

$$\frac{\partial L}{\partial p_k} = \frac{1}{\ln 2} \frac{g_{kk}}{g_{kk} p_k + \sum_{i \neq k} g_{ik} p_i + \sigma_k^2} - \sum_{j \neq k} \frac{\gamma_j p_j g_{ik}}{\sum_{i \neq j} g_{ij} p_i + \sigma_k^2} - \lambda \tag{6}$$

According to Karush-Kuhn-Tucker (KKT) condition, we can set it to zero, and then obtain the expression of p_k, that is

$$p_k = \left[\frac{1}{\lambda \ln 2 + \sum_{j \neq k} \frac{\gamma_j p_j g_{jk}}{\sum_{i \neq j} g_{ij} p_i + \sigma_j^2}} - \frac{1}{\gamma_k} \right]^+ \tag{7}$$

where $[x]^+ = \max\{x, 0\}$, $\gamma_k = \dfrac{g_{kk}}{\sum_{i \neq k}^{K} g_{ik} p_i + \sigma_k^2}$. From the form of p_k, it is easy to find that the allocated power is relative to its channel quality γ_k. This kind of problem can be easily solved by the water-filling algorithm to get the optimum power allocation.

3   Water Filling Based Power Allocation

This section details the water-filling based power allocation. Its main idea is to allocate more power to the high quality channel to acquire more throughput gains. In this part, we give the iteratively searching water filling algorithm, which is to obtain the optimum water-filling level by the iterative formula according to a certain step length.

From (7), the allocated power of the serving BS of the MS k is proportional to γ_k. According to the idea of water filling algorithm, when the MS suffers little interference from other BS, its serving BS should be allocated more power to achieve greater sum rate gains. And for the MS which suffer terrible interference, their serving BS should be allocated less and even no power. As [10], regard the interference generated by the BS as the constant, and set

$$\beta = \frac{1}{\lambda \ln 2 + \sum\limits_{j \neq k} \frac{\gamma_j p_j g_{jk}}{\sum\limits_{i \neq j} g_{ij} p_i + \sigma_j^2}} \tag{8}$$

where β represents the water-filling level, then (8) can be rewritten as

$$p_k = \left[\beta - \frac{1}{\gamma_k} \right]^+ \tag{9}$$

We can't get the optimum power allocation directly according to (9), since the optimum water-filling level can't be determined directly. The water-filling level β can be obtained by an iterative method. Fist, give the initial value of β

$$\beta = \frac{1}{K} \left[P_{\max} + \sum_{k=1}^{K} \frac{1}{\gamma_k} \right] \tag{10}$$

According to the initial water-filling level, the initial power allocation can be obtained. Then update the water-filling level iteratively. The updating rule obeys the following expression

$$\beta \leftarrow \beta + \mu \frac{1}{N_{on}} \left(P_{\max} - \sum_{k=1}^{K} p_k \right) \tag{11}$$

where $0 < \mu < 1$, is the adjustment step size. N_{on} represents the number of the indeed turn-on BS. Renew the value of β until it converges, the convergence value is the optimum water filling level. According to (9), the optimum power allocation is obtained.

4 Simulation Results

In this section, we evaluate the performance of the both water filling based algorithms by the computer simulations. 100 BS are uniformly and randomly deployed in the $300 \times 300 m^2$ area, and 10 MS distribute randomly in the area. The channel is the randomly generated unit variance Rayleigh fading channel. The path loss exponent is

set to 3.75. And the variance of the noise is 0.1. In the following subsections, we show the different performance between the average power allocation and the iteratively searching water filling based power allocation.

As shown in Fig.1, when the average allocated power of each MS various from − 10dBm to 40dBm, the sum rates increase exponentially in terms of the average allocated power. The iteratively searching water filling based power allocation can achieve great improvements of the sum rate, and the greatest gain can reach and even exceed 100%. Because the key idea of the water filling algorithm is when the SINR of the MS is high, allocating more power to it can acquire more rate gains than the MS whose channel qualities are not good enough.
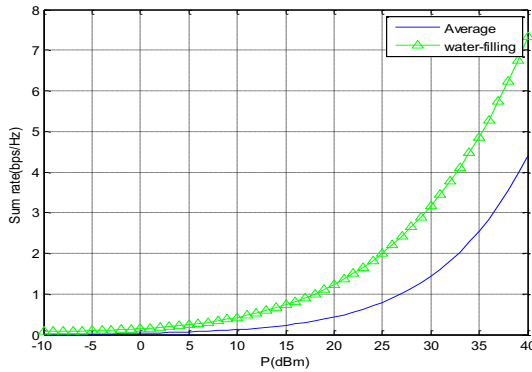
Fig. 1. The achievable sum rates of the iteratively searching water filling algorithm power allocation, the rapid water filling algorithm power allocation and the average power allocation.

5   Conclusions

This paper aims to improve the sum rate of the whole users in the ultra-dense network under the limited total power constraint. We first regard the interference as constant and derive the expression of the allocated power of each user. Since the expression is not a closed-form solution, the iteratively water filling algorithm is applied to obtain the optimum power allocation. From the simulation results, we can see that both the iteratively searching water-filling based power allocation can increase the sum rate by 100% compared to the average power allocation. In the subsequent research, the density of BS can be considered to balance the average rate of each user and the BS deployment cost.

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Mobility Load Balancing with Multi-Cells for Parameter Control Resolution in Ultra-Dense Network[1]

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Abstract. Ultra-Dense Network (UND) is seen as a major development trend in the evolution of future networks, due to its ability to provide more capacity to the whole system and meet higher users' Quality of Service (QoS). Mobility Load Balancing (MLB) is an important Self-Organizing Network (SON) use case in Ultra-Dense Networks. In this paper, we propose a novel algorithm with concurrent MLB among ultra-dense cells. Simulation results show that balancing load among multi-cells by implementing the proposed MLB scheme is compared with the conventional MLB scheme.

Keywords: Ultra-Dense Network, Mobility Load Balancing, handover, Quality of Service.

1   Introduction

Current heterogeneous network is consisted of macro-cells and small cells. This network structure could not be able to meet the traffic demand which is increasing rapidly in future 5G. In [1], it is predicted that the traffic demands would increase at least a 1000-fold network capacity in 2020. To meet the larger traffic demands, enhanced technologies are essential. So far, there are some potential candidates in [2], such as Ultra-Dense Network, massive MIMO, and non-orthogonal multiple access (NOMA). This paper focuses on Ultra-Dense Network which is seen as a major development trend in the evolution of future networks, due to its ability to provide more capacity to the whole system and meet higher users' Quality of Service (QoS). Both the industry and academia are working together, e.g., METIS and 5GNOW1, to meet the capacity demand of the 5th generation mobile communication systems [3], [4].

Ultra-Dense Network easily appears overloaded cells. So overloaded cells need to offload to light cells. But this will cause a high spending. In order to meet the exponentially growing demand of mobile data, the number of eNodeBs (eNBs) and

TOTal EXpenditures (TOTEX), i.e. sum of CAPital EXpenditures (CAPEX) and OPerational EXpenditures (OPEX), in next generation broadband cellular networks are also growing exponentially [5]. To reduce the TOTal EXpenditures (TOTEX) for the Ultra-Dense Network, the term " Self-Organizing Network (SON) " has been proposed. This paper focuses on the self-optimization in Ultra-Dense Network.

Mobility Load Balancing (MLB) is an important self-optimization use case in ultra-dense networks. In this paper, HandOver (HO) event is based on A3 event, which is accurately represented as [6].

In this paper, we present a new algorithm about adjusting the value of the cell individual offset (CIO), which can enhance the whole performance observably. The remainder of this paper is organized as follows: Section 2 describes the system model. Section 3 presents the proposed MLB scheme. Section 4 introduces simulation results on the balancing load among multi-cells and a comparison with the conventional MLB scheme. Finally, conclusions are provided in Section 5.

2   System Model

We assume User Equipment (UE) u with the related cell i. Also, we assume B_{cell} is the cell bandwidth and BW_{PRB} is the bandwidth of one Physical Resource block (PRB) in Hz, i.e. 180kHz. Here, we assume all the cells have the same bandwidth. $\sum N_{u,i}$ represents the number of PRBs that has been used by all the UEs in cell i. The load of cell i is described by Eq. (1) .

$$\rho_i = \frac{\sum N_{u,i}}{B_{cell} \Big/ BW_{PRB}} \quad . \tag{1}$$

In this paper, we assume cell 1 is the source cell while cell 2 is the target cell. Also, HO event is based on A3 event in [7], which is accurately represented as Eq. (2) .

$$R_2 > R_1 + Hys + O_{1,2} - O_{2,1} \quad . \tag{2}$$

where R1 and R2, respectively, are the filtered reference signal received power (RSRP) from the serving cell 1 and from the target cell 2 in dBm, $O_{1,2}$ is the CIO of cell 1 towards cell 2 in dB, $O_{2,1}$ is the CIO of cell 2 towards cell 1 in dB, and Hys is the HO margin (HOM) in dB. If the Eq. (2) maintains at least of the Time-to-Trigger (TTT) , a HO could be triggered.

Setting $CIO_{1,2} = O_{1,2} - O_{2,1}$, the HO procedure can be simplified as Eq. (3) .

$$R_2 > R_1 + Hys + CIO_{1,2} \tag{3}$$

From Eq. (3) , we can see that if $CIO_{1,2}$ decreases, UEs in cell 1 will handover to

cell 2 more easily. However $CIO_{2,1}$ increases, UEs in cell 2 will handover to cell 1 more difficulty. Then, we can make cell 1 unload to cell 2 by this way.

3 The Proposed MLB Scheme

In this paper, we classify load value into three kinds of load conditions (Table 1) . The two load thresholds is described according to Eq. (4) .

$$Th_c = \begin{cases} \rho_{T\arg et} + \rho_{hyst}, c = High \\ \rho_{T\arg et} - \rho_{hyst}, c = Low \end{cases} . \tag{4}$$

Table 1. MLB Cell Status.

Cell status	Condition	Action
Passive	$\rho_i < Th_{Low}$	Receive UEs from overloaded cell
Neutral	$Th_{Low} \le \rho_i \le Th_{High}$	Do not participate in MLB
Active	$\rho_i > Th_{High}$	Request removing UEs to lightloaded cell

We propose a scheme about MLB region in this paper. The scheme is summarized as follow: First, the active cell selects adjacent passive cells in ascending order of cell IDs; Second, there is only one active cell in a specific region; Final, every passive cell only participate a MLB procedure..

In Fig. 1, the active cell named cell 1 is overloaded. It will firstly choose the passive cell named cell 2 to balance the load. To achieve this objective, we should adjust the $CIO_{1,2}$ to make the UEs handover from cell 1 to cell 2 more easily and guarantee that the cell 2 have enough resource to receive the UEs. From Eq. (3) , we know that the smaller the value of $CIO_{1,2}$ is, the earlier UEs will handover from cell 1 to cell 2. Therefore, we can get the minimum $CIO_{1,2}$ by Eq. (5) .

$$CIO_{1,2\min} = M_{TH} - M_{1high} - Hys . \tag{5}$$

where M_{TH} is the threshold of the RSRP which exactly can meet the telecommunication transmission, M_{1high} is the RSRP of the UE from cell 1 when the UE receives the RSRP is equal to M_{TH} . To prevent the too early handover from cell 1 to cell 2, $CIO_{1,2}$ should be adjusted to be $CIO'_{1,2}$, which is between the value of the current $CIO_{1,2}$ and $CIO_{1,2\min}$. The handover parameters are changed as follows:

$$\Delta_{1,2} = (CIO_{1,2} - CIO_{1,2\min}) \cdot (1 - \frac{\rho_2}{\rho_1}) \quad . \tag{6}$$

and

$$CIO_{1,2}^{'} = CIO_{1,2} - \Delta_{1,2} \quad . \tag{7}$$

where the step $\Delta_{1,2}$ is decided by the load of cell 1 and cell 2. The larger the value of ρ_1 is, the larger the value of $\Delta_{1,2}$ is, while the larger the value of ρ_2 is, the smaller the value of $\Delta_{1,2}$ is. In this way, we can make UEs handover from cell 1 to cell 2, thus can decrease the load of cell 1. Also, this can guarantee the load value of cell 2 is not too high.
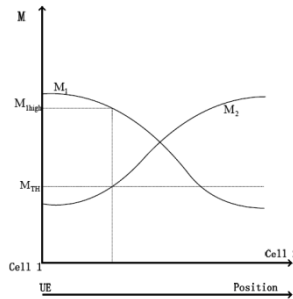
Fig. 1. Different UEs locate different places between cell 1 and cell 2. Cell 1 is an active cell and cell 2 is a passive cell, and UEs need handover from cell 1 to cell 2.

MLB is triggered by active cells. The proposed MLB scheme implements among multiple active cells and multiple passive cells. The active cell may offload to several passive cells. And there are multi-MLB procedures implement at the same time in this paper.

4   Simulation Results and Analysis

In this section, we evaluate the proposed scheme by a system level simulator. In this simulation, we map 19 cells to be 61 cells by using wrap-around. Through this way, our simulation will have reliable interference calculation.

As shown in Fig. 2, the cell 17 unloads some UEs to other light cells by implementing the proposed MLB scheme, while the cell 17 can not unload because there is not any cell-edge UEs between the cell 17 and the lightest neighbor cell. Also, the cell 11 has so light load before doing MLB, and the proposed MLB scheme can

increase its load by receiving other cell's UEs. However, the conventional MLB scheme can not increase the load of cell 11. This is because the propose algorithm is in consideration of the load of source cell and target cell. Compared with the conventional MLB scheme, simulation shows that our proposed MLB scheme is more balancing than the conventional MLB scheme.
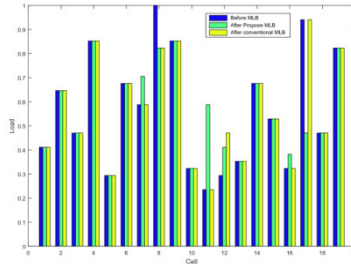
Fig. 2. The load of 19 cells before doing MLB procedure. Also, the load of 19 cells after implementing the conventional MLB procedure compares with the load of 19 cells after implement the proposed MLB procedure.

5   Conclusions

This paper aims to improve the resource utilization rate of whole system with the proposed MLB scheme. Additionally, Ultra-Dense Network needs multi-cells assistance to obtain high performance gain. And our scheme implements among multi-cells based on the characteristic of UDN. Therefore, our scheme is more appropriate for UDN scene. Analysis and simulation results show that the proposed MLB scheme is more balanced than the conventional MLB scheme.

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Empirical Model for the Design of Printed Butterfly Antennas

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Abstract. An empirical model for the synthesis of microstrip butterfly antenna without ground plane is proposed in this work. A fast design method, properly taking into account the effect of feed connector, is discussed to obtain a compact radiating element (75% reduction with respect to standard patch antenna), with a large bandwidth (about 18%) and an excellent rejection of cross-polar field components. Experimental validations on an UHF butterfly antenna prototype are discussed to show the effectiveness of the approach.

Keywords: Butterfly antenna, compact antennas, microstrip antennas.

1 Introduction

Printed microstrip antennas are widely used in several applications due to their low profile, light weight, low cost and easy methods of fabrication and installation. In order to overcome drawbacks due to large radiating dimensions and narrow bandwidth feature, several configurations have been studied in literature in the last 30 years. The butterfly antenna represents a planar version of the biconical antenna [1] and allows to obtain a large operating bandwidth as well as a good size reduction with respect to microstrip patch. The classical butterfly antenna is composed by a bow-tie shaped patch printed on a dielectric substrate (Fig. 1(a)), with a coaxial feed whose position significantly affects both the impedance matching as well as the correct behavior of the fundamental TM_{10} mode of the antenna. An interesting synthesis technique is developed in [2], starting from the set of equations proposed in [3] to find all geometrical parameters of the antenna (except the positions of the feeding point) on the basis of the imposed operating frequency. As a strong drawback, the butterfly antenna with ground plane (Fig. 1(a)) does not allow significant bandwidth enlargement, neither a significant size reduction, with respect to simpler microstrip configurations, such as U-slotted antennas [4]-[7]. The ground plane-free version of the bow tie antenna is composed by two identical triangular patches separated by a gap and excited by a differential pair feeding. The feeding point is located into one of the two arms near the gap, while the ground of the connector (usually the shield of a

coaxial cable) is placed in the symmetric point on the other arm of the antenna, as illustrated in Fig. 1(b).

(a)   (b)
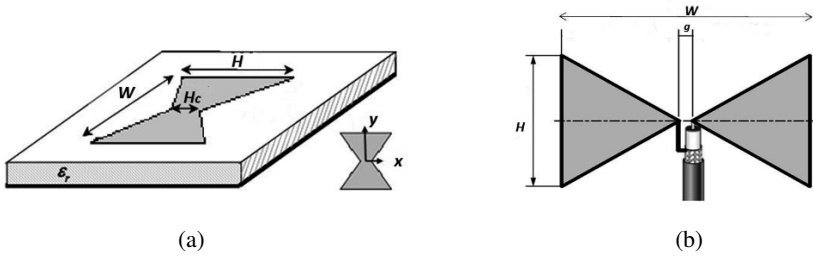
Fig. 1. Butterfly antenna (a) with ground-plane and (b) without ground-plane.

In this particular case, an excellent behavior of the return loss bandwidth can be achieved by acting on the feed technique, or properly modifying the shape of the butterfly wigs [8]-[10]. All these designs exploit the presence of multiple resonances to produce an unique wideband behavior, however, due to the different nature of the excited modes, the ratio between co-polar and cross-polar field components dramatically degrades with frequency, especially in the basic configuration admitting linear polarization.

This serious drawback is properly faced in this work, with the aim to obtain a reduced-size radiating element but maintaining a good trade-off between the bandwidth performances and the quality of the radiation pattern. The above enhanced features are obtained by acting only on the first resonant mode of the antenna, thus avoiding cross-polarization effects. A novel synthesis technique, based on empirical relations, is derived in this paper to properly design a wideband butterfly antenna without ground plane, by taking into account also the capacitive effects of the feeding connector, usually causing an undesired frequency shift with respect to the operating frequency predicted by existing models [2].

2 Empirical Model for Butterfly Antenna Synthesis

An accurate antenna modeling able to include also the effects of the feeding connector is not a trivial task, due to the large variety of possible feeding techniques and their different influence on the antenna modes. In this work, Sub-Miniature version A (SMA) connectors are considered. They are widely used as microstrip antenna feed, and consist of semi-precision coaxial RF connectors with a screw type coupling mechanism. Instead of considering an ideal differential pair feed between the arms of the bow-tie antenna, a rectangular metallic sheet is assumed to model the square flange of an SMA, connecting the inning pin to the extremity of the first arm, and a via hole between the flange and the symmetric point on the other arm. The top layer and a lateral view of the simulated structure are shown in Fig. 2.
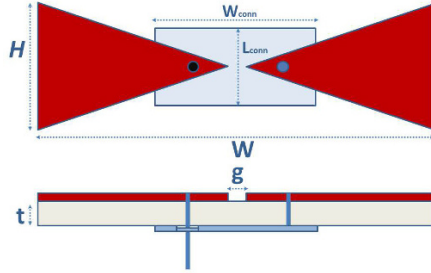
Fig. 2. Top layer and lateral view of simulated butterfly antenna without ground plane.

According to Fig. 2, parameters H and W denote, respectively, the height and the width of the radiating element, while g is the gap between the arms of the butterfly antenna. For convenience, the flange dimensions are fixed in the model as indicated by eqs. (1) and (2).

$$W_{conn} = 3g . \tag{1}$$
$$L_{conn} = g . \tag{2}$$

Assuming the above configuration, a preliminary simulation stage is performed on CAD Ansys Designer to derive the design curves illustrated in Fig. 3, where the variations of the antenna width W (Fig. 3 (a)) and the ratios g/W and H/W (Fig. 3(b)) are reported versus the resonant wavelength λ of the antenna.

(a)   (b)
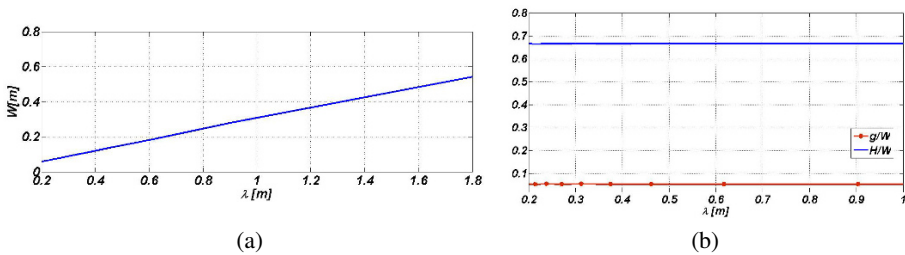
Fig. 3. Variation of (a) the antenna width W and (b) the gap-width and the height-width ratios vs. resonant wavelength.

In particular, from the curve illustrated in Fig. 3(a), a linear dependence between the patch width W and resonant wavelength λ is derived, which gives the following interpolation formula:

$$W = 0.3047\,\lambda - 0.0017 . \tag{3}$$

Parameters W and λ into eq. (2) are intended in meter.

It is straightforward to deduce that eq. (3) is only valid when W > 0, namely when f < 54.5GHz, thus totally covering the frequencies of interest for the application described in the present work.

Similarly, from data reported in Fig. 3(b) a linear dependence between the width W and the height H of the bow-tie is derived under optimal matching conditions, to give the following relationship:

$$H = 2/3W .\tag{4}$$

Finally, the following relation is derived between the total width W and the gap g at the two arms of the bow-tie:

$$g = 0.055W .\tag{5}$$

When applying the empirical model given by eqs. (1)-(5) for the design of microstrip butterfly antenna without ground plane, an optimum prediction is achieved for the working resonant frequency, as it can be observed in Fig. 4, where the frequency curve given by our model is in excellent agreement with the ideal (imposed) one. For comparison, the result obtained with the model discussed in [2] is reported, which gives a less accurate prediction of the operating frequency.
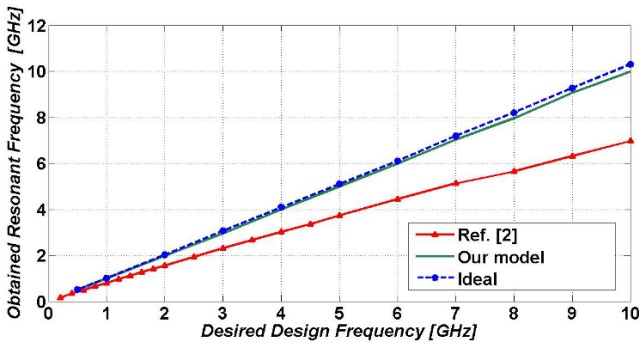
Fig. 4. Predicted working frequency of butterfly antenna.

3 Experimental Validations

On the basis of the synthesis procedure outlined in Section 2, a butterfly antenna prototype working in the UHF range is fully designed, simulated, realized and tested in the Microwave Laboratory at University of Calabria. A central frequency equal to 830 MHz is chosen, and a rectangular flange SMA connector, with solder pot contact, is considered as antenna feed. The empirical relations given by eqs. (1)-(5) are applied to obtain the dimensions summarized in Table 1, and a photograph of the fabricated radiating element is reported in Fig. 5.

To demonstrate the effectiveness of the approach, a comparative simulation is performed between the simplified model for the flange (according to eqs. (1)–(2)) and a more accurate design of the connector (see Fig. 6), taking into account the real position and the dimension of flange, contacts, and the location for the supporting nylon screws.

Table 1. Butterfly antenna dimensions @ 830 MHz (model given by eqs. (1)-(5)).

Parameter	Dimension [mm]
H	72
W	108
g	6.0
H_{conn}	6.0
W_{conn}	18

Fig. 5. Realized UHF butterfly antenna prototype.
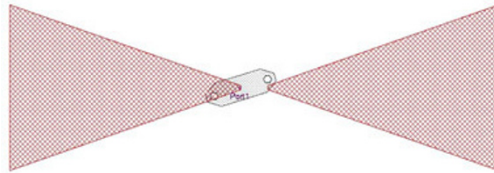
Fig. 6. Butterfly antenna fed by an SMA connector.

In Fig. 7, the comparison between the measured and the simulated (both simplified and real flange model for the feed) is reported. It can be easily observed that both the structure simulated with the simplified rectangular feed model, as well as that including the real dimensions of the rectangular flange, perform the desired central frequency and the expected bandwidth, thus proving the effectiveness of the proposed empirical approach.

In Fig. 8, the measured H-plane field patterns are reported at various frequencies within the operating frequency range. It can be observed that cross-polar field components are properly maintained below the co-polar ones within the frequency band, for a wide angular range. In the classical design of ground plane-free bow-tie antennas, multiple resonances (used to enlarge the input impedance bandwidth) totally destroy the right ratio between co-polar and cross-polar components, thus producing un undesired reduction of the -3dB radiation pattern bandwidth. In our case, an excellent compromise between the operating bandwidth and the proper behavior of cross-polar components is obtained, according to a measured gain of about 2.5 dB, a typical value assumed for ground-plane free microstrip printed antennas with small dimensions. But the main advantage obtained by using the outlined design technique consists in the strong reduction of the total radiating area of the radiating element with respect to a classical rectangular microstrip patch antenna (75% reduction with the values outlined in Tab. 1).
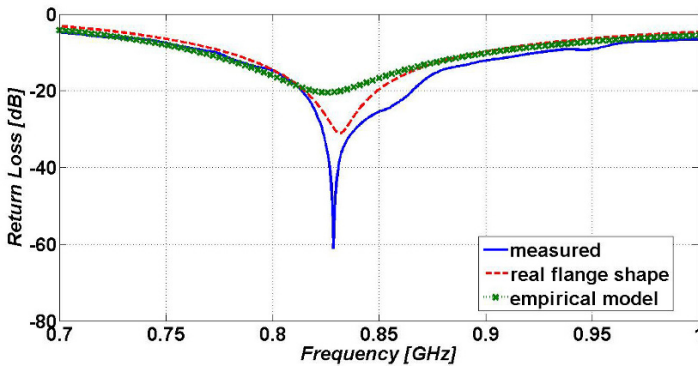
Fig. 7. Comparison between measured and simulated return loss of UHF butterfly antenna.
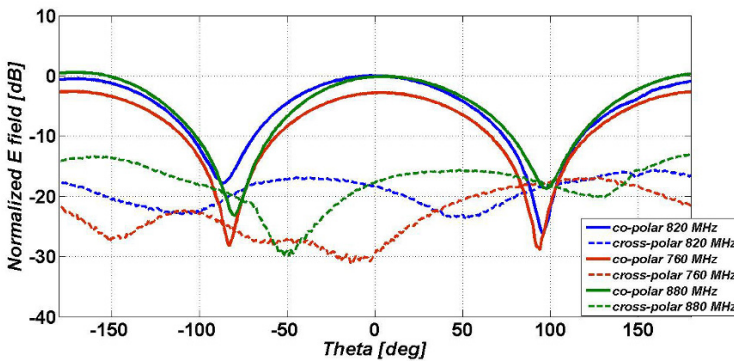
Fig. 8. Measured far field pattern (H-plane) of UHF butterfly antenna at various frequencies.

3 Conclusions

A simple empirical method has been proposed in this work for a fast design of compact and wideband butterfly antennas without ground plane. The adopted model properly takes into account the effect of the rectangular flange of SMA connectors usually adopted as feeding and performs a more accurate prediction of the geometrical parameters with respect to existing models in the literature. To validate the proposed method, a prototype working in the UHF range, 75% smaller in terms of surface area with respect to a microstrip rectangular patch and performing a 18% bandwidth (without wasting the performance in terms of cross-polar rejection), has been designed trough the empirical formulas, and fully experimentally validated into the Microwave Laboratory at University of Calabria. Future work will be addressed to refine the model for a further bandwidth enlargement, leaving unchanged the ratio between co-polar and cross-polar field components.

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SDN-Enabled C-RAN: An Intelligent Radio Access Network Architecture

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Abstract. With the development of wireless access technology and mobile internet, the demand of network traffic is growing rapidly. Traditional radio access network can not satisfy the requirement of ever growing capacity. C-RAN (Cloud-Radio Access Network) is a novel radio access network [1] architecture which can support growing users' needs. In C-RAN architecture, BBUs (Base Band Units) decouple from RRHs (Remote Radio Heads) and are centralized and shared among RRHs in BBU pool. RRHs can be flexibly and densely arranged to increase network capacity. But the deployment of dense network brings great pressure to network management. The current C-RAN architecture can not effectively deal with the changes of network station caused by users' mobility. The SDN technology can simplify and optimize the network management. Hence we propose a SDN-enabled C-RAN architecture, it can intelligently and dynamically build RAN under the control of SDN controller. And we put forward a use case to briefly describe the working procedure.

Keywords: C-RAN, SDN, network management, intelligence.

1   Introduction

Along with the incessant expansion of the mobile internet and rapid increase of data traffic, traditional radio access network can't meet the requirement of ever growing capacity. Network densification deployment supported by C-RAN is one of the effective solutions to cope with the capacity requirement. C-RAN decouples the BBU from the RRH, allowing processing resource to be shared. Meanwhile, RRH can be flexibly and densely arranged to increase network capacity [1]. Due to the dense deployment of cells and the reduction of cell area, frequent handover between different cells will occur and the resource requirement in each cell will be changed as users move from time to time. The Current C-RAN architecture can't effectively respond to these changes in RAN. The SDN as a promising technology can simplify and optimize the management of network. SDN decouples the control plane and data plane and

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centralizes the control functions of network to achieve more flexible and optimal management [2]. In this paper, we present an SDN-Enabled C-RAN architecture, the core benefits of this architecture are the abilities of adaptive optimization and reconfiguration. The status of RAN would change with time and users' mobility. SDN controller in this architecture can get the RAN information in real time, adaptively readjust the connections between RRHs and BBUs, and redistribute the resource between BBUs, so we can built an intelligent RAN architecture.

We organize this paper as following: Section 2 present the related work. The SDN-enabled C-RAN architecture is elaborated in Section 3. Section 4 is the use case which is applied to mobility management. Finally, we summarize our conclusions in Section 5.

2   Related work

There are lots of research about C-RAN architecture. [3] compares the performance of handover procedure on C-RAN Architecture with traditional Architecture, because of the BBUs centralized in C-RAN, the information exchanged between source BS and target BS becomes the internal processing procedure, which reduces the handover delay. [4][5] present the concept of a virtual BS controlled by controller, ease the management for operator. Controller concentrated the bulk of control function, such as resources allocation, power control, and the BS only retains fewer control function. From the consumer point of view, [4] still need to handover when moving between different BSs. Through centralized control of the controller can reduce the ping pong effect. [5] will generate a virtual dedicated eNodeB for every user, but the virtual cell is fixed. [6] put part of handover functions of core network to BBU pool in order to mitigate the burden of hugs signaling overhead of core network, however, the links between RRHs and BBUs can't be dynamically changed.

About the application of SDN in wireless network. Most research are focus on the integration of SDN controller and core network equipment. In [7][8][9], SDN controller assemble the core equipment (MME, SGW) which are related to handover. In these architecture, SDN controller controls the handover procedure directly, so it can reduce the information interaction between source BS and target BS and   simplify the handover procedure. Meanwhile [6] adds the handover between wireless access points and BS, [9] uses SDN controller to establish the optimum path between target BS and IP Router in the backhaul network.

Based on the previous work, we proposed SDN-enabled C-RAN architecture, owing to the centralizing management of SDN controller, the data storage of SDN controller can achieve the overall information, and optimize mobility management, link load balance and BBUs resource load balance along with other components of SDN controller.

3   SDN-Enabled C-RAN Architecture

In this section, we will introduce the SDN-Enabled C-RAN architecture and describe the components of this architecture in detail.

3.1   Overview

Our goal is to build an intelligent RAN architecture. Fig 1 shows the overall framework of the architecture which we proposed. SDN controller is the most important component in this architecture. It can perceive the state information of RAN by communicating with OF-Switches and BBUS in real time. So the SDN controller can intelligently allocate resources for BBUs based on the BBUs' load condition and change the connections between RRHs and BBUs to create logic cells based on the users' moving condition. This makes the architecture more intelligent and flexible to fit the changing of resource requirements in different areas where the RAN covers.
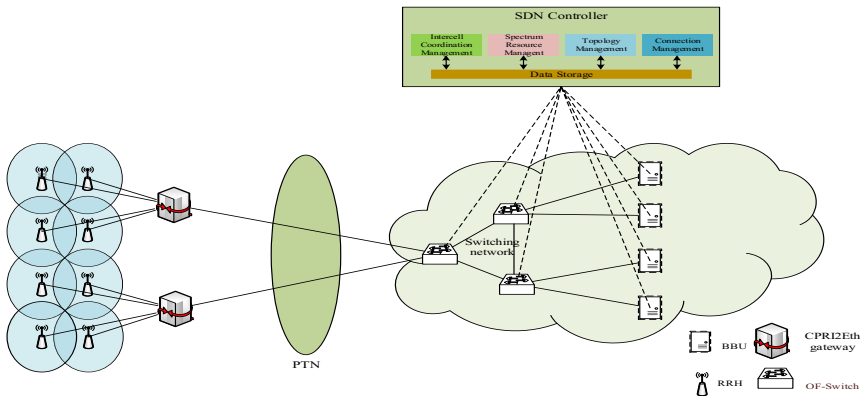
Fig. 1. SDN-enabled C-RAN architecture

3.2   Architecture

The SDN-Enabled C-RAN architecture contains six main components: RRH, CPRI2Eth gateway, PTN (Packet Transport Network), Switching network, BBU and SDN controller. While the functions of RRH and BBU in this architecture are almost same as the functions in C-RAN architecture, we will introduce the components of this architecture except RRH and BBU. Note that the BBUs in this architecture are added SDN-enabled agents so that they can communicate with SDN controller using OpenFlow protocol.

CPRI2Eth Gateway. CPRI2Eth gateway is needed to map CPRI data to Ethernet data because we chose Carrier Ethernet as the fronthaul network. It should satisfy the strict

requirements to synchronization and syntonization, so the IEEE 1588 protocol is used in the CPRIEth gateway and BBU pool, the switches between them [10].

PTN. PTN, namely Carrier Ethernet, is used to transport the baseband data between RRHs and BBU pool. Using PTN makes it more flexible to deploy this architecture compared with optical transport network.

Switching Network. Switching network is composed of OF-Switches. OF-Switches forward baseband data according to the flow tables. Switching network dynamically connects RRHs and BBUs under the control of SDN controller to achieve the load balance between BBUs and flexibly form logic cell.

SDN controller. SDN controller manages and controls the whole RAN network. In the SDN controller, there are five main components: Data storage, Path Computing, Topology Management, Resource Management and Connection Control.

  Data Storage. Data Storage takes charge of collecting and storing the data getting from OF-Switches and BBUs. These data include every BBU's load, resource allocation, user's information, handover information between adjacent cells and the whole RAN topology information etc. These information can be used for SDN controller to manage the switching network and BBUs.

  Intercell Coordination Management. This component is used to pick out proper BBUs to jointly process some users' data. It can pick out the most appropriate BBUs to jointly process users' data based on the GNV, this can improve user experience.

  Resource Management. This component takes charge of managing the spectrum resource and processing resource of BBUs based on the information of BBUs' load.

  Topology Management. This component is used to maintain and manage the topology of the whole RAN. SDN controller gets the topology information through communicating with the OF-Switches and BBUs. The topology information includes the entire paths between RRHs and BBUs, the bandwidth and delay of every link. This component makes SDN Controller having the GNV of the entire RAN, so that SDN controller can make the optimal decision for resource management and connection control based on the GNV.

  Connection Management. Connection Management is used to control the connection between RRHs and BBUs based on the BBUs' load and /or users' moving condition.

3.3   Benefits

The core benefits of the SDN-enabled C-RAN architecture are the abilities of adaptive optimization and reconfiguration. The status of RAN would change with time and users' mobility. SDN controller in this architecture can get the RAN information in real time, adaptively readjust the connections between RRHs and BBUs, and redistribute the resource between BBUs.

  The abilities of adaptive optimization and reconfiguration are advantage to mobility management and the load balancing of BBUs and switching network etc. In the area of mobility management, the SDN controller can find out the areas where there are mass

and frequent handover events by statistical analyzing the data about handover between BBUs, then the SDN controller can control switching network to connect related RRHs which cover that areas connect to the same BBU to reduce the number of handover. This can improve user' experience and decrease the signaling cost of the core network.

For load balancing of BBUs and switching network, it would be easier and more optimal to implement under SDN controller because of the SDN controller has the GNV information. The topology management component in SDN controller can reasonably allocate load to each link based on the link's bandwidth and delay. Similarly, the SDN controller can flexilbly allocate resource for BBUs according to BBUs' load, and it can preassign resource for certain BBUs based on the moving trends of users.

4   Use Case

In this section, we simplify the architecture which we proposed ahead, there are only RRHs presents in Fig. 2, which depict the changing procedure of the connection between RRHs and BBUs. We assume that there are eight RRHs, and regard the coverage of a RRH as a cell. At first, the yellow cells and blue cells connect to a BBU respectively, and RRHs can dynamically connect to BBUs through switching network which are controlled by SDN controller. The functions of SDN controller are presented in section 3.
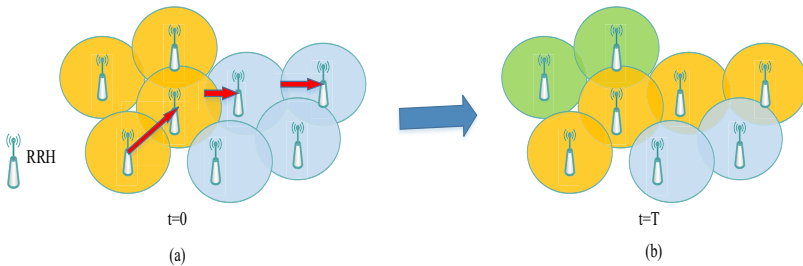
Fig. 2. Use Case

The data storage component of SDN controller collects the user information in terms of handover signaling to summarize the users' movement rule. Every half hour, the SDN controller changes the connections of RRHs and BBUs according to the decision criteria. The coverage of the RRHs is regarded as a logic cell, therefore it can reduce handover frequency of mobile users who are moving in the logic cell. As show in Fig. 2 (a), the four yellow cells and four blue cells are regard as two logic cells. After a period of time, if there are frequent users moving in the places of red arrows, this would cause frequent cell switching, and the core network will bear a heavier signaling overhead, the users' experience would be reduced accordingly. After T time, the SDN controller discovers this phenomenon and makes decision according to the decision criteria. If the criteria is satisfied, the SDN controller hand out instruction to switching network to connect the four yellow RRHs to the same BBU. As shown in In Fig. 2(b),

so the users needn't handover when they move in the red arrows areas, and the user experience will be improved as well.

5   Conclusion

The architecture of C-RAN integrating with SDN would be a feasible method to solve the problem faced by traditional RAN with rapid growth of mobile data. Due to the limitations of network management in C-RAN architecture, we propose a SDN-based C-RAN Architecture, The control function centralized in SDN controller which has GNV of whole network, and the data storage of SDN controller can achieve the overall information, along with other components of SDN controller, it can bring some boosting in some aspects, such as mobility management, link load balance, BBU resource load balance and so on. Meanwhile, we present a use case applied to mobility management. SDN controller collects various information of customer to statistics the mobility change pattern, if the criteria is satisfied, the SDN controller controls RRHs dynamically connecting to assigned BBUs in BBU pool through the OF-Switch. In area of a large flow of users, this method will enormously reduce the number of handover.

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Environmental effects on the performances of a UHF passive tag-based commercial RFID system

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Abstract. A simple setup for the evaluation of the environmental effects on the performance of a passive tags-based commercial RFID system is described in this work. A standard classroom/office room is assumed as test scenario, and the evaluation of field emission as well as the minimum power threshold required for an accurate detection in the presence of obstacles is performed. This preliminary measurement campaign can be helpfully applied to properly highlight the potentialities as well as the limitations of the RFID systems when applied for the accurate tracking of items located into a real noisy scenario.

Keywords: RFID systems, passive tags, indoor test.

1 Introduction

Radio Frequency Identification (RFID) approach gives a simple and low cost technique to easily identify and track objects [1]. A basic RFID system [2] is composed of a radio scanning unit, called reader, and several remote transponders, called tags, uniquely identifying the objects encapsulating them. Each tag include an antenna, for receiving and retransmitting the signal emitted by the reader, and a microchip, which modulates the signal on the basis of the included identification data. We can distinguish active tags, where a local source feeds both the antenna as well as the microchip, and passive tags, which exploit the energy received by the reader in order to backscatter the signal containing the identification data. The possibility to choice a lower cost system, composed of passive tags, or a longer range system, using active tags, makes an RFID system a versatile solution for several applications in different fields. Supply chains can be supported by RFID systems for inventory tracking and logistics management. They can be employed in manufacturing industry for warehouse fulfillment, inventory and production process monitoring. RFID systems can represent a smart solution in several scenarios for access control, attendee tracking, counterfeiting and theft control and prevention. The use of low-cost passive tags leads a wide diffusion of this type of technology also in those scenarios where a lot of items have to be detected simultaneously, and the cost of the item itself does not justify a cost for the tag for more than a few cents. However, a serious limitation for RFID systems based on passive tags is due to the short distance at which reader can

correctly detect tags [3]. As a matter of fact, at UHF frequencies and using a limited transmitted power, the coverage of the system usually does not exceed few meters. Another important aspect to take into account is the wave propagation in the scenario where the system operate. Factors such as the presence of metallic objects, humidity, or the same human presence in the environment, can significantly affect the correct signal path between reader and tags. In this case, the number of reader antennas and their placement in the scenario are very important tasks for the correct operation mode of the system [4]. A preliminary theoretical analysis of the operating wireless environment should be performed at this purpose, not only to properly define the design parameters of the RFID system, but also to avoid health damages to people or interference with other devices.

A complete electromagnetic description of a complex environment is, in general, a very hard task, so preliminary tests on the operative scenario should be performed in order to properly manage the signal degradation due to undesired reflections, media absorption and multipath effect. In this work, a guidelines method based on experimental tests performed in a real noisy scenario is provided, in order to give a rough but reliable evaluation of the environmental effects on the performances of a commercial UHF passive tag-based RFID system, thus properly identifying the application limits when considering the problem of accurate detection and/or tracking of a set of different items into an indoor noisy environment.

2 System Setup and Scenario

The system under test is composed of commercial modules, using a dedicated Multi-Reader for Speedway Gen2 RFID software, provided by Inpinj. The reader module is a Speedway R420, which delivers a maximum value of 30dBm transmitting power and presents 4 available channels for antennas connection. Each channel can be used in both transmitting and receiving path. The antenna reader is composed of a circularly polarized module (Laird S8658PL), allowing 8.5dBi gain, 1dB of axial ratio and 70° of 3dB beam-width in the azimuth direction. The connection between the antenna and the reader is made up through coaxial cable and only one antenna is used in our tests. Information provided by the reader and control messages by the PC are transferred through Ethernet. Standard Inpinj Monza 4, using a GEN2 protocol are as passive tags in these tests. A simplified block diagram of the system architecture is shown in Fig. 1.

 A standard office room, whose layout is shown in Fig. 2, is exploited as scenario under test for the experimental evaluation of the RFID system performances, whose possible practical application could be the access and presence control of the employers into an office room, smart attendee tracking and so on. Some pictures of the location where the system is set up are reported in Fig. 3.

Signal paths between the reader and the tags are significantly influenced by the objects in the scenario and a prediction of the RFID system performances without an extensive set of measurements is a complicated task due to the complexity of the scene. In Section III, the results of an extensive experimental characterization of the

scenario under test, to be adopted as basic information for an accurate prediction of the detection capabilities of the RFID system, are fully discussed.
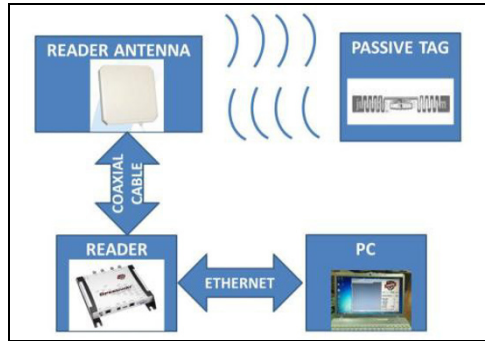
Fig. 1. RFID System under test.
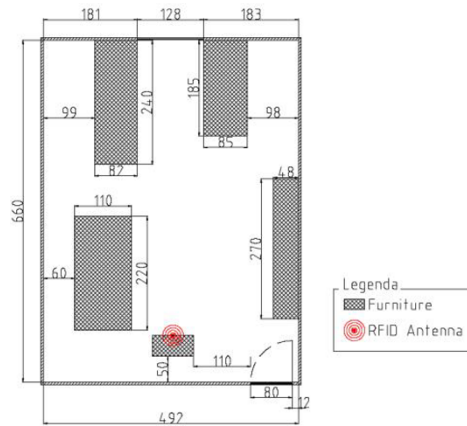
Fig. 2. Layout of the scenario (units in cm).

Fig. 3. Scenario under test.

3 Experimental Tests

Controlling the electromagnetic emissions of a device, in order to avoid health damages to the people or interference with other devices, represents a priority for the design of a wireless system. In the case of RFID systems working into an indoor scenario characterized by human presence most of the day, a limitation of the transmitted power and the respect of regulations in terms of emissions must be always guaranteed. However, a minimum power threshold is necessary to be transferred in each point where tag could be positioned, in order to maintain a correct identification; this aspect assumes a particular importance in RFID system based on passive tags, because the energy supplied by the reader antenna is retransmitted by the tag without other available sources.

A mapping of the electric field in the scenario where the system is located is relevant to verifying the correct position of the antenna reader and thus avoiding the regions where tags could not be detected . Therefore, a first set of measurements, using an electromagnetic probe located at different points into the office (Fig. 4), is carried out once imposing the maximum power supplied to the reader antenna. In Fig. 5, the field levels measured in the office scenario, by varying the distance and the azimuth angle between the probe and the reader antenna, are illustrated.

Fig. 4. Field emissions measurement of RFID system.

In particular, high values can be observed only in the proximity on the antenna location, with no significant interference with other instrumentations or possible risks for human health. A significant decrease of the electric field can be observed about 3 meters far from the source, especially for those angulations which are not covered by the -3dB beam-width of the reader antenna. In order to test how the field distribution affects the performance of the system in terms of tag detection, a margin test [5] is also carried out. Namely, the minimum source power which allows a correct detection is measured by varying the tag position with respect to the antenna, in terms of distance and azimuthal angle. In order to firstly evaluate the tag detection in a noiseless and zero reflection environment, a preliminary margin test into the anechoic chamber of the Microwave Laboratory at University of Calabria (Italy) is performed (Fig. 6).
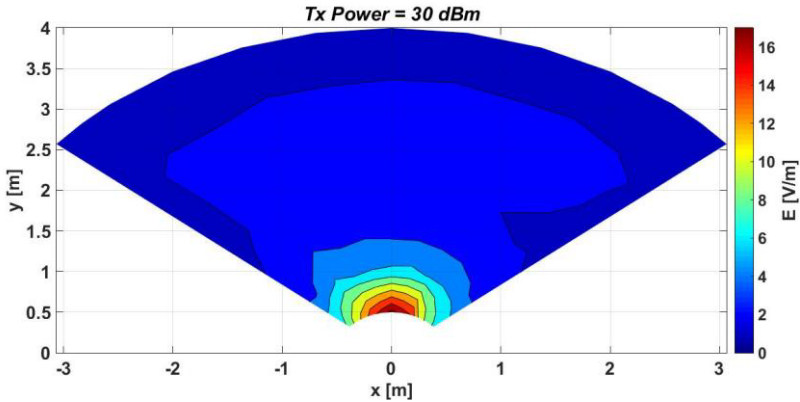
Fig. 5. Field emissions of the RFID system using the maximum available power.
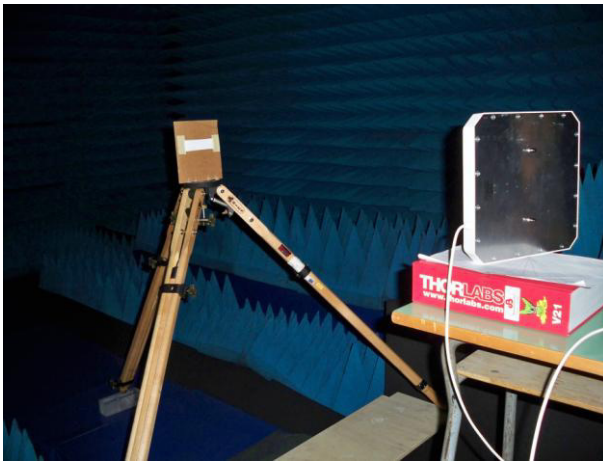
Fig. 6. Margin test setup in anechoic chamber.

From data reported in Fig. 7, it can be observed that the minimum power threshold, set at the source in order to have a correct detection of the tag, increases with distance due to the path loss, and changes also with azimuthal angle, due to the non perfect omnidirectional pattern of the antenna. In particular, a significant angular asymmetry is measured 0.5 meters away from the source, because of reactive field components not completely vanished at such distance. By increasing the distance, the tag should need, for being read, a power greater than the one allowed by the system: in this case a correct detection is not possible. The same test is repeated in the office room (Fig. 8), in order to evaluate how furniture and other objects affect the tag detection. The relative results are reported in Fig. 9.
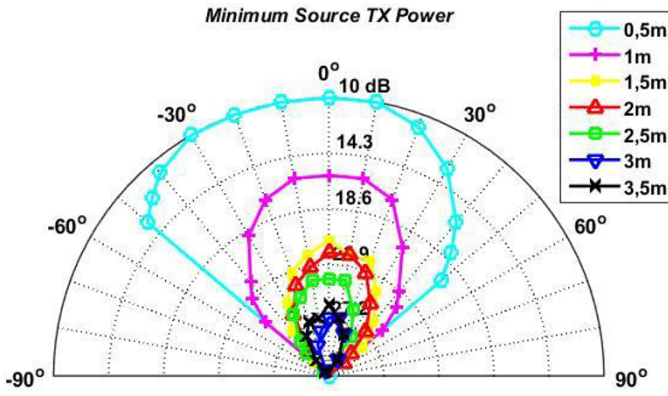
Fig. 7. Margin test results in anechoic chamber.

Fig. 8. Margin test setup in the office room.
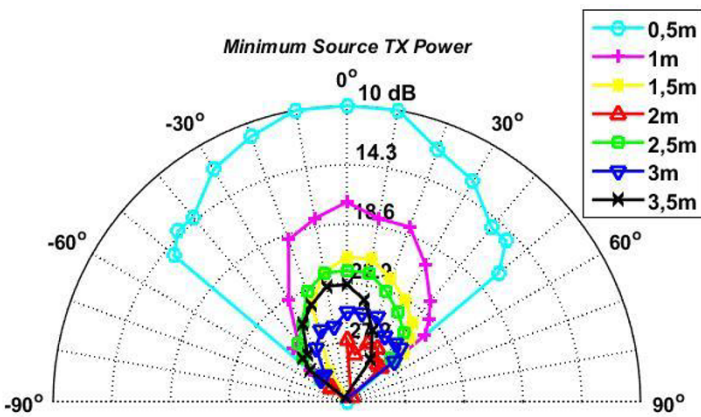
Fig. 9. Margin test performed in the office room

By comparing data from Fig. 7 and Fig. 9, no significant difference can be observed in the area near the transmitting antenna, due to the lack of obstacles. An interesting behavior can be noticed around 2 meters away the antenna, where reflections decrease the signal delivered to the tags, so the minimum power for a correct detection increases with respect to the zero reflection environment. Due to the complex nature of the scenario, an inversion of the detection behavior can be noticed in the range 2.5m - 3.5m, where the sum of signal reflections caused by the items increases the total power and, consequently, a decrease of the minimum necessary source power to read the tag can be observed. In this case, reflections due to the object located in the left side of the scenario cause positive effects on the system performance in a significant portion of the area under analysis. This behavior could be further taken into consideration in order to improve tag detection in a specific real scenario using appropriate reflectors that reproduce the same effects observed in the above comparative measurements.

4   Conclusions

A simple experimental setup has been proposed and discussed in this work for the preliminary performances characterization of passive tags-based RFID systems, usually having strong limitations in terms of maximum detectable range. The adopted measurement procedure has included two main steps: the field emissions characterization for different transmitting power levels, which is necessary to prevent unwanted biological effects on people, and the margin tests execution, specifically devoted to the identification of the minimum power required for an accurate tag detection, in the presence of environmental obstacles. Even if limited to a single scenario, this preliminary measurement campaign can be successfully adopted to properly setup the RFID systems, in terms of input power, antenna locations and maximum detectable tags. It can be particularly useful in those situations where a theoretical characterization of a real complex scenario cannot be practicable.

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Software-Defined Radar System for Landslides Monitoring

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Abstract.   An integrated system for landslides early warning, based on a flexible network architecture and including different sensors, is described to monitoring landslides evolution in critical scenarios. Particular focus is devoted on the experimental assessment of an L-band Software Defined Radar sensor, specifically designed for the application, by discussing the measurement results obtained on a real landslide scenario located on the A3 highway in Calabria (Italy). In particular, a mathematical estimator useful for the proper detection of landslide movements is defined and applied to the measured range profiles, thus demonstrating the usefulness of the proposed radar monitoring approach.

Keywords: Software Defined Radar, Landslides Early Warning.

1   Introduction

A landslide is a complex geological phenomenon involving a wide range of possible ground movements, such as rock-falls, deep failure of slopes, and shallow debris flows. Due to the large set of physical parameters involved in the phenomenon, landslides monitoring is a complex operation, which requires expertise in various different fields [1]. In recent years, early warning systems are becoming increasingly important for the landslide monitoring, due to their effectiveness in the reduction of risk, with the adoption of low-cost equipment when compared to traditional engineered mitigation tools [2]. As a matter of fact, the reduction of the total cost, both in terms of employed devices as well as in terms of management, is one of the main goal for the design of early warning systems, especially in those areas where financial resources are not so adequate to face the problem with a complex structural approach. In order to maintain a good scalability, a distributed sensor measurement system, with the possibility to integrate different devices located in different points of the monitored scenario, should be arranged. In this way, several typology of heterogeneous sensors may be used for obtaining a precise description of the scenario under analysis and a realistic evaluation of the landslide risk. All data should be

collected and analyzed into a control center using a flexible network for the communication with devices.

Using low-cost radar systems, developed with a Software Defined Radar (SDRadar) approach [3-5], significantly decreases the total cost of the system and leads to a fast and practical monitoring activity.

In the framework of a national project on "Landslides Early Warning" , a Software Defined Radar, a radar scatterometer, and other different devices are integrated into the same system in order to monitoring real landslide scenarios [6]. In this work, the final architecture of the whole system is fully described. Furthermore, the experimental assessment of the realized L-band SDRadar on a real scenario is discussed to show the ability to retrieve real-time landslide movements.

The paper is organized as follows: the system architecture is described in Section2, while the experimental results obtained on the A3 highway in Calabria (Italy) are reported in Section 3. Finally, conclusions are outlined in Section 4.

2 System Architecture

An integrated system for "Landslide Monitoring, Early Warning and Risk Mitigation along Lifelines", with acronym LEWIS, is a project inserted in the framework of the National Operational Programme 2007-13 "Research and Competitiveness", co-funded by the European Regional Development Fund, and funded by the Ministry of Research (MIUR) [6].

The system includes many heterogeneous components related each other and allows many different operations. Standard criteria for the evaluation and mapping of landslides susceptibility are adopted, and different sensors are placed and linked to a center for data acquisition and processing through a telecommunication network with an ad-hoc multithread based architecture. The main operations of the system are reported in Fig. 1.
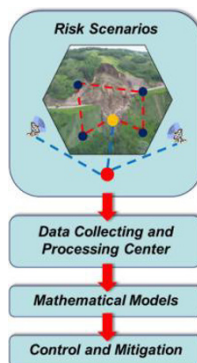
Fig. 1. Different operations of Lewis System

For a direct evaluation of the parameters characterizing the scenario, a set of punctual monitoring devices are placed directly on the landslide front. Areal monitoring devices, namely an X-band scatterometer and the L-band SDRadar, are also integrated in order to completely cover the scenario. After a local pre-processing, measured data are transmitted through a transmission network to a data collecting and processing center, where they are stored in real time and further elaborated. The transmission network is developed in order to interface heterogeneous data, using an ad hoc transmission protocol and a flexible middleware ready for future expanding of the system to include other typologies of sensors. A set of mathematical models are considered to evaluate landslide movements and eventually transmit a warning to a control and mitigation center, where operative decisions are taken on the basis of the warning. Due to the above described complexity, the LEWIS project involves several different research groups with different competences, and the experimental validation of the different parts of the system are carried out, by considering as monitoring scenarios three Italian highway sections recently involved in landslides phenomena. The L-band SDRadar module, fully realized into the Microwave Laboratory at University of Calabria, gives one of the most significant areal sensor of the system. Its schematic block diagram is shown in Fig. 2.
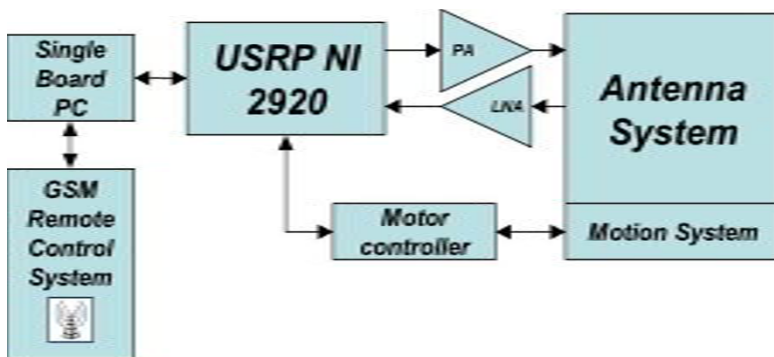
Fig. 2. Schematic configuration of L-band SDRadar system.

A Universal Software Radio Peripheral transceiver (NI USRP 2920) is adopted to replace most of the hardware operations through software implementation, thus significantly reducing the total cost of the areal sensor. In particular, the modulation and demodulation, mixing, signal generation and A/D and D/A conversions are performed without specific hardware devices. A Lab-View code, implemented on a compact PC (MXE 5302), controls the overall USRP operation. A horn antenna with a fixed position is adopted in the transmission path, while a patch array moved by a stepped motor, and having a configuration specifically designed for this application, is adopted in the receiving path. Two GSM modules are used for the communication between the device and the data collecting and control center, by adopting a protocol shared with the other devices of the LEWIS system. A photograph of the final configuration of the radar system is shown in Fig. 3, where a own designed compact receiving array antenna can be observed [6]-[7].

Fig. 3. Photograph of the complete L-band SDRadar system.

Preliminary laboratory measurements carried out to validate the L-band SDRadar are described in [8]. In this work, the final experimental assessment on the operative scenario, including the radar installation and its complete integration with the LEWIS system, are fully described to prove the effective ability of monitoring landslide movements.

3 Experimental Results on A3 Highway in Calabria (Italy)

In recent years, a specific hill side in proximity of the national A3 highway (Mancarelli, Calabria, Italy) is being frequently interested by landslides events with significant damages for road pavement and vehicles passing through. This particular area (39.2545°N, 16.2722°E) is chosen in the framework of LEWIS project to be monitored by the L-Band SDRadar. A photograph of the structure containing all the instrumentation of the radar system is shown in Fig. 4(a), while the position of the areal sensor with respect to the monitoring area (divided into 5 different sectors, each one corresponding to an azimuthal rotation of the receiving antenna, considering a 10° scan angle between two successive positions), is shown in Fig. 4(b).
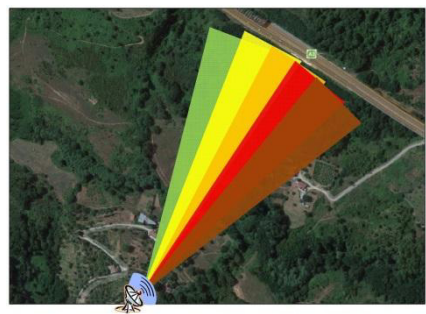
Fig. 4. (a) Shelter structure for radar installation and (b) position of the areal sensor with respect to the monitoring area.

For each sector, a High Range Resolution (HRR) profile, obtained by a Stretch Processing Technique [9], is elaborated, stored and transmitted to the control center for evaluating possible landslide events. In Fig. 5, the measured HRR profiles of the described monitored area on the five sectors, for different consecutive acquisitions at 5 min time steps, are reported.
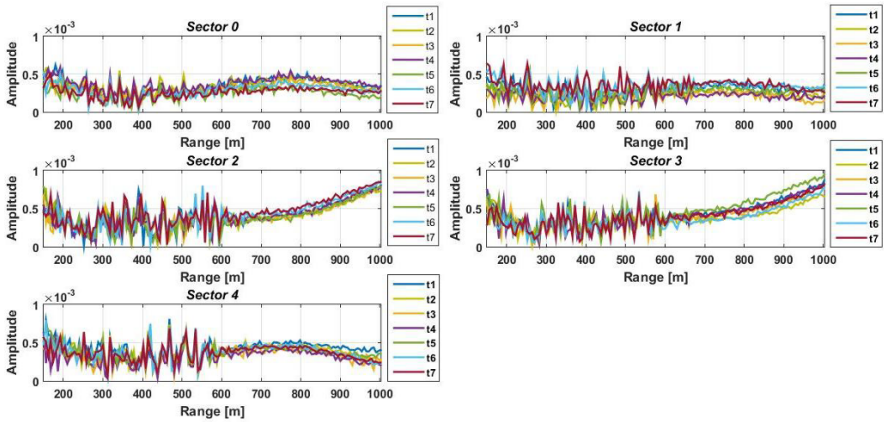
Fig. 5. HRR profiles obtained through experimental test on the A3 highway scenario in Calabria, Italy.

The absolute variations in the HRR profile cannot be easily related to a critical movement of the monitored scenario. As a matter of fact, the backscattered power received from the scene depends on the radar cross section, the orientation and the reflectivity of the target. Furthermore, the absolute value of the received signal is also affected by the path loss, so this effect should be properly considered to effectively evaluate the target backscattering.

In order to perform a useful quantitative estimation, an ad hoc estimator $\xi(r)$, taking into account the relative variation of two successive profiles $(i\text{-}1,i)$, and weighted with respect to the maximum value of the profile and the distance r, is introduced in this work. First of all, the relative power variation $\varepsilon_i(r)$ between two range profiles, respectively equal to $S_{i\text{-}1}(r)$ and $S_i(r)$, is defined by the following expression:

$$\varepsilon_i(r) = \frac{S_i(r)^2 - S_{i-1}(r)^2}{S_{i-1}(r)^2} \tag{1}$$

In order to assign more relevance to the relative variation of higher values in the profile, another term is considered in this evaluation as providing the normalized power $\hat{S}_i(r)$:

$$\hat{S}_i(r) = \frac{S_i(r)^2}{max\{S_i(r)^2\}} \tag{2}$$

The last term considered in the analysis is the normalized distance $\hat{d}(r)$ with respect to the total observation range, in order to compensate the effect of the path loss on the data observation, namely:

$$\hat{d}(r) = \frac{r}{max\{r\}} \tag{3}$$

The value of the estimator $\xi(r)$ is defined as the product of the above three terms, by considering a -2 exponent for the normalized distance, in order to contrast the quadratic decreasing of the power signal due to the path loss, namely:

$$\xi_i(r) = \varepsilon_i(r)\hat{s}_i(r)\hat{d}(r)^{-2} \tag{4}$$

The estimator (4) is computed for each sector, considering the range profiles obtained in Fig. 5, and the results of this elaboration are reported in Fig. 6.
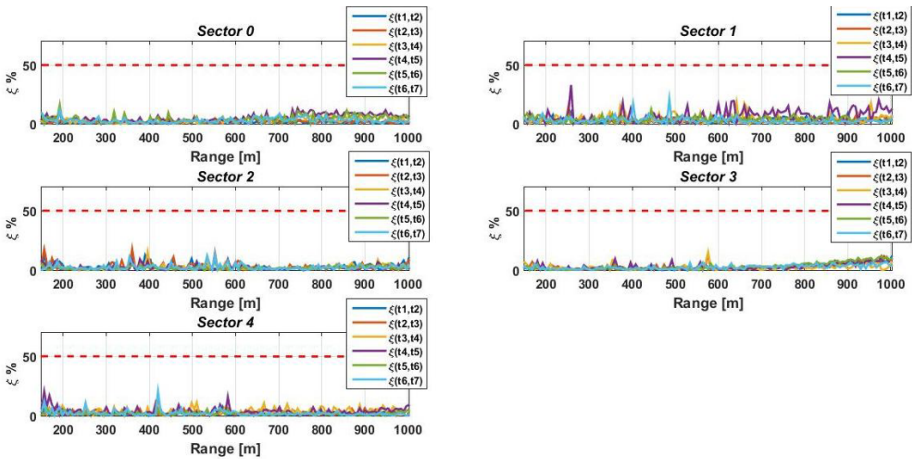
Fig. 6. Evolution of the estimator ξ between two successive time steps.

Some variations can be mainly observed in the range profiles elaborations of Fig. 6 for the Sectors 1-2, namely those directly facing the landslide scenario. They reveal some kind of dynamic changes in the observed scene, which however cannot be attributed to possible significant landslide movements, as all estimator values maintain below the prescribed limit of 50% variation. In order to advise a possible risk event, the above limit should be exceeded, with the risk level related to the range extension within which the limit overcome happens.

4 Conclusions

The experimental assessment of an SDRadar system for landslides monitoring has been described in this work. After the complete integration of the radar into the LEWIS system [5], a set of tests on a real Italy (Calabria) scenario involved few years ago in landslide events have been carried out, and a mathematical estimator useful for the proper detection of landslide movements is defined and applied to the measured range profile. The obtained preliminary results have revealed the usefulness of the proposed radar monitoring approach. A more extensive measurement campaign will be performed in future work, and a comparison with theoretical models for lansdlides prediction and analysis will be performed to further assess the proposed approach.

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Equivalent Circuit Modeling of Active Reflectarray Element with Varactor Loaded Radial Phasing Line

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Abstract. A very simple modeling approach is adopted in this paper to perform a fast preliminary investigation of a novel broadband varactor loaded phasing line, specifically designed to add frequency agility features to an existing active aperture-coupled reflectarray cell. The proposed circuit-model approach is adopted to compare frequency performances of radial and linear phasing line geometries. The method allows to demonstrate the effective contribution of a radial line geometry for the enhancement of the unit cell frequency operational range.

Keywords: Radial line, varactor, reflectarray.

1 Introduction

Active reflectarrays represent a viable and very attractive solution for the realization of modern reconfigurable antenna systems, able to offer a lot of reconfiguration functions such as beam-steering, radiation pattern reshaping, frequency and polarization agility. Several papers discussed in [1]-[3] show how reflectarrays can effectively replace mechanically moved reflectors or phased arrays, providing additional benefits, such as low profile, instantaneous radar beam positioning, absence of mechanical vibrations, simpler architectures and increased efficiencies. Furthermore, reconfigurable reflectarrays allow to simultaneously achieve one or more of the above functionalities, simply by acting at the unit cell level by designing, for example, tunable reflectarray elements characterized by more than one degree of freedom. Many reflectarray configurations, among those collected and outlined in [2], offer polarization flexibility, frequency agility or multi-band operation through the use/integration of one or more tunable components, such as MEMS and PIN/varactor diodes. A dual polarized reflectarray cell loaded by two varactor pairs is proposed in [4]. A first proof-of-concept of multi-band reflectarray is reported in [5], which describes a dual-band cell. A reflectarray cell based on the use of a varactor and a couple of PIN-diodes is presented in [6], to tune the element reflection phase within a wide frequency range. Recently, a promising and highly versatile reconfigurable reflectarray cell has been proposed by the authors in [7]-[10]. It consists of a patch aperture-coupled to a uniform microstrip line loaded by a single varactor diode; by

changing the bias voltage across the diode, the element reflection phase is actively tuned, thus providing a dynamic control of the unit cell backscattering response. The proposed element has been experimentally validated in [10], demonstrating good beam steering as well as pattern reshaping capabilities. The above configuration is properly modified in [11], with the aim to improve unit cell frequency performances, in order to add frequency agility to well-established beam-scanning and pattern reshaping functions. In particular, by adopting a couple of radial lines instead of the linear stubs used in [10], the unit cell operational bandwidth (i.e. the frequency range within which is possible to effectively tune the unit cell reflection phase in a quite full phase-range) is roughly tripled, so achieving a certain degree of frequency agility. Practically, the structure proposed in [10] exploits the wideband behavior of the radial line geometry [12] to enhance unit cell reconfiguration performances, without adding any further tunable components. In this paper, a simplified circuit-model approach is adopted to analyze and demonstrate the wider band behavior of radial phasing line configuration [11] with respect to the classic linear one [10]. The adopted analysis method is fruitfully implemented to perform a fast and preliminary investigation on the improvements provided by the radial shaped varactor loaded phasing line in terms of reflectarray unit cell frequency agility.

2 Operational Bandwidth of Varactor Loaded Reflectarray Cell: Comparison Between Linear and Radial Phasing Lines

The reflectarray unit cells analyzed in this work are depicted in Fig. 1. Both cells have been proposed by the authors in some previous papers [10], [11]. In particular, the configuration depicted in Fig. 1(a) has been extensively discussed and tested in [10], while the cell illustrated in Fig. 1(b) has been proposed in [11] as a modified version of the former with the aim to improve overall unit cell frequency performances.
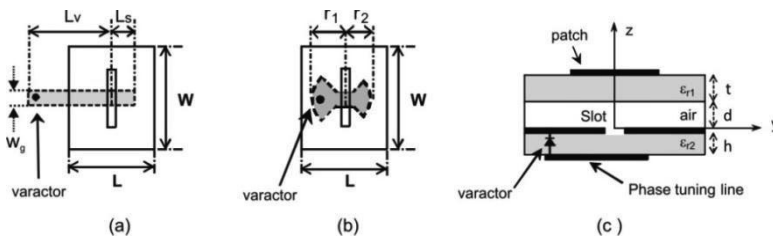
Fig. 1. Element layout : (a) aperture-coupled cell with linear phasing line; (b) aperture-coupled cell with radial phasing line; (c) layers stratification of the cell.

The basic structure, common to both cells, consists of a rectangular patch aperture-coupled to a microstrip phasing line loaded by a single varactor diode, whose variable capacitance allows to actively tune the cells phase response. The difference between the two considered cells lies in the phasing line geometry. As a matter of fact, the first cell depicted in Fig. 1(a) is electronically driven by a classic uniform microstrip line

composed by two linear segments L_s and L_v, while the second cell (Fig. 1(b)) is controlled by a phasing line composed by two radial stubs, having a 90°aperture angle and radius respectively equal to r_1 and r_2. As demonstrated in [11], the last phasing line configuration allows to improve the frequency performances of the unit cell, thanks to the wideband behavior of radial stubs that are typically characterized by an input impedance showing slower changes with the frequency, if compared with the reactance of an equivalent linear stub [12]. A case study demonstrating the above statements is reported under Fig. 2, which illustrates the comparison between the reflection phase curves versus frequency [11] computed for different varactor capacitances, both for the cell loaded by a radial phasing line Fig. 1(b) as well as for the one tuned by a linear phasing line Fig. 1(a). Either cells are characterized by sizes equal to $0.45\lambda_0 \times 0.45\lambda_0$ and the following layers stratification (Fig. 1(c)): ε_{r1}= 2.33 (Diclad870), t= 0.762 mm and ε_r= 1 (Air), d= 1.524 mm, for the antenna substrate; ε_{r2}=6.15 (TC600), h=0.762 mm, for the phasing line substrate. Both phasing lines are properly sized (L_s= 6 mm, L_v= 4.6 mm (Fig. 1(a)) and r_1=4.3mm, r_2=2.7mm (Fig. 1(b)) to achieve an alternate capacitive-inductive behavior in the phase of the signal reflected towards the aperture-coupled patch (Fig. 1), only by changing the diode capacitance within the values range allowed by the adopted model (see [11] for details). Moreover, the patch and the slot sizes are chosen to simultaneously achieve the antenna resonance and the matching with the phasing line, achieving in both cases the following dimensions (Fig. 1): L=8.9mm, W=6.8mm, L_a=6.7mm, W_a=0.7mm. The above unit cells are analyzed through the use of the infinite array approach, assuming a normally incident plane wave. The curves depicted in Fig. 2 show that the unit cell operational bandwidth (i.e. the frequency range within which is possible to effectively tune the unit cell reflection phase in a quite full phase-range) increases threefold when a radial shaped phasing line is adopted instead of a classic linear one. These results confirm the possibility to design an aperture-coupled cell with a certain degree of frequency agility, through a proper shaping of the active tuning line, without adding any further active components.
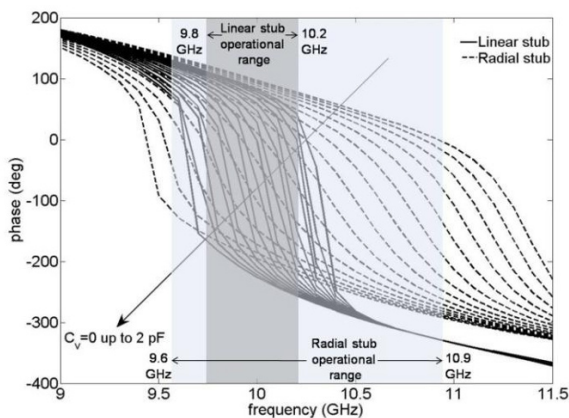
Fig. 2. Simulated reflection phase vs. frequency for different values of the varactor capacitance C_v: comparison between cells driven by linear and radial phasing lines.

3   Equivalent Circuit Modeling of Varactor Loaded Radial Phasing Line

As pointed out in the above paragraph, the slower frequency variations characterizing the radial stubs input impedance are fruitfully exploited in [11] to design a novel broadband varactor loaded phasing line, suitable to improve the frequency performances of the aperture-coupled reflectarray cell proposed in [10].

In order to better justify the above results, a preliminary numerical characterization of the adopted radial phasing line geometry is performed in this paragraph. The reflection phase behavior at the line section corresponding to the slot centre is evaluated through the use of the equivalent-circuit model approach illustrated in Fig. 3(a). The radial phasing line input impedance $Z_{AA'}$ (Fig. 3(a)) is computed as the series combination of the two radial stubs impedances, which in turns are calculated by adopting the simplified numerical approach proposed in [13]. This last method models the radial microstrip line with a set of cascaded interconnections of uniform transmission lines having incremental length dl_k and width w_k fixed by the radial shape (Fig. 3(b)).
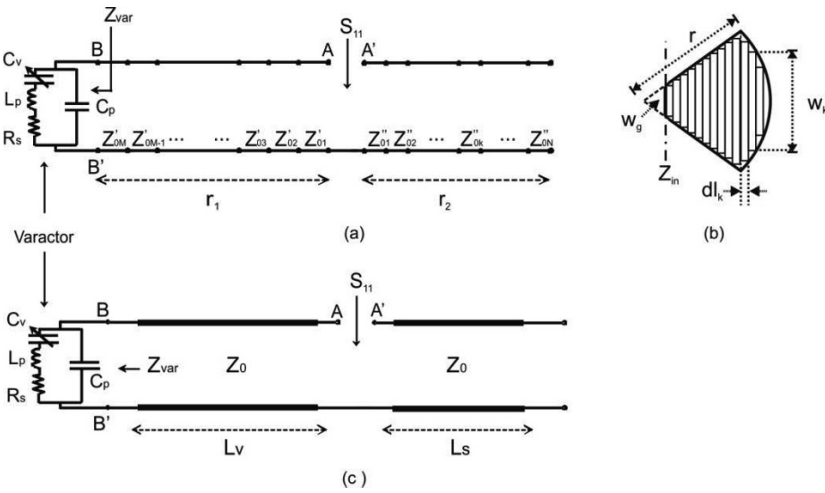
Fig. 3. Phasing line circuit model: (a) circuit model of radial phasing line; (b) radial stub geometry approximation; (c) circuit model of linear phasing line.

The input impedance of each radial stub is recursively calculated by computing the input impedance of the kth cascaded uniform transmission line, starting from the one placed at the open end of the stub down to the input section having width w_g (Fig. 3(b)). The input impedance of the kth cascaded transmission line is computed as:

$$Z_{in}^{(k)} = Z_{0k} \frac{Z_{in}^{(k+1)} + jZ_{0k} \tan \beta_k dl_k}{Z_{0k} + jZ_{in}^{(k+1)} \tan \beta_k dl_k} \tag{1}$$

where $Z_{in}^{(k+1)}$ is the load impedance of the kth line, that is equal to the input impedance of the $(k+1)^{th}$ section (Fig. 3(a)). Z_{0k} and β_k are the characteristic impedance and the phase constant of the kth transmission line segment, respectively, computed through the formulas reported in [14]. For the sake of simplicity, both dielectric and conductor losses are neglected. Even if more accurate methods can be adopted to estimate the radial stub input impedance (e.g. the closed-form formula derived in [12]), the above simplified approach is sufficient to get a rough idea on the radial stub input parameters behavior. Furthermore, it can take into account the variable capacitive load, simply by loading the Mth line section at the end of stub r_1 with the varactor impedance Z_{var} (Fig. 3(a)). The above circuit model is adopted in this work to perform a preliminary analysis of the benefits offered by the radial phasing line geometry, in terms of reflection phase frequency stability, and to find out the motivations that lead to these improved frequency performances . At this purpose, the radial phasing line is properly sized to achieve a fully tunable reflection phase at section AA' (i.e. $arg(S_{11})$), in correspondence to the design frequency f = 10 GHz. The input port width w_g is fixed equal to 1.6mm, which corresponds to a characteristic impedance equal to $Z_0' = Z_0'' = 40$ Ω, when the line is printed on a substrate having ε_r=6.15 and thickness h=0.762mm. The diode impedance Z_{var} is modeled with the equivalent circuit depicted in Fig. 3, composed by a tunable capacitance C_v, a diode series resistance R_s=1.36Ω, and package parasitic inductance/capacitance respectively equal to L_p=0.2nH and C_p=0.15pF. The stubs radii are fixed to r_1=6.06mm and r_2=5.9mm, respectively, so that, by varying C_v from 0.2pF to 2pF, a reflection phase variation range greater than 300° is achieved within a quite large neighborhood of the 10 GHz (Fig. 4), greater than that offered by the equivalent linear phasing line (fig. 3(c)) printed on the same substrate and characterized by L_v=4.25mm and L_s=6.5mm (Fig. 4).
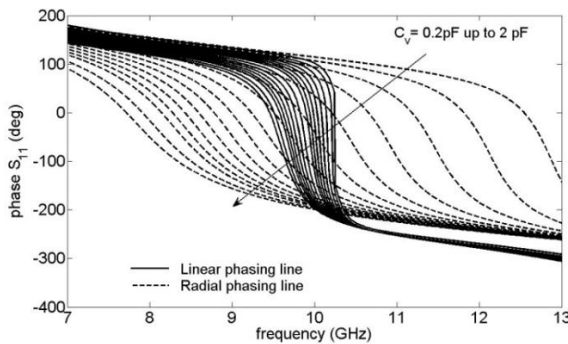
Fig. 4. Phase of coefficient S_{11} vs. frequency for different diode capacitance C_v: comparison between linear and radial phasing line geometry.

The above result can be attributed to the slower frequency changes characterizing the radial phasing line input impedance $Z_{AA'}$ as demonstrated by Fig. 5(a), that shows a comparison between reactance curves evaluated for both phasing line configurations at different C_v values. Furthermore, Fig. 5(b) demonstrates how the slower frequency variations characterizing the radial phasing line input reactance give rise to a reflection phase curve (i.e. $arg(S_{11}(f))$ with a very smooth and linear behavior within the considered frequency range, which is a measure of the radial geometry effectiveness in achieving wider band performances, also when it is applied to design a varactor-based phase tuning line.
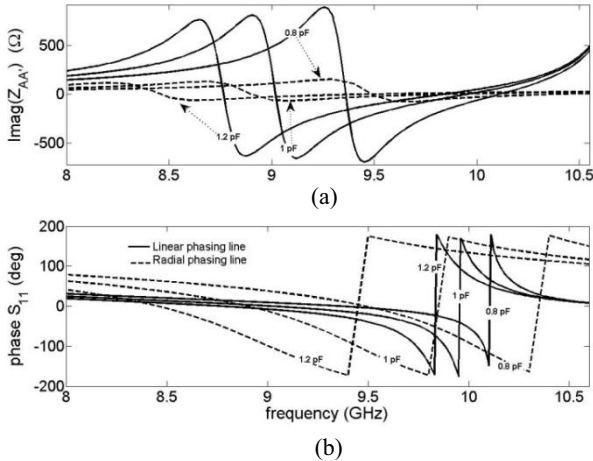
Fig. 5. Comparison between linear and radial phasing line behavior at port AA' vs. frequency for different C_v: (a) input reactance; (b) phase of S_{11}.

4   Conclusion

A wideband varactor loaded phasing line, based on the use of a couple of radial stubs, has been considered to dynamically tune the reflection phase of an aperture-coupled reflectarray cell. A simplified circuit-model approach has been adopted to perform a preliminary investigation on the improvements achievable with the radial phasing line geometry, in terms of unit cell frequency agility. The method has been fruitfully adopted to demonstrate and justify the wider band performances of the radial geometry with respect to the classical linear one, when it is applied to design a varactor-based phase tuning line. The results achieved for a 10 GHz unit cell demonstrate the possibility to design a frequency agile unit cell, through a proper shaping of the active tuning line, without adding any further active components, so limiting the DC-biasing network complexity.

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Next Generation Network (NGN) Challenges on Access Networks

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Abstract. Telecom infrastructures are facing unprecedented challenges, with increasing demands on network capacity. With the increased demand for high-speed data services and the constant evolution of broadband access technologies, operators are faced with a number of issues when choosing the technology and building the network. Today, network operators are facing the challenge of how to expand the existing access network infrastructure into networks capable of satisfying the user's requirements. Thus, in this context, providers need to identify the technological solution that enables them to profitably serve customers and support future needs. However, the identification of the "best" solution is a difficult task.

Keywords: Access Networks; NGNs; Broadband Access Networks; Architecture; Techno-economic Model.

1 Introduction

The development of the information society is dependent on a universal broadband access network capable of reaching everybody. Broadband deployment is increasingly considered a key driver of economic development, productivity, job growth, and social advancement.

The rapid development of new-generation applications, such as high-definition television (HDTV), peer-to-peer (P2P) applications, video on demand, interactive games, e-learning, use of multiple personal computers (PCs) at home, and higher throughput requirements and communication demands make upgrading the access infrastructure a necessity. Ubiquitous broadband access requires a minimum bit rate that is sufficient to allow all citizens to benefit from these services. As a result, to run voice, data, video, and advanced Internet applications, residential users may soon need connections of more than 30 Mbps [1].

The needs of telecommunication networks with higher capacity are becoming a reality all over the world. However, the limitation of local access networks is the major bottleneck to providing broadband access [2]. It is recognized that there is a disparity between broadband availability in urban and rural areas. The pre-existing telecommunications infrastructure is generally poor and unevenly distributed in favor of urban centers [3]. In most rural areas, low population density and high deployment costs discourage private investments, creating a negative feedback of limited capacity,

high prices, and low service demand. Building telecommunications networks in rural areas is costly. Further, in many cases, there is not a good commercial business case for rural deployments. Whereas established and competitive service providers already offer solutions for urban and suburban areas, there is little or no commitment to connect areas that include smaller towns and rural villages [4]. The deployment of access network broadband services on low-competition areas is characterized by low subscriber densities, longer loop lengths, lower duct availability, and consequently higher infrastructure cost compared to high-competition areas.

Service providers, network operators, and Internet access providers are faced with the challenge of providing higher capacity access to the end user and offering wider services. Consequently, new Internet infrastructure and technologies that are capable of providing high-speed and high-quality services are needed to accommodate multimedia applications with diverse quality of service (QoS) requirements. Until a few years ago, Internet access for residential users was almost exclusively provided via public switched telephone networks (PSTN) over the twisted copper pair. The new quadruple play services (i.e., voice, video, data, and mobility), which require high-speed broadband access, created new challenges for the modern broadband wireless/wired access networks [5]. The new services led to both the development of several different last-mile solutions to make the access network capable of supporting the requirements and a stronger integration of optical and wireless access networks.

2 Next-generation networks (NGNs)

The move toward next-generation networks (NGNs) has significant implications for the technical architecture and design of access network infrastructure, as well as the value chains and business models of electronic communications service provision [6]. This migration has begun to transform the telecommunication sector from distinct single-service markets into converging markets. NGNs allow consumers to choose between different access network technologies to access their service environment Sometimes, the NGN architecture will be limited to the developments of network architectures in the access network (local loop), referred to as the next-generation access network (NGAN).

NGANs are being deployed across the world with technologies such as fiber, copper-utilizing xDSL technologies, coaxial cable, powerline communications (PLC), wireless solutions, or hybrid deployment of these technologies. Wireless networks typically use a range of different technologies, including high-speed packet access (HSPA), HSPA+, worldwide interoperability for microwave access (WiMAX), and long-term evolution (LTE). Further, wireline networks are increasingly employing some form of fiber, such as fiber-to-the-home (FTTH) and fiber-to-the-curb/cabinet (FTTC). NGN access in a fixed network was initially a broadband access-based on the copper loops. However, many countries are developing projects to provide higher speed using fiber-based technology, such as very high-speed digital subscriber line (VDSL) or fiber-to-the-building/home (FTTB/H). For cable networks, it is of the case that the only voice service is Internet protocol (IP)-based, whereas for mobile networks, the migration to IP voice is more complex [7].

As broadband access networks require considerable investments, before the investment decision is made it is important to compare the different technologies. The investment costs depend on the technology to be used, as well as on the demography of the service area and subscriber and throughput demand forecasts. The choice of a specific technology for NGAN can differ among countries, geographic areas, and operators. In recent years, there has been an increase in the number, coverage, and market share of "alternative" networks or operators, such as resellers, unbundling operators, cable network operators, operators using frequencies for WLL/WiMAX, or operators deploying optical fiber in the local loop [8]. This has resulted in differences in competitive conditions among geographic areas, which has led to increasing arguments (especially from incumbent operators) that geographical aspects should be recognized in market/competition analyses and regulatory decisions. There are several factors that might be responsible for this discrepancy [9]: state and age of the existing network infrastructure; length of the local loop; population density and structure of the housing market; distribution of the number of users and street cabinets for local exchange; level of intermodal competition in the market; willingness to pay for broadband services; and existence of ad hoc national government plans for broadband development.

3   NGN regulation

Broadband in the OECD is still dominated by DSL, but there is an obvious trend emerging to upgrade last-mile access networks to support the new services requirements [2]. To address these network requirements, many carriers in emerging markets must move from legacy platforms toward next-generation solutions with a combination of wireless and wireline technologies, such as WiMAX, IP-Ethernet, and new forms of DSL technology and fiber.

In the past, the residential wireline telephony access network was characterized by monopolistic bottlenecks. With the advent of NGNs, economists began to challenge this view, as convergence sparked the hope for infrastructure competition in the local loop [10]. It is recognized that regulation can inhibit investment on the part of incumbents [7]. In addition, most European regulators argue that a simple withdrawal of regulation is not the most appropriate solution, as it inhibits investments on the part of competitive entrants, which quantitatively are often just as significant as those made by incumbents. The change in regulation can also restrict consumer choice and inhibit competition. For example, when the incumbent operator simultaneously has a monopoly in the access network and activity in the retail market, price regulation is an important issue. Without it, the incumbent can use his or her power in the market to stop or impede the entrance of new operators in the retail market. However, if a regulatory authority rigidly controls the access price, it might reduce the incentive for the incumbent to make investments in the network. The regulatory authority should not increase uncertainties and must provide clear incentives and guidance for the investment required for deploying NGANs [11]. [12] argues that in the case of high Internet penetrations the competition policy could lead to maximum welfare with

market price equal to marginal cost. However, for low-penetration markets the social welfare maximum is not achieved without subsidies to operators or customers.

Regulators should ensure that local loop unbundling (LLU) and sub-loop unbundling, bitstream, the transition to NGA, access to ducts and dark fiber, inside (building) wiring, collocation, and backhaul are defined in a transparent, efficient, and technologically neutral manner [8] (see Figure 1.1).
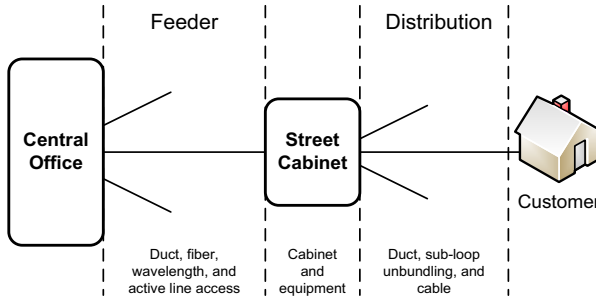
Fig. 1. Competition levels and locations

Although the cost of bandwidth in the active layer has reduced significantly (and continually) in recent years, the cost of civil works (such as digging and trenching) represents a major barrier for operators to deploy NGA infrastructure. Studies and deployments show that civil infrastructure is the largest proportion of the costs of fixed access deployment (up to 80%). Duct is a critical part of the next-generation access networks and its sharing would reduce or eliminate this capital cost and barrier to entry. However, duct access may need to be complemented by extra civil work to increase infrastructure capacity, the use of dark fiber (where available), or the use of conduits of alternative infrastructure providers. This also highlights that different and/or complementary regulatory tools may be required in different parts of the network [13].

3.1 Segmented regulation

Segmented regulation has been identified as a regulatory framework that can potentially provide both incentives and controls for the deployment of NGNs [14]. OECD regulatory authorities have traditionally adopted a national geographic area focus when framing the geographic scope of telecommunications markets. However, with the increase in the number, coverage, and market share of "alternative" networks (or operators), different competitive conditions between geographic areas have occurred [8]. Based on results of market analyses, economists have suggested that differential regulation should be considered between geographic areas in which facility-based competition has developed and those in which it has not. Competition can be promoted at many levels and locations through contestability and innovation [15].

After the decision of several countries to implement geographic regulations, there has been increased interest in these questions. In the literature on the regulation of future access networks, the discussion on regulation and investment has taken center stage, given the pending infrastructure investments in many countries [16]. The

geographically segmented regulation should aim not only at facilitating deregulation, but also at strengthening regulation in those regions where competition is viewed as ineffective. Then, segmented regulation can assist regulators in ensuring that the regulatory framework they apply is appropriately tailored to the competition situation [8]. Local decisions of a national regulator might lead to inefficiencies deriving from discrepancies between local and global cost-benefit evolutions. Segmented regulation may be helpful because it allows different solutions for the deployment of NGNs in urban and rural areas to evolve at different paces [14].

Figure 2 illustrates a scenario of the differences in competitive circumstances that may warrant geographically segmented regulation. There are geographical differences in conditions of competition, including the number of suppliers and market shares [17]. The deregulation of high-density areas might help to avoid the unnecessary protection of access-based competitors and strengthen incentives to invest in infrastructure. Further, maintaining regulation of low-density areas might promote competition with national offers because alternative operators are enabled to extend geographical coverage.
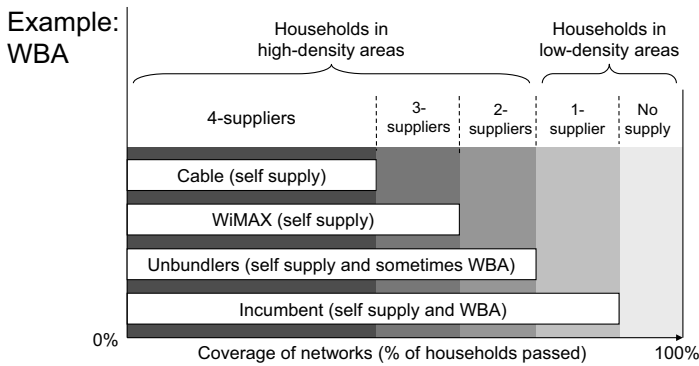
Fig. 2. Geographically segmented regulation [17]

3.2 Geographic differentiation

The analyses of several regulatory inquiries [15, 16, 18] on the national level show that access providers (usually the incumbent operators and former monopoly operators) are generally in favor of geographic differentiation. For example, a Spanish operator (Telefonica) argues that the geographical segmentation model can push investments and gradual deregulation, which permits to users enjoy the best possible scenario. The operator also defends the notion that differentiated regulation would prevent the increase of the digital divide. In Australia, Telstra argued that geographically segmented regulation will promote competition, giving service providers the appropriate incentives to use and extend alternative infrastructure, and will also promote competition by encouraging other carriers to offer wholesale local services.

For consumers, the impact of geographic differentiation is also important, given the often-repeated statements by politicians and regulators that policy and regulation are

designed to be in the long-term interest of consumers [8]. For business users, the breakup of market analysis to the sub-national level is a source of significant alarm, especially with regard to wholesale broadband access services. For multinational business users, inconsistency of national regulations and the consequent inability to obtain seamless international network services without service quality, costs, and administrative disadvantages is already a serious problem.

4   NGNs challenges

To deliver the new services to end customers, a large variety of access network technologies and architectures are available for operators to include both narrowband and broadband technologies with and without wires. The selection of the best solution requires an understanding of the technical possibilities and limitations of the different alternatives, as well as an understanding of the costs resulting from building and operating the networks. Therefore, the use of cost models for measuring the costs of providing telecommunications services has become commonplace [9].

The advent of NGNs creates new challenges for network operators, service providers and regulators. When network operators want to make investment decisions, they must consider the present utilization and emerging innovative uses of the Internet services (such as P2P applications, video downloads, next generations of videoconferencing, interactive video and television, collaborative gaming, and network-based backups) that lead users to adopt bandwidth intensive behaviors, which imposes additional costs on network operators.

Business modeling is broadly used by operators and regulatory authorities. Operators, existent or new entrants, use models for strategic planning, project analysis and selection, etc. The existent operators (e.g. incumbents) can use business modeling to study tariffs, analyze the cost of services, analyze competition, analyze of alternative technology strategies, business case evaluation, definition of the rollout strategy, appraising alternative investment opportunities and determining economically appropriate cost floors. To new entrants, these models give important information in the deployment of network infrastructures. For example, a cost model, with a series of calculations based on a certain costing methodology, provides the costs that a firm incurs to provide different services using different technologies.

One of the most important roles of any regulatory authority (NRA) is to impose cost oriented pricing to operators with significant market power - regulators require good cost models for the purpose of establishing the prices of regulated telecommunications services. However, without a detailed understanding of the costs of delivering services, regulators cannot impose appropriate rates for either retail or wholesale services [19]. In addition, regulators need the information produced in cost models to define strategies and policies [20].

Cost models deliver several benefits to operators and regulatory bodies. However, [19] contended that a new, accurate, and more flexible cost model for the new multi-service NGN networks are needed. More than ever, not being able to understand the cost drivers and model the costs of an NGN network leads to significant risk for both regulators and network operators. The current models are not adequate when faced with

the challenge of delivering a range of new and complex services over a radically different network infrastructure.

4.1 Methodologies for telecommunications modeling and simulation

Several cost methodologies can be adopted by network operators, service providers, and regulators. For example, [20, 21] identified several alternatives for performing telecommunications modeling and simulation: (a) economic models that are used for analyzing dynamics within the telecommunications market; (b) engineering cost models that are used to sum up the capital expenditure (CAPEX) for each network element (e.g., the long-run incremental cost model (LRIC)); (c) techno-economic models that are designed to evaluate deployment scenarios and to support the selection of optimal technology and deployment time; and (d) game-theoretic models that can be used to capture non-cooperative interactions between operators, such as exploring entry strategies and how market outcomes are affected by competition or regulation.

In dynamic and competitive markets, including telecommunications, firms base their decisions on the relationship between prices and forward-looking (or long-run) economic costs - costs that would be incurred if a new service were provided. Forward-looking economic cost computer models might enable regulatory authorities to estimate the forward-looking cost of network facilities and services. In the United States, the Federal Communications Commission (FCC) uses these methodologies as a basis for determining universal service support levels, cost-based access charges, and pricing for interconnection and unbundled network elements [9].

The LRIC methodology is often used by NRAs to determine the cost-orientation of regulated operators and set pricing levels for wholesale services. However, it is also a valuable tool for determining the cost of a single service, whereas a network typically provides multiple services. The European regulatory framework recommends the use of the LRIC standard for controlling dominant operator interconnection rates, which should be cost-oriented [22]. There are two main sub-methodologies for the LRIC. The total service long-run incremental cost (TSLRIC) type considers each service as a cost increment factor. This framework was first developed in the late 1970s and early 1980s to deal with issues surrounding the application of common cost concepts in firms producing more than one product or service [23]. The cost estimate developed using a TSLRIC framework shows the cost a firm would avoid in the long run if it no longer provided the service, holding all of its other production activity constant.

The total element long-run incremental cost (TELRIC) type is based on network elements. It allows the economies of scale achieved by different network elements to be distributed among services in relation to the intensity of use that each service makes of the element. Also assures that the cost allocated to a service is related to its use to the network with respect to the rest of services [22]. If market (or regulated) prices in a competitive framework exceed long-run economic costs, new providers will be attracted to the market; this entrance would be efficient. On the other hand, if prices fall short of economic costs, no new competitor will have an incentive to enter the market. In addition, some incumbent firms may decide to leave.

The techno-economic model enables network managers to evaluate the benefits of innovative technological developments in the context of global economics of the

business of telecommunication services. Using a given set of input parameters, this methodology calculates several results, such as cost and revenue, and performs risk and sensitivity analyses that support the management of network operators to elaborate adequate strategic guidelines for the medium-term planning of the network and service evolutions. It is normally implemented in spreadsheets, such as Excel. Moreover, it is useful for comparing the CAPEX of broadband access technologies.

An engineering-economic model starts with an engineering model of the underlying network (physical local exchange network) followed by an economic model that calculates the costs of the projected network. The design of the engineering model usually follows the procedure used in the planning of a realistic network, which involves the choice of system architecture, equipment planning, service and capacity prediction, and infrastructure planning.

Once the costing methodology is chosen, the model can be designed under two main network modeling approaches (see next table): top-down (based on financial accounting) and bottom-up (based on traffic demand). However, it is common to see models that result from the combination of both approaches. Hybrid models combine the advantages of bottom-up and top-down models and, consequently, provide a high-quality standard [24].

Table 1. Top-down and bottom-up modeling approaches main characteristics

Top-down approach	Bottom-up approach
Uses the existing network as a starting point from which an attempt is made to find the most accurate mapping of cost centers, costed units of output, and activity-based allocations [24]. The top-down model uses data from the operator accounts to calculate the costs of particular services.	The bottom-up modeling approach represents an efficient cost structure, objective and based on available information.
The bottom-up approach involves the development of an engineering-economic model to calculate the costs of particular network elements and in turn particular services.	Bottom up cost models are an attempt to determine analytically which network components are necessary to efficiently satisfy a given demand. So, using the traffic demands, it identifies the required network elements to provide the different services.
	Based on engineering and economic principles, each service is related to the network elements quantities required for producing it and the corresponding cost.

However, the described models for telecommunication analysis do not consider the influence of factors, such as competition, policy, and regulation. Therefore, in this context, game-theoretic models have successfully been used to analyze market dynamics in telecommunications (infrastructure competition). They can also be employed to analyze competition between firms to find a dominant strategy for each player or an equilibrium with which all players are content [21]. Game-theory models are concerned with the analysis of optimal decision making in competitive situations, although it is important to note that game theory does not predict the outcome of competition [21, 25]. Instead, it is a set of mathematical expressions used as a language for logical behavior. Given presumptions about the conducts of players, game theory maps the available strategies of each player in the game. To determine the likely outcome, game theory uses the concept of Nash equilibrium.

As seen above, the complexity of business modeling requires the use of software tools for manipulation with input and output parameters, modeling relationships, and calculating results. [26] define a business model as a framework for creating economic, social, and/or other forms of value. However, the term "business model" is used for a broad range of informal and formal descriptions to represent core aspects of a business, including purpose, offerings, strategies, infrastructure, organizational structures, trading practices, and operational processes and policies. Because of its simplicity, Microsoft Excel is frequently used as a general-purpose tool for business modeling, but it is not a good option in cases where more complex techno-economic interactions must be modeled.

5   Conclusions

As seen in the previous paragraphs, in order to meet the emerging demands for broadband services, adequate telecommunication access network designs are crucial for network operators, service providers, and equipment vendors. With the high number of technical candidates and design options for developing access networks, it is necessary to perform calculations to identify cost-efficient combinations of technologies, functionalities, and network structures. In addition, other issues, such as regulatory and competitive aspects, should be considered.

However, competition in telecommunications is more complex than in many other industries because of the nature of communications networks. A correct construction of a techno-economic model permits the minimization of errors in the network development phase and calculation of results, allowing for an evolutionary development of the network solution. The detailed modeling, including offered services, serving area, equipment, operational cost processes, revenues, and other related techno-economic elements, assures a significant conformity between techno-economic models and real deployment.

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Part IV
Internet, Business and Social Networks

The Security Policy Application Process: Action Research

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Abstract. It is crucial for companies to acknowledge the need for applying security policies because, without such policies, there is no reliable way to define, implement, and enforce a security plan within an organization. Small and medium sized enterprises (SME) are no exception. Within the organizational universe, SMEs assume a unique relevance due to their high number, which makes information security efficiency a paramount issue. There are several measures which can be implemented in order to ensure the effective protection of information assets, among which the adoption of ISS policies stands out. A recent survey concluded that from 307 SMEs, only 15 indicated to have an ISS policy [1]. The conclusion drawn from that study was that the adoption of ISS policies has not become a reality yet. As an attempt to mitigate this fact, security policies were formulated, implemented and adopted in 10 SMEs which had stated not to have this security measure. These interventions were conceived as Action Research (AR) projects.

Keywords: Formulation, Implementation and Adoption of Information Security Policies, Information Security, Small and Medium Sized Enterprises.

1 Introduction

Security requirements change at a bewildering speed both in large companies and in SMEs. Companies manipulate increasingly more and larger quantities of information, which is why increasingly stricter and wider security controls are essential. The technological process can work as a catalyst of threats, but is not enough on its own to ensure information security [1].

Information security encompasses technology, processes, and people. Technical measures such as passwords, biometrics, and firewalls alone are not sufficient in mitigating threats to information. A combination of measures is required to secure systems and protect information against harm [2].

Within this context, we consider that, in order to achieve organizations' wellness, it is important to implement security measures which take into account the confidentiality, integrity and availability of the information contained in information system IS [3,4] so as to prevent, detect and respond to the threats which such systems are exposed to and therefore, protect information.

Information security is understood as the maintenance, assurance and compliance with the following features of information:

- Confidentiality: Information assets can only be accessed and handled by users who have permission for that.
- Integrity: The content of information assets must remain unaltered and complete. Any changes made must be recorded ensuring their reliability.
- Availability: Information assets can only be obtained in short term by users who have the appropriate permissions.

Information systems security (ISS) policies consist essentially of documents which guide or regulate the actions of people or systems within the ISS domain [5]. ISS policies are pointed out in literature as one of the main measures to be taken by organizations for protecting their IS.

Considering the fact that this work addresses SMEs, it is essential to define this latter concept. The status of SME is defined in the Decree-Law n. 272/2007 of November 6, according to the companies' number of permanent workers, which must be under 250; the turnover, which must be under or equal to 50 million Euros; and an annual balance-sheet total which must be under or equal to 43 million Euros.

In Table 1, we present the number of workers and their representativeness within Portuguese business.

Table 1. Number of workers and percentage in 2012 in Portugal

Type of Enterprise	N. of Workers	Percentage
Micro	1-9	94.6
Small	10-49	4.7
Medium sized	50-249	0.7
SME= 1+2+3	1-249	99.8

As shown in the table above, SMEs in Portugal represent 99.8% of business. Their representativeness is extremely high, which makes them deserve more attention in many respects.

The research question that guided this work was to what extent AR methodology is adequate to support the process leading to the adoption of ISS policies.

The aim was to conduct the whole process of applying an ISS policy in 10 SMEs by using the AR research method. Structurally, this paper is organized as follows. After this contextualization of the subject, in section 2, we analyze the process of applying a security policy. Consecutively, we present the main features of the AR research method. In section 4, we describe the efforts made to formulate, implement and adopt ISS policies in 10 SMEs, which is followed by a discussion. Finally, we enumerate the papers' main contribution, and suggestions for future work.

2   Deployment of a security policy

In order to adopt an ISS policy, an organization must follow a sequence of steps, starting by writing the policy, then implementing it, and later on, at predefined moments or whenever circumstances require it, by reviewing its provisions, which

may prompt modifications in the policy. Indeed, this sequence of steps may be viewed as a cycle (figure 1).

```
┌─────────────┐    ┌──────────────────┐    ┌──────────────┐
│ Formulation │ ▷─│  Implementation  │ ▷─│   Adoption   │
└─────────────┘    └──────────────────┘    └──────────────┘
      ▲△──────────────────────────────────────────┘
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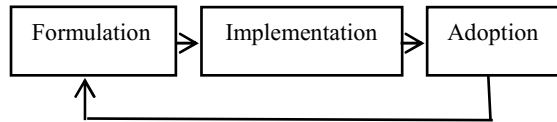
Fig. 1. The security policy application process.

The steps of this sequence, which starts with the formulation of the policy and ends with its adoption by the company, are consecutively described per se.

2.1 Formulation

In order to make IS secure, authors such as [6] claim that it is not always easy to write an IS policy document. Actually, the authors of such documents often make use of commercial sources or minutes which are available, and make copies of these documents, which therefore do not reflect the true culture of the organization, thus not resulting in an effective document regarding ISS.

Writing an ISS policy is an essential component for all successful information security efforts. The policies establish the stage for a wide variety of information security efforts [7]. However, the formulation of such a policy is not a straightforward task and depends on a variety of factors.

The formulation of a policy takes place at a planning stage, in most cases as part of a wider security plan which aims to provide adequate protection to IS through a set of security measures and practices [8].

According to [9], the development of a security policy within an organization involves four activities:

- Assessing and understanding the security needs;
- Reviewing the policies and procedures in use, if they happen to exist;
- Defining the protection requirements;
- Formalizing the security policy.

Although there are several contributions which provide guidelines to the formulation of an ISS policy (norms for security management, best practices, etc.), the formulation process represents a very demanding and considerably complex task.

In figure 2, we present a process of ISS policy formulation [10]. This process includes input elements which feed certain activity processes which, in turn, will originate a set of outputs.

It is within the formulation process that efforts must be undertaken in order to conceive policies which have clear goals, guidelines and procedures. Also, it is important to consider the inclusion of a well-defined "exception to the rule" provision, which will provide the policy with a certain level of flexibility which will be needed if circumstances so require [11].

Input	Activities	Output
• Results of the risk evaluation assessment • Legal requirements • Information on the structure and cultural characteristics of the organization • Existing security practices • Knowledge of information technology and security controls • Guidelines for security management standards and best practice	• Identify security requirements for the IS • Identify required security controls • Compile security policy document • Write down security procedures • Compile the specifications for technical security controls	• Security policy for IS • Specification for countermeasures

Fig. 2. The process of security policy formulation.

Besides what has been said regarding the ISS policy formulation process, it is crucial to know that there is not only one unique method to develop an ISS policy. Factors as diverse as the target audience, the kind of business, the size of the company or the possible existence of an ISS policy play an important role in influencing the ISS policies formulation process.

2.2 Implementation

The implementation of a policy is considered as a set of activities which aim to prescribe what is written in the policy document.

There are six main principles to be considered within the process of implementing an ISS policy [12]:

1. The organization will ensure that its information is kept safe and used in an appropriate way;
2. The organization will provide clear guidance to human resources regarding information security;
3. All human resources working for and on the behalf of the organization will cooperate with the information security policy within the organization;
4. The organization will ensure that its human resources know all the relevant guidelines regarding the organization's information security;
5. The organization will inform its clients about the way their records will be kept safe as well as of who will have access to them;
6. The organization will comply with all the national legislation as well as with the best guidance regarding information security.

The implementation of a policy is the process throughout which policies are turned into guidelines, procedures and lists of what to do and are put into practice by the information system users [10]. Thus, the implementation of an ISS policy can be considered as a set of activities aiming to prescribe what is written in the policy document.

In figure 3, we present a process of ISS policy implementation [10]. This process includes input elements which feed certain activity processes which, in turn, will originate a set of outputs.

Input	Activities	Output
• Security policy document • Knowledge on the culture of the organization	• Provide instructions on the application of the security policy • Provide the users of the IS with adequate training and education on the use of the security policy and procedures • Monitor and evaluate the use of the security policy • Monitor and evaluate security procedures • Implement technical and organizational security controls	• Security awareness • Evaluation of the implementation of use of the security policy and the application of security procedures

Fig. 3. The process of security policy implementation

This process ultimately results in the implementation and subsequent conscientiousness of both users and managers regarding the obligation of using the policy with utmost rigor and seriousness.

2.3 Adoption

Due to the nature of the diverse organizations where different and distinct users access and use the IS, the adoption and concomitant compliance with ISS policies is essential to enable the detection of flaws and incoherencies in the adoption process and to lead to their correction.

According to [10], the adoption of a policy includes elements of input, which feed certain procedures of activities, which in turn originate a set of outputs. figure 4 represents a scheme illustrating these authors' view.

Input	Activities	Output
• Evaluation of the use of the Security Policy • Established security procedures and work practices that implement the security policy • Education and training programs	• Establish norms that support security management • Promote the issue of security to IS users • Resolve possible conflicts and difficulties in the application of the security controls • Keep users and management informed on the IS security agenda	• Security culture • Proposals and requirements for improving and adjusting the security policy

Fig. 4. The process of security policy adoption

Within the process of adoption of an ISS policy, inputs include the evaluation of the policy during its implementation, the procedures and working practices which implement the security policy, and the users' training and education processes. Based on this information, the following process includes solving possible conflicts and difficulties detected in the application of certain parameters contained in the policy, and keeping users and managers informed on the ISS agenda.

3   Perspectives on Action Research

Both the description of the application of any research method and the lessons learnt from that application require a previous clarification. Such clarification goes from the way the different practitioners understand the research method to the method's main features and the way it is applied, as well as its areas of applicability.

As its name suggests, Action Research is a methodology which has a twofold objective of action and research, as it intends to obtain results in both areas [13]:

Action – the aim is to reach change within a community, organization or program;

Research – by increasing understanding by the practitioner, client or community.

Although different authors may have diverse perspectives concerning the usefulness of the AR method, there seem to be broad consensus regarding the method's general architecture. In short, the AR method starts with the detection of a problem, from which some changes are projected aiming to solve the problem. This process is cyclic as when applied to organizations or other social groups, it is unlikely that a problem is considered permanently solved and will rather suffer alterations and require new intervention. Thus, AR constitutes a methodological approach directed towards change: it is not limited to the understanding of phenomena but it also deliberately aims to change those phenomena.

The authors Susman and Evered [14] view a general AR project as a cyclical process, which is referred to by them as the AR cycle. According to their view, the typical AR cycle is composed of five stages: diagnosing; action planning; action taking; evaluating; and specifying learning. Diagnosing is concerned with the identification and definition of a problem to be solved in the client's organization. Action planning considers alternative courses of action to solve the problem. Action taking includes the selection and execution of one course of action. Evaluating comprises the study of the outcomes of the selected course of action. Specifying learning is the stage in which the study accomplished in the previous phases will be structured in the form of general findings.

As suggested in figure 5, the AR cycle takes place just after the Preparation phase. The Diagnosing involves a cooperative work between the researcher and the organization so that a problem to be solved during the research can be clearly identified. This identification has a more limited scope than that of the view expressed in the Preparation phase, and takes into consideration real implementation issues, e.g. the need for pilot projects and the availability of software systems. Following the Diagnosing are the Action Planning, Action Taking and Evaluating stages, all carried out in cooperation between the researcher and the client's organization. The next stage is Specifying Learning, typically carried out only by the researcher. This is the

stage in which the researcher will structure results so as to refine the set of open-ended questions, yet with appropriate answers to a number of them, and the preliminary model. Here, the researcher will decide if they will either proceed again in the cycle or go out to the Post-evaluation stage, summarized in the next section.
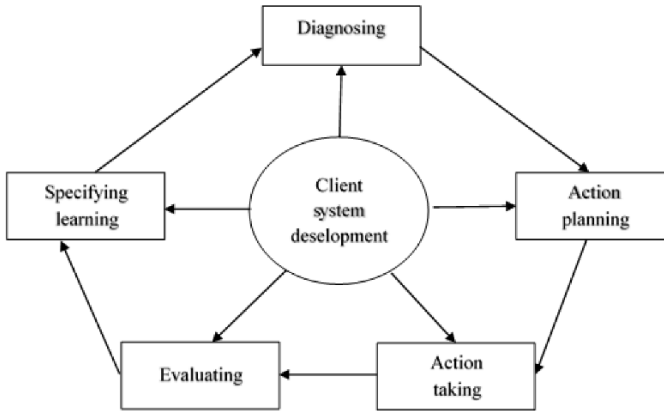
Fig. 5. Five steps AR cycle

Associated with each of the stages included in this model are the following goals:
- Diagnosing – Identification of a problematic situation, related to the need of change of a certain organization;
- Action Planning – Specification of the organizational actions which must be undertaken in order to solve the problems identified in the diagnostic;
- Action Taking – Implementation of the actions previously planned which will supposedly lead to changes;
- Evaluating – Assessment of the intended goals achievement and solution;
- Specifying Learning – Specification of the knowledge acquired with the introduced change.

4   Action Research applied to the security policy application process

This study involved ten SMEs through direct contact with the correspondent information technology departments and indirect contact with the direction as well as the users of the IS. This work reports on the use and appropriateness of AR applied to the formulation, implementation and adoption of ISS policies, thus contributing as an empirical study on the application of that method in the field of IS.

After drafting the first version of the document, we selected the companies where the joint formulation of the document and its subsequent implementation would take place.

Four essential aspects were taken into account for the selection of the SMEs: The SMEs geographic location; Their dimension; The fact that they did not have an

implemented ISS policy and The fact that they did not know how to formulate an ISS policy.

With regard to the first point, and considering that AR is a participatory research method which requires some time spent on-site in each one of the companies, we limited its implementation to one district in Portugal.

As far as the company dimension is concerned, and bearing in mind that SMEs are composed of Micro, Small and Medium Sized companies, we tried to cover the three types, thus selecting some Micro (1), Small (3) and Medium Sized (6) companies.

After selecting the companies and drafting a first version of the ISS policy, we moved on to the next stage, contacting directly with the head of the information technology department (8 cases) and with the owner of the company (2 cases).

After these steps, the policy document was finalized jointly with the stakeholders mentioned above and we proceeded to its implementation. As far as the adoption of the policies by the companies is concerned, this step was taken 8 months after implementation. This time lag was owed to the fact that not all the policies which are implemented are consecutively adopted. They often fade to oblivion, what is defined in the document is not followed by the information system users, the policies are never reviewed or updated.

In the first stage – Diagnosing – a problematic situation was identified, namely the non adoption of an ISS policy in SMEs. In other words, although the problem was recognized and assumed, the organizations had not been able to create the conditions to change the situation. Such acknowledgement reinforced the conviction that the AR method might prove to be particularly appropriate to change the current practice.

In the second stage of AR – Action Planning – the organizational actions which must be undertaken in order to solve the problems identified in the diagnostic are specified. In the present study, this process started with the drafting of the ISS policy document. We planned to draft the policy following a model proposed by the researcher, but adapted to the reality of each SME in a joint work with the elements from the information technology department.

In the third stage of the AR cycle, called – Action Taking – the planned actions are implemented in the hope that they will lead to some change in the organization. In our study, this stage involved several steps, namely the implementation of the policy; its approval; and its further dissemination.

The fourth stage – Evaluating – assesses whether the goals intended with the implementation of the ISS policy were achieved or not. Such evaluation involves the review of the policy, which must take place on a regular basis and particularly whenever significant changes occur within the company, in order to ensure that the policy continues to fulfill the purposes for which it was implemented. In this study, evaluation was carried out by checking users' compliance with the policy. A review of the policies was not considered necessary at this point.

The last stage – Specifying Learning – takes place in the end, as a conclusion of the whole process. However, this stage is actually present throughout the whole AR cycle. In this study, learning throughout the cycle provided a starting point for a new planning, thus, setting the beginning of a new sequence of the cycle.

The various phases of AR which were explained above are now summarized in Table 2, in which we present the five stages of Susman and Evered (figure 5) model as well as the main facts developed during each of them.

Table 2. AR stages in the implementation of an ISS policy

Diagnosing	Action Planning	Action Taking	Evaluating	Specifying Learning
-Lack of an ISS policy -Lack of initiative -Lack of an ISS policy model -Importance of a policy -Defining a problem	-Providing an ISS policy model -Drafting an ISS policy document -Planning the policy implementation -Defining ways to approve and disseminate the policy	-Implementing what was defined in the last stage	-Checking compliance with the policy -Checking the policy updating	-Assessing -Stopping if the problem is solved or if not, starting a second cycle.

5 Discussion

With this work, above all, we intended to help these SMEs change a concrete situation, which was the non-adoption of an ISS policy, as well as understand that situation and alter it.

The formulation of an ISS policy following the AR method was aimed at the construction of a solution to generate new knowledge useful to the participants on how to implement an ISS policy and improve its practice through successive evaluations and associated changes whenever necessary. Not only did the researchers cooperate in that process, but they also aimed to contribute to the existing knowledge, trying to understand the hindrances faced by organizations in the process of ISS policy adoption and to research on the effectiveness of initiatives put into practice to overcome those difficulties. This dual interest of researchers – helping to change the specific context of practice (Action) and adding to the general knowledge of the ISS policy adoption process (Research) – raises some questions. Since the intervention is based on a cooperative structure, and since the control over intervention by researchers is limited, the clear articulation and negotiation of the goals, views, and interests of the two groups of participants is particularly relevant.

Given the collaborative nature of this study, the insights of the participating researcher were often debated and brought to reflection in order to produce a shared understanding that led to change. Indeed, it was not intended that the researcher would unilaterally propose a change plan, but to build such a plan jointly with the other actors involved in the transformation. Therefore, the model initially proposed by the researchers was merely a prototype, which was altered and shaped to fit each one of the 10 SMEs in a further joint work with the companies.

This research method allows the participants to obtain a very wide knowledge of the company, which enables the formulation, implementation and adoption of a policy which can fit perfectly into the reality of each SME.

An ISS policy must constitute a constructive and protective vehicle and not a mechanism that hinders the good development of the organization's work. Therefore, before formulating a policy, we must take into consideration the company's goals as well as its organizational processes and culture.

6   Conclusion

The results of the study suggest that AR is a promising means for the institutionalization of ISS policies adoption. It can both act as a research method, improving the understanding among researchers about the issues that hinder such adoption, and as a change method, assisting practitioners to overcome barriers that have prevented the formulation, implementation and adoption of ISS policies in SMEs.

Among the works which might be carried out in the future, we highlight the proposal of an ISS policy model, thought up for the national reality, and which may work as a starting point to the adoption of ISS policies by SMEs, so as to invert the reduced number of policies existent in the SMEs. The provision of that document by SMEs and the use of AR as a method for planning and promoting change, in which researchers and practitioners project actions, implement them, and evaluate their impacts, may prove to be two important tools for the institutionalization of ISS policies in organizations.

Acknowledgment

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Broadband Access and Digital Divide

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Abstract. It is recognized that there is a disparity between broadband availability in urban and rural areas. The pre-existing telecommunications infrastructure is generally poor and unevenly distributed in favor of urban centers. In most rural areas, low population density and high deployment costs discourage private investments, creating a negative feedback of limited capacity, high prices, and low service demand. Building telecommunications networks in rural areas is costly. Further, in many cases, there is not a good commercial business case for rural deployments. Whereas established and competitive service providers already offer solutions for urban and suburban areas, there is little or no commitment to connect areas that include smaller towns and rural villages. The deployment of access network broadband services on low-competition areas is characterized by low subscriber densities, longer loop lengths, lower duct availability, and consequently higher infrastructure cost compared to high-competition areas.

Keywords: Access Networks; NGNs; Broadband Access Networks; Digital Divide.

1 Introduction

Communication networks have become a key economic and social infrastructure in OECD economies. The evolution in telecommunication technologies has dramatically changed the dynamics and opportunities in the global economy. The second International Broadband Data Report [1] suggests a positive correlation between broadband adoption and income, population size, and population density. Governments and corporations all over the world recognize that in order to sustain economic growth, substantial changes must be supported [2, 3].

However, there is a broad consensus among economists and policymakers concerning two major phenomena: the EU's economic performance has not matched the ambitions formulated in the Lisbon agenda of 2000 and the EU has not reaped the same benefits from modern ICT as the United States. The EU's economic performance has been particularly disappointing, given the strong expansion of the global and US economies in the first years [4]. Policymakers across Europe have acknowledged this situation and reacted with a number of policy initiatives at both the EU- and national level.

2 Digital divide

Access to ICT as a development tool for society is recognized as an important political, economic, and social issue. One of the factors mitigating this digital divide is broadband access, not only in urban areas, but also in rural and developing areas. In this context, local communities and governments are taking various steps to foster economic development in urban and suburban areas and to fight the so-called "digital divide" between well-served urban communities and underserved areas.

Despite the fact that 300 million EU citizens (58% of total EU population) live in rural, remote and mountainous areas, only 25% of such areas are covered by fast (download > 30 Mbit/s) or ultra-fast broadband (download > 100 Mbit/s), as compared to around 70% coverage in urban areas (source: EC, 2015). Digital divide between urban and rural areas is therefore a fact of life. However, broadband coverage in rural areas has improved in recent years. In comparison to 2010, the rates have doubled in 2013, but the availability of broadband remains uneven.

As previously mentioned, several governments and organizations recognize that there is a disparity between broadband availability in urban and rural areas. Levels of competition among Internet service providers varies among the different OECD member countries and between rural and urban areas within each country [5]. Rural areas are defined as having a scattered population pattern, including small villages or towns. In these areas, network operators traditionally have found it to be less economically attractive to provide broadband access [6]. In most rural areas, low population density and high deployment costs discourage private investments, creating a negative feedback of limited capacity, high prices, and low service demand [7]. The typical view is that there are too few customers per point of presence (POP), making it too expensive for broadband deployment. Whereas established and competitive service providers already offer solutions for urban and suburban areas, there is little or no commitment to connect areas that include smaller towns and rural villages [8, 9]. The biggest problem for improving the access to broadband is that the private investments are not profitable, due to population dispersion across big areas.

2.1 The situation in rural and remote areas

It is believed that the geographical isolation of rural and remote areas is historically a major obstacle for economic development, cultural interchange, and, in general, access to any type of services. With the advances in telecommunication technologies, the lack of infrastructures in rural and remote areas has increased the "digital gap". It is specifically noted that the use of broadband services is concentrated in urban areas.

The low density of the rural and peripheral areas highly spreads and, with long distances to cover in order to be connected to the telecommunication, networks increase the transport infrastructure cost. Due to this latter point, in order to extend broadband networks to rural and remote areas to 100% of the population, it is not a business for telecommunication operators [10]. The challenge of providing broadband services in rural and remote areas has gained increased attention in recent years. The majority of these areas are not currently covered by cable or DSL.

Broadband can have a much larger impact on the development of rural areas than any other communications infrastructure, including roads, railways, and telephones [11]. Full broadband coverage is highly important for bridging the digital divide. The digital divide refers to the difference in the ability for people to communicate and utilize e-based business and services relative to their geographical location, living standards, and education level.
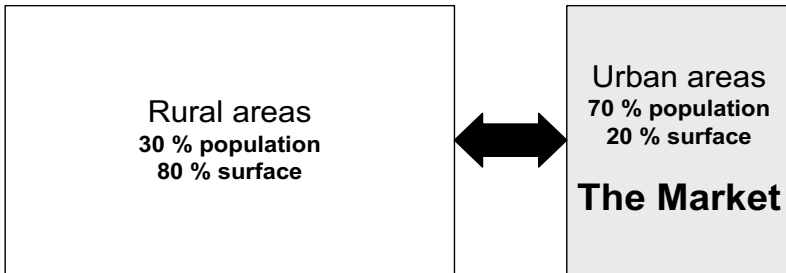
Fig. 1. Rural areas VS Urban areas

Figure 2 illustrates the discrepancies between urban and rural areas, for fixed broadband technologies. Overall coverage of fixed broadband increased by 2 percentage points in the last two years, but there was a remarkable progress in rural areas from 79.9% in 2011 to 89.8% in 2013.
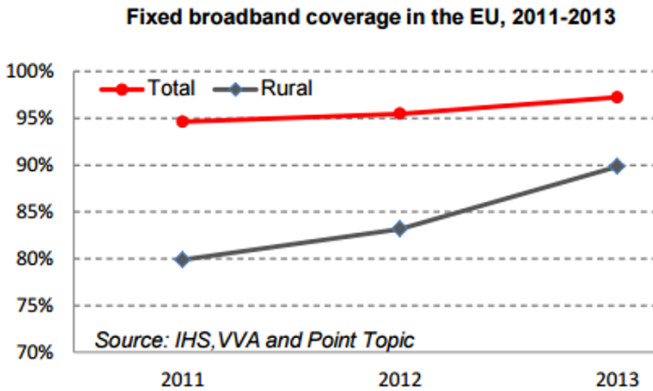
Fig. 2. Fixed broadband coverage in the EU: 2011-13

Figure 3 shows, the penetration discrepancies between rural areas and national levels. The rural areas have deficient coverage limit penetration and the late introduction of broadband in those areas has created further delays in take-up.
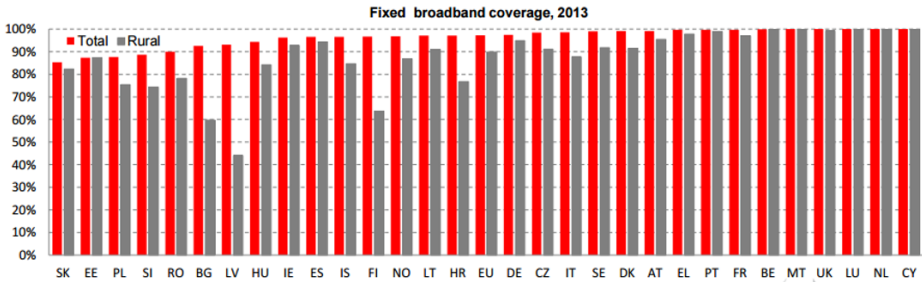
Fig. 3. Fixed broadband coverage: 2013 (Source: IHS and VVA)

Next Generation Access includes VDSL, Cable Docsis 3.0 and FTTP. At the end of 2013, Cable Docsis 3.0 had the largest NGA coverage at 41.2%, followed by VDSL (31.2%) and FTTP (14.5%). Developments until 2012 were dominated by the upgrade of cable networks, while VDSL coverage grew by more than 60% in the last two years. NGA networks are currently very much limited to urban areas: rural coverage is only 18.1%, coming mainly from VDSL [12].
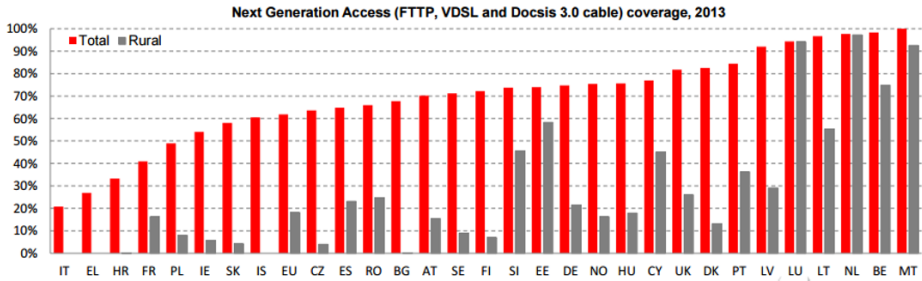
Fig. 4. NGA coverage: 2013 (Source: IHS and VVA)

The lack of telecommunication infrastructure in rural areas is primarily due to the high costs of building "last-mile" networks in the communities. Sparseness of the population, difficult terrain in which to install copper pairs, and insufficient revenues to justify costs are some of the reasons for this limitation. The growth of the Internet and rapid deployment of broadband services in urban cities make rural areas more vulnerable to not receiving access to advanced telecommunication and information services. Therefore, it is possible that the digital gap between the information "haves" and "have nots" will widen. The digital society increased the rapid bandwidth demand, which put pressure on the network. Although national networks are frequently upgraded to cope with this demand, a bottleneck remains over the "last (or first) mile" between the costumer and the first node in the network. Building telecommunications networks in rural areas is costly. In addition, in many cases, there is not a good commercial business case for rural deployments. Then, prices for Internet access in some markets remain high, and users might have a limited choice of broadband providers.

Significant shares of copper wirelines in both rural and urban areas have excessive lengths, which prevents high-capacity communication. In rural areas, long xDSL lines often correspond to the scattered population outside of the densely populated areas.

Cable operators have extensive coverage in some countries, but their networks are often limited to high- to medium-density housing. As a result, the first 5-10 km wireline access part may be difficult to set up in rural or remote areas. Consequently, alternatives to xDSL must be used to fill the coverage gap. These alternatives are primarily wireless networks, such as BFWA and DTT or DVB-S, with return channels. Forums, such as WiMAX, have demonstrated the possibility of deploying additional wireless networks that are competitive or better than xDSL solutions. In scattered areas, access to fiber backhaul can be difficult to achieve, making wireless technologies, such as satellite or terrestrial radio, an interesting solution, including both point-to-point and point-to-multipoint systems.

As a result, some researchers have begun to question the cost-benefit rationale of extending Internet access to these high-cost, low-income areas. For example, [13] argued that in order to address the informational needs of the rural poor, traditional technologies, such as broadcast radio, provide a more cost-effective alternative. Over the last decade, numerous demonstration projects have been undertaken to demonstrate the benefits of Internet connectivity for a variety of rural development goals. However, long-term sustainability and wider-scale replication are rarely obtained. The reasons are complex, but most researchers point to a combination of poor design and implementation that does not properly account for local conditions, as well as the use of technologies developed for urban markets.

3 Conclusions

There has been significant progress toward reaching rural and remote areas with broadband. However, as previously mentioned, rural areas are unlikely to attract new entrants because they are costly to serve and have insufficient demand. Nevertheless, recent developments in wireless technologies are raising new hopes for sustainable Internet diffusion in rural areas of the developing world. These technologies permit drastic reductions in deployment costs, particularly for last-mile connectivity in low-density areas. Incumbent providers are conducting trials using WiMAX to provide broadband access services to areas in which it is not economical to upgrade DSL. New wireless technologies make possible an infrastructure development model based on community-shared resources, small-scale investments, and user experimentation.

However, these promising new technologies, such as WiMAX, LTE, and PLC, have not been a major part of these broadband deployments. Cable, DSL, satellite, and various fixed-wireless access technologies are still the technologies supplying Internet access to rural areas. New DSL technologies that increase the distance of data transmission have played an important role in this areas. The dramatic cost reduction of DSL equipment during the last several years and the development of smaller units (e.g., mini or micro DSLAMs) have steadily decreased this threshold, although the backhaul costs are still prohibitive in some areas.

Therefore, wireless solutions will play an important role in connecting these areas, but there will likely be greater demand for high-capacity fiber to reach as widely as possible into these areas in order to feed wireless connections. Results of research show that hybrid architectures that combine the advantages of different wireless or

wired technologies are central in delivering broadband services to rural areas in a cost-effective manner.

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Recommendations for a New Portuguese Teacher Placement System

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Abstract. Portuguese teacher placements' system is a centralized system managed by the Portuguese government, specifically by the Ministry of Education and Science. It is a system with some issues and, therefore, has been criticized by its stakeholders, mainly by teachers. This paper aims to do a systematic review and a meta-analysis of the Portuguese teacher placements' system. An objective is to understand and describe how similar system works in European Union countries. Another objective is to interview school specialists, in this particular case - teachers, to find solutions for teacher placements' system. Finally, from solutions from European Union countries and from solutions arising from schools' specialists, a set of requirements is identified that the teacher placements' system should take into account, in order to avoid the issues identified.

Keywords: High School; Teaching System; Teacher Placement.

1   Introduction

Whenever a new school year begins in Portugal, the teacher placement system has been criticized because the occurrence of problems, namely: the fact of teachers are placed far from their residential area; the criteria that determine the ranking of teachers for subsequent placement in a school are not fully understood and, possibly, are wrong; and the number of school jobs vacancies is not according of the needs of each school, forcing schools to open additional job vacancies [1] [2].

This impacts and causes disorder to teachers at several levels: at professional level, because, if teachers do not get a job vacancy or teachers only get a part-time job vacancy, this may cause absence or reduction of monthly remuneration; at personal

level, because it forces the teachers, in most cases, to change their local of residence, sometimes very far from home and friends, causing, every year, the teachers have to start a new life from scratch; and at family level, because, sometimes, this cause a separation from teachers' family (husband's/spouse's and children's).

This system also impacts on students, because if a school job vacancy are not filled on time, may causes a (long) time without classes to a particular discipline, which jeopardize students learning and respective school success. We emphasizes that the teacher placement system affects thousands of teacher candidates to school vacancies and many of them are not placed in a school when many schools are left with unfilled vacancies. Therefore, it is pertinent to describe the process of teachers' placement in Portugal, i.e., what are the criteria used for teachers' placement in a particular school, understand the failures, and thus, improve the process of teachers' placement system.

Portugal is part of the European Union, so it is important to compare the teachers' placement system in Portugal with other European countries and describe the differences between these countries. This study must take into account who knows the education system, i.e. teachers. The main goal is to collect and realize the teachers' opinion about the system that is in place in Portugal and understand they agreement, or not, about replace the existing system by implementing a new system.

This paper presents the following objectives: describe the process at national level; describe the process at other European countries; identify proposals for improvements; and conduct a survey to collect and realize the teachers' opinion about the current process of teachers' placement system.

The paper is organized as follows: Section 2 presents the teacher placement system in Portugal and other European countries. It also presents a comparison between the existing system in Portugal and other European countries; Section 3 describes three proposals to improve the Portuguese teachers' placement system; Section 4 presents the results obtained from the questionnaire done; Section 5 provides a list of recommendations / requirements need to be incorporated into a new teachers' placement system; and finally, conclusions are presented.

2   Teachers Placement System in Portugal

The current system for place teachers in schools vacancies in Portugal is divided into two parts: the internal placement system; and the external placement system [3].

2.1   Internal Placement System

To start the process, a teacher select a Pedagogical Zone Board (PZB), a PZB is a defined territorial region of Portugal, in Figure 1 shows ten Portugal PZB's [4], [5], [6]. After that, a teacher can apply for a certain number of schools by choosing the preference school, i.e., in descending order the teacher refers schools where prefer to work [6].
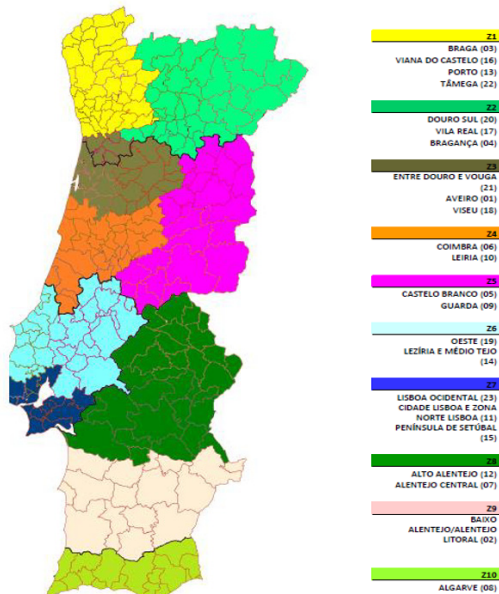
Figure. 1. Country division into ten PZB's.

If a teacher is placed in a school, it is important to remark, in the next year he/she can change the school by moving to another school with vacancies on the school board, the teacher can do this by Internal Mobility system [7]. After the teacher apply to a PZB or to a school, the teacher placement is independent of the PZB of he/she belongs, i.e., if a teacher wants to apply for an existing school vacancy, from the same PZB or different PZB, he/she can do it if there are school board vacancies, or if there a teacher at this school in the same situation [7]. Here is an example: if a teacher wants to change from one city school to another different city school, for any reason, he/she can do it by providing if there are vacancies at the school where he/she wants to go. It is important to remark, that this process occurs every year.

2.2 External Placement System

Teachers can apply to three different types of schools [5]:
- Schools with autonomy agreement, these schools have autonomy to hire teachers. These are usually schools with students with special features, such art schools, music schools [4] [8];
- Special schools are schools dealing with students from different ethnic groups with disadvantaged social classes, with affected households and who are in degraded areas [4] [9];
- Normal schools [4].

Within the external placement system, teachers firstly apply to normal schools by defining a priority ranking from 1 to 100.

Teachers who have not been placed in a school vacancy, transit to a *Recruitment List*, the teacher in the application form can choose if he/she wants to enter in this *Recruitment List* [10]. The *Recruitment List* aims to identify teachers available, if necessary, to replace teachers that became unable to teach.

With regard to schools with autonomy agreement and special schools [11], teachers who have not been placed transit to a *School Recruitment List* [6].

In the *Recruitment List* teachers are ordered using the formula (1) [5] [19]:

$$PC \text{ (final course grade)} + DP \text{ (experience)} \tag{1}$$

Where *PC* corresponds to the Professional Classification (final course grade between 10 to 20 points) and *DP* corresponds to Degree Professional (for every 365 working days is assigned 1 point).

In *School Recruitment List* teachers are ordered using the following formula (2).

$$PC \text{ (final course grade)} + Test\_Curriculum \text{ (questions to teachers)} \tag{2}$$

Where *PC* corresponds to the Professional Classification (final course grade between 10 to 20 points) and *Test_Curriculum* (schools evaluate teachers through a set of questions and at the end the teacher is evaluated by a grade between 0 to 200 points).

2.3   System placement in other European Countries

We performed a brief description of the process of schools vacancies placement / recruitment of teachers in European countries, namely UK (Scotland), Netherlands, Spain, Italy, France and Germany.

The Scottish Government together with the General Teaching Council for Scotland, local authorities, teachers' unions and universities manage the teacher placement process. The method used for the school vacancies placement of teachers, undergoes a process of raising some relevant information such as: the number of existing students; the number of teachers needed; the number of teachers leaving the profession; and the number of teachers entering the profession in the next school year. The system calculates the number of teachers needed to fill the gap between supply and demand. With this, the method permits to hire a precise and exact number of teachers to fill the needs [13].

In Netherlands the placement of teachers is done through an open recruitment, i.e., the responsibility for disclosure of vacancies available for teachers to apply is the responsibility of the schools, sometimes acting in conjunction with local authorities. The schools decide and implement the procedures and methods for teachers' recruitment. Thus, the process for school vacancy placing teachers is a decentralized process, because who decides to hire teachers are schools [14].

In Spain the teacher recruitment method is done through an exam, i.e., if a teacher wants to teach in a public school, he/she must subject to an exam and obtain a positive classification. The process for school vacancy placing teachers is centralized [14].

In Italy the recruitment method used in Italy is through an examination, such as in Spain [14]. The teachers are divided in regions (provinces) and the exam enable to

sort teachers by exam classification in each region [15]. According to Italian legislation, the exam is intended only to form a list of qualified candidates at regional level. In fact, a teacher already contracted is under the Regional School Office, this office belong to the Italian Ministry of Education. On the other hand, teachers without a contract, or temporary contracted, are recruited from a regional list and the contract is made directly with the school [14].

In France there is an exam [13]. Firstly, teachers must have a university grade or equivalent degree to be submitted to exam [16]. If the teachers are approved, they spent a year training at *Institut Universitaire de Formation des Maîtres* (IUFM), with the label of paid trainee teachers. Finally, if teachers are approved at trainee, a school to work is attributed.

In Germany teachers are recruited through a list of candidates and the decision of school vacancies placement is from German State responsibility, although in some *Länder* (states), when are not enough candidates to fill the existing vacancies, local authorities have influence on recruitment [17] [18]. The candidates list is sorted by academic performance, i.e., the final classification of the university graduation. The system in German may have some school vacancies placement delays due to candidate's geographical preferences. The teachers' preferences are taken into account by authorities, which leads to teachers' greater satisfaction [18].

Comparing and analyzing the placement systems from various countries there was a certain balance in terms of systems centralization and decentralization.

3   Improvement Proposals

Due to the complexity of the subject, because it involves political issues, some proposed improvements to the teachers' placement system are not implemented or even divulgated. However, after some research, three proposals are identified.

National Association of Teachers suggested to the Ministry of Education to decentralize the school recruitment list. Finally, suggested to other schools (with autonomy agreement and special schools) the sort criteria should be as follows: 75% for Professional Classification and 25% for other criteria [19].

National Federation of Teachers proposed two different improvement proposals. Firstly, proposed a qualified teachers' sort priority, the process should occurs every year, stabilization of teachers through stabilization of schools vacancies, the ranking of the candidates settle in Professional Classification, and proposed a priority to teachers that have worked at public schools in the last recent years [20]. Secondly, proposed to open a list weekly updated with school vacancies available all school year, suggested augment the number of PZB's, and suggested that all qualified teachers can apply to a school vacancy regardless of the criteria adopted [20].

National Union of Licensed Teachers from Polytechnic and Universities presents a work proposal to Ministry of Education to promote the teaching stability and employment, basically by resizing the number of school vacancies and augment the number of PZB's [21].

4 Quantitative Analysis

To collect teachers' opinions, a survey based in a questionnaire was send to teachers in Portugal in order to identify improvements to the current process of teachers' placement system. This was distributed using the *Qualtrics* online platform.

Statistical tests were applied to show evidence of possible statistical differences between groups of teachers in independent regimes. The Mann-Whitney test for two independent samples and Kruskal-Wallis test for three or more independent samples. The significance level was 0.05.

The following results are intended to firstly characterize the sample. It may be noted that 75% of respondents are female and 25% male. With regard to age, most respondents, 53%, is comprised between 30-40 years, then between 40-50 years old is 31%, with regard to age matched between 50-60 years, represents 11% of respondents, and finally, with only 5%, is the youngest respondents who are between 20-30 years old. See figure 2.
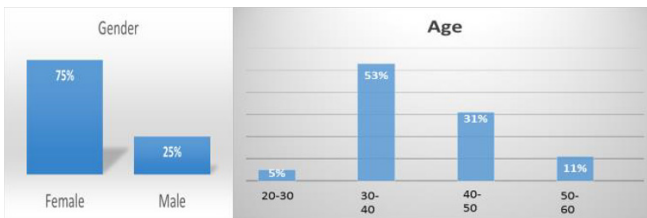
Figure. 2. Sample characteristics.

In Figure 3, in the left graph, 81% of respondents are teaching at the time of response and 19% not. Because 81% of the sample meet the teaching is an asset for this study because they have a better perception of functioning, such as problems with current teacher's placement system. In the right chart, is represented type of school that 81% of respondents is teaching, the majority, 55% of the sample, is found teaching a normal school (represented in blue on the graph), 26% in a school with autonomy agreement (shown in orange in the chart), 11% in special school (TEIP) (represented by gray in the graph) and finally 8% schools is teaching another type (private schools, vocational and education schools) (shown in yellow in the graph).
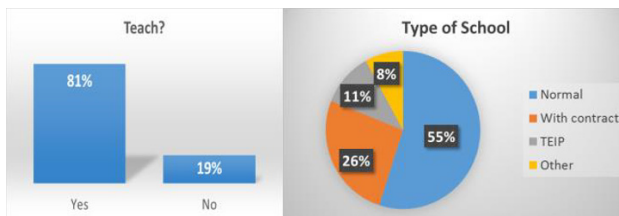
Figure. 3. Sample analysis I

Moving on to the analysis of the Internal and External school teachers' placement system, it was asked to respondents to rate the system between "Bad", "Reasonable",

"Good" or "very good", see figure 4. The left chart represents the classification of Internal Placement System. Thus, 50% of the sample classifies the placement system as "Bad", 40% classifies it as "Reasonable", 8% rate it as "Good" and only 2% classify the system as "Very Good". The right chart represents the classification of External Placement System. Thus, 68% of respondents rate it as "Bad", 24% classify it as "Reasonable", 7% as "Good" and only 1% as "Very Good". We can conclude that there may be some dissatisfaction with those who interact with both systems due to the classification that they attributed to him.
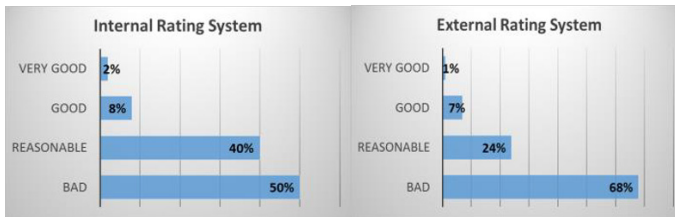
Figure. 4. Sample analysis II

The Mann-Whitney test is used to see if the classification distribution of Internal and External system by teachers' gender and those who are teaching or not are different. Regarding the type of school that teaches and age groups we used the Kruskal-Wallis test to check the differences in the distribution of the internal and external system classification. See Table 1.

Table. 1. The table shows the cross-checks made after the statistical analysis.

	p values	
	Internal	**External**
Gender	0.063	0.467
It is to teach	0.094	0.656
Type of school	0.021*	0.113
Age Group	0.013*	0.056

The results demonstrate a significant statistical evidence to assert that the classification of the internal system is considered differently by teachers working in different kind of school and for different age groups, for a significance level of 0.05.

With regard to PZB's division implemented, the respondents' advocates increased number of PZB's, with 58% of responses, 21% of the respondents believes that the division should be done in municipalities, 8% decreased the number existing PZB's, 7% was the division following the division into regions, only 4% of the sample is satisfied with the current division and finally 2% advocated another option, such the elimination of PZB's.

We asked the respondents if they agree with some list of recruitment, 61% of the respondents not agree with any of the recruitment lists, only 27% agree only with the *Recruitment List*, but 7% of the respondents agree with the actual process, that is, with the two recruitment lists, finally, 5% of the respondents agree only with the *School Recruitment List*.

To propose a solution to please everyone, 90% of the respondents agree with the existence of only one list of recruitment and 10% disagreed with the idea.

To determine what is the best formula for sorting teachers in the recruitment list, 41% of the respondents supports the Professional Graduation as principal and fair criteria, 28% believes that the best criteria should be Professional Classification, 21% support the Professional Rating + Curriculum should be the fair formula for sorting teachers and, finally, 10% of the sample believes that the Professional Classification + Service Time should be the most effective way to sort teachers.

5 Recommendations for a new Teacher Placement System in Portugal

Based on problems and issues identified and solutions presented by teachers, a list of suggested recommendations / requirements to the new system has been presented.
In table 2 a list of requirements for Internal and External school teachers' placement system is presented. For each requirement, we describe the "Aspect Improve" which describes the problem identified, "Change" describes the proposed solution and "Tips" where the proposed solution is detailed and explained.

Table. 2. Requirements to improve the Teachers Placement System.

Internal Placement System		
To improve	**Changes**	**Suggestions**
PZB's	Reduce the size of existing PZB's	Some current PZBs address various districts. By using the district as split area, the number of PZB's increments from ten to eighteen.
External Placement System		
Existing recruitment lists	Only use a recruitment list	All teachers will be placed by a single list and will later be recruited from this list always taking into account the requirements and needs of each school.
Existing formulas placement	Implement a new formula	The Professional Graduation (GP) was the main criteria, especially highlighting the substantive issues. The Professional Classification (CP) was the second criteria mentioned. It considers that the curriculum will be necessary for the criteria, that is, which allows selecting teachers to be able to teaching students with special needs. In the GP criteria, the addition of Teacher Assessment criteria, this assessment will be given by the school where the teacher taught in such a way to evaluate their performance and professionalism. The scale is 0-1 and will have a weight of 50% of GP, the other 50% will be assigned to the corresponding value at the time of service. One option is to assign weights to various criteria.

		Objectively it was not possible to set a weight value for each criteria, but it is noticeable that the GP criteria will have the greatest weight, followed by CP and then Curriculum.
Time delay in the teachers placement system	Reduce the trial period of one month to 10 days.	The teacher placement process is a long time process. One way to reduce this time is to reduce the trial period, i.e., we proposed that a teacher has only 10 working days to decide if he/she wants to stay at a new school. If a teacher chooses to stay at the new school, the teacher leaves the recruiting list and frees the position in the list. If a teacher decides to leave the new school, he/she releases the job place to other candidates.

6 Conclusions

The work presented in this paper has several objectives that were accomplished: Describe the process of teacher's placement system in Portugal; describe the methods that are used in countries of European Union such as UK (Scotland), Netherlands, Spain, France, Italy and Germany and make a comparative analysis with Portugal method of teacher's placement system; identify proposals for improving the system; collect teacher's opinions about the method and process of teacher's placement system through a questionnaire; analyze the data collected through the questionnaire with quantitative analysis and propose a list of improvements to the teacher's placement system.

The current teacher's placement system in Portugal has issues and errors, particularly because it is a closed system not taking into account some relevant factors to teachers: professional, personal and family. Most countries make use of the open recruitment for the placement of teachers. It appears that there is no great discrepancy in terms of centralization and decentralization of teacher placement system.

There are some proposals to improvements to the current teacher's placement system, but for political reasons, some are not heard or implemented. Making use of a teacher's questionnaire with the goal to gather the teacher's opinion, some improvements to the current teacher's placement system are identified.

Finally, from all the data collected a list of recommendations / requirements was presented to be incorporated into a new teacher's placement system in Portugal.

Acknowledgments

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Computer Supported Cooperative Work - Exploratory Study on CSCW and Groupware Technologies and its Applicability in the Health Area

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Abstract. Since the dawn of human civilization that cooperation among individuals is observed. In the most primitive stage this phenomenon was manifested through hunting groups, progressing to the construction of objects and buildings and in a later phase in the construction of modern society itself. Nowadays with the advent of technology and rise of ICT, collaborative processes across workgroups in organizations have been increasingly supported by this concept. The use of technology for supporting collaborative processes of working groups led to the creation of areas of study as CSCW and Groupware. In the health area, collaborative platforms have been used for supporting medical distance learning, social networks for collaboration, patient monitoring, discussion forums and sharing of medical media content. This paper has the goal of analyzing technological advances and the application of collaborative platforms in the health area, through an exploratory work of literature and application analysis and discussion.

Keywords: CSCW; Collaborative Platforms; Groupware; Health; Case Study.

1 Introduction

Nowadays, the modern society lives in the Information and Knowledge era, often called as Information Society. This concept is often utilized to describe a society and an economy that does the best use possible of the Information and Communication Technologies (ICTs) in order to deal with the information and that take that as a central element of all human activity [1]. With the advent of the ICTs and the Internet, new forms of cooperation emerged between people performing duties, regardless of the area of application. That intentional combination involved in tasks and/or common objectives is associated with the concept of Computer Supported Cooperative Work (CSCW) [2][3]. One of the areas most benefited from the CSCW systems was the Health Care area, given the need to, for instance, obtain information resulting from the cooperation between health professionals with different responsibilities, for the treatment of patients [4].

Under the present work, there was a conceptual study on CSCW and its applicability in healthcare through the analysis of some cooperatives platforms used in this area. The

study will allow an understanding of the inherent topics and an identification on the opportunities and challenges that lay ahead, particularly in what concerns the application of the concept to the health area.

2   Conceptual approach about CSCW and Groupware

2.1   Motivations

Collaborative platforms in the past few years have been claiming more and more within organizations as a viable and effective way to support cooperative work, especially when applied in situations where the collaborators are geographically dispersed [5][6].

The use of such platforms have been due to various reasons [7][8]: to facilitate interaction and cooperation between the elements of a work group; more impersonal and less threatening environment which can contribute to increased creativity and cooperation; real-time collaboration with geographically dispersed people; definition of the logic of tasks through work flows optimizing the implementation and coordination of activities; sharing data, information and knowledge through user permissions; incentive to productivity and interpersonal relationship; facilitate the processes of communication between the elements of the work group; overcome professional integration barriers, notably in the case of ethnic minorities; contribution to the era of the Information Society; ongoing cooperative development giving greater autonomy to cooperative groups; dynamic composition of teams between projects or during projects; increased real-time interaction, in geographically distributed teams, exponentiation of creativity, information sharing and knowledge of these elements; reducing travel costs; more comfortable for collaborators who have a disability (temporary or permanent); log of all history of team work collaboration; motivation for collaborators to contribute to the tasks, providing a sense of accomplishment and ownership regarding the artifacts that produces and that has edition/visualization permissions and to incorporate asynchronous communications, makes possible the participation of all team work collaborators, avoiding the feeling of exclusion.

The successful application of the ICTs to support the cooperative work of an organization, much depends on the technological characteristics, as well as the culture, structure and organizational strategy, and on the motivation of the users to use these platforms and the resistance to change they demonstrate to those technology structures [8][9].

2.2   CSCW Characteristics

The organizations are entities that emerged to meet the needs of the society and they are constituted of an intentional and integrated combination of people and technology, inserted into a particular social and economic context and possess a set of objectives [10][11]. The cooperation is characterized by the interdependency of multiple authors that interact among themselves, by the number of participants, what is their function in

the cooperation, the structural complexity of the area of work (interactions and heterogeneity), and the level of specialization of the participants [12].

The CSCW concept can be translated as the set of cooperative processes that unite and involve individuals from a work group, in a way they can work altogether to achieve a specific objective or to effective accomplish a specific task, independently of its physical location and of the synchronism of its communication. For the correct development of CSCW from within the organization, it is important to account for the interdisciplinary questions related to organizational behavior, technology, anthropology, psychology, linguistics, management and administration, as well as the questions about Man-Computer interaction, ergonomics, accessibility and usability [13]. One of the most important characteristics of the CSCW concept is multidisciplinarity. There is a set of disciplines/perspectives to account for so the cooperative application is successful: Artificial Intelligence (to give human characteristics to the systems like to think and to solve problems), Social Theory (human behavior and understanding of the interaction processes between individuals in collective environments), Man-computer Interaction (application of the best practices on interaction between people and computers), Communication (communication protocols to exchange information between system participants) and Distributed Systems (System Information and control decentralization, important for the temporal and spatial distribution of the users) [14].

Beyond the multi-disciplinarity, there is a set of characteristics that must be accounted for those systems to be successful [15]: definition of the common tasks and objectives, definition of the shared environment (which are the participants, which are the permissions that each participant has, what are the resources to share), information sharing, awareness (awareness of the activity of the other participants in the system, providing context for its own action), coordination (availability, organization and management of tasks, resources and information) and synchronicity of the communications (synchronous, i.e. real-time or asynchronous in certain periods of time). The development of a collaborative platform must meet a set of requirements: number of participants on the platform, mapping, file sharing, files version control and definition of a repository to store the information, authentication mechanisms, nonrepudiation assurance, work group task management and integration with other applications that are necessary to ensure fulfilment of the objectives of the work group [16]. Applications of this type must also ensure [17]: 1) Promoting the integration of collaborators in periods of change in order to minimize the negative impacts that may be caused; 2) Allowing remote access to data, regardless of the location of users; 3) Allowing the recovery of information stored in the data repository; 4) Ensuring the data integrity when accessed by more than one user (ensure ACID rules - Atomicity, Consistence, Integrity and Durability); 5) Allowing redefinition of procedures and processes; 6) Deciding whether to build smaller applications and inter-related with existing ones; and 7) Ensuring that the information used in cooperative work is disseminated by all the constituents of the team by the corresponding permissions.

2.3 Groupware

Associated with the concept of CSCW is the concept of Groupware. The main difference between this terms is that in the first, the study center goes through the discovery of new forms of cooperation and exploitation of the potential of the ICTs that support cooperative application for improving the interaction of the participants while the second term is used to describe the technology that supports cooperation groups [18] and is also the term that categorizes collaborative platform [19].

To collaborative groups take advantage of this type of software is important that in its development is accounted for a set of transverse requirements, regardless of the extent to which they apply, notably [8]: a) Given the dynamic nature of the responsibilities of the collaborators, there should be flexibility on the part of the system so that they can be changed; b) Concerning the existence of peer-to-peer communication between the different objects (e.g. duties and activities) located in various work posts; c) Providing awareness mechanisms, that is, there must be mechanisms that allow to know the activities done by other collaborators and the respective sequence of execution; d) Interoperability between applications, support for multiple tasks and working methods, maintenance of behavioral characteristics and scalability of collaborative group; e) Access control through user authentication; f) Ensure security properties for users such as confidentiality, non-repudiation and integrity of communications; and g) Creating a favorable environment to formal collaboration (work) and informal collaboration (socialization), flexible arrangement of users, using digital metaphors for representing real objects in order to give context and achieve greater success in the usability issues of the collaborative platform, as well as in the surroundings of the users.

The groupware applications can be described and organized by the type of function that they make possible. The most common function types in such applications are [20]: 1) Messaging: allow users to communicate synchronously (e.g. exchange of messages via chat like MSN or Facebook chat) and asynchronous (e.g. similar to the operation of e-mail systems); 2) Conference (conversation): provide a common communication channel, with interface (e.g. using metaphors simulating an office) to chat and share content (e.g. simulating the setting of a conventional meeting); 3) Decision Support: access to documentation and information about a particular subject, which is shared among the participants responsible for decision-making processes; 4) Document Management: delivering features such as indexing, searching, creating, editing, removal and distribution of documents, upon the permissions of the employee; 5) Document Version management: access to historical documents, ensure version control and management of change processes; and 6) Work flow: enabling the automation of procedures through the logical definition of the processes.

It is important to define the architecture of groupware applications as to how the collaboration is made. Collaboration management architecture can take three forms [21]: centralized, having a central server on which all data is exchanged via an access point (t-server); replicated, where collaboration is managed by all network peers, and that all data and information is exchanged between all peers equally (peer-to-peer); and hybrid, where it can be seen as a peer-to-peer architecture, where only a few points of the network make manage the collaboration (called master peers) and data and information to be exchanged and who should have access to those. The focus (or center)

of the collaboration should also be well perceived to optimize the use of these collaborative platforms. At this point it is possible to find three types of focus [22]: user, in which the user creates a channel of communication with other collaborators, but is not interested in what these collaborators do in the channel when they are not cooperating with him; topic, in which is saved the entire history of collaboration that goes with it (there are similarities with the publisher/subscriber paradigm); and collaborative environment, wherein the work space is shared by a group of users, but can exist without users (e.g. chat rooms).

In this type of applications other important factor is time, i.e. which are the criteria to perform communications. With regard to this factor, four time scenarios can be identified [20]: synchronous, where collaboration is performed in real time, being implemented locking mechanisms and messages collision detection; asynchronous, where collaboration is made at distinct times, allowing collaborators to perform other tasks without being dependent on the requested employee; mixed, in which cooperation can be done synchronously or asynchronously; sequential (serial or in series) where communication is asynchronous with the exception that when a user must perform a specific task before another employee can continue with other task (e.g. exchange of e-mails). In order to use this type of application is necessary to define how they are performed. The execution of such applications can be observed in four ways [23]: through mobile devices (e.g. tablet, smartphone), via Web browser, through desktop applications or through embedded applications in the operating system of the devices.

2.4 Potential risks and causes of failure

Despite the motivations for the use of computing power to support the cooperative work, there are some associated risks that can lead to failure of such projects. Some of the risks associated with these platforms undergo privacy concerns from the users; intrusion and misuse blocking capabilities of the platforms or changing content/functionality without permission to do so; acquisition cost of these platforms may be too high to yield short/medium-term return; the lack of context in new working practices; dilution of organizational aspects (e.g. Hierarchical); resistance to change on the part of users by not taking active part in the use of these platforms; not understanding the direct advantages of using these applications for users; the systems may not incorporate the natural unpredictability of collaborative work (lack of flexibility in the definition of work flows); Accessibility and usability issues related to the processes of interaction between Man-Computer, which may contain inappropriate use of metaphors, thus, making learning more difficult; failure to meet the established objectives for the use of groupware; interoperability restricted by lack of standards; inefficient communication, making the cooperation processes slower; social risk associated with social exclusion of certain collaborators or inadequacy to new forms of cooperation; feeling of exclusion of collaborators with poor performance and possibility of creating barriers to social interaction causing feelings of estrangement among people [8]. One of the ways used to get around these risks often responsible for failures in this type of project is using the Ethnography. This has been increasingly highlighted by the researchers working on building collaborative platforms, as with classroom analysis of the work environment, one can obtain information relevant to the

construction of work processes and system settings making more realistic and immersive collaboration experience for its users [24].

2.5   Main areas of application

Cooperatives platforms can be applied in different areas of activity of the society, especially the areas of Education, Software Engineering, Health (Telemedicine), Telecommuting, Psychology, e-Learning, Sociology, Culture, Public Administration, Virtual Worlds, Gaming and business transactions supported by the Web, [8][25].

    One of the areas in which the use of collaborative platforms to perform tasks is most evidenced is the health area [26] where there have been extensive range collaborative platforms over the last 25 years for different purposes [27]. In the next section the application of such platforms in health care will be addressed.

3   Collaborative Platforms in the Health Area

3.1   Contextualization

Technological developments in information technology has produced equipment with increasingly high quality, capacity, reliability, low cost and reduced size. This has spread the use of computers in various areas and activities [28]. In this range of areas is included the area of Health care, which encompasses complex processes of diagnosis, treatment and prevention of diseases, injuries and other physical or mental, temporary or permanent disabilities. The health care sector is the economically fastest growing in developed countries, as is the case in Western Europe, North America and even in emerging economies like China and India [29]. The processes of data collection, management and use on Health care have a key role in the detection of medical problems, identifying solutions to these problems and designing resources to treat them. Given the importance of these processes is essential that they are streamlined and, for that, the ICTs have being used to improve health services [30]. This behavior, according to the World Health Organization (WHO), allows that, in addition to streamline the processes mentioned above, the collected data shows a higher degree of reliability. During the last 20 years, the explosion of ICTs and the rise of the concepts of CSCW and Groupware dramatically changed the way the collaboration between elements of an organization is made. Another important aspect in the use of ICTs in this area was the influence it had in organizational collaboration processes. One of the success factors to any organization is the organizational and coordination skills among its collaborators, which basically comes down to collaboration [31]. In the case of hospitals, efficient collaboration between doctors and nurses is critical to patient care and for that are used collaborative platforms [32]. Also, differently from the other industrialized areas, health care services are not routine, which makes it difficult to manage the local provision of medical services, especially the operating rooms, and as such is encouraged to use collaborative platforms so there is a knowledge of the activities of other collaborators in order to optimize the occupation of such spaces [33].

3.2   Application of Collaborative Platforms in Health Care

Sermo - Social network for Health care professionals

Social networks aimed at a particular area of expertise, allow professionals to learn through practice, discussion and interaction with other colleagues. Groups of professionals who share a problem and cooperate trying to solve it, are creating their identity and impact in these networks and at the same time building and sharing knowledge that leads to problem solving. Today, there are social networks comprised only of health care professionals that discuss a variety of issues on this area of activity. Health care professionals who use these specialized social networks for its scope of action, causes that they become more experienced in the matters they debate, making it able to act effectively when they encounter discussed situations, making it more productive and efficient, providing better health care to their patients and increasing the success of the organization they represent [34]. The Sermo social network was developed by Daniel Palestrant in September 2006, and is designed only for interaction and cooperation between health professionals, particularly doctors. In this social network, an informal atmosphere is presented where collaborators can expose the clinical cases that they deal with to share knowledge, can expose clinical questions, formulate hypotheses and discuss them in custom topics, asking for opinions to solve problems among many other situations.

Sana - Open Source and Mobile Collaborative Platform

In recent years, with the development of mobile devices and their exponential utilization, health officials have adopted these technologies to support their services. Increasingly, doctors and health care professionals believe that the use of these devices allows to break the limitations of time and space in relations with patients [35]. With these medical devices, doctors can obtain patient data by, for example, Multimedia Messaging Service (MMS), or through the use of Radio Frequency Identification (RFID) is possible to make the recognition of patients present in the waiting rooms of institutions that provide this type of care [36]. Given the advantages of the use of mobile devices in the practice of health care, the collaborative platform Sana was developed for Android mobile devices and was developed by Massachusetts students (MIT) in 2010, with the purpose of providing health care and medical content applied in remote regions, where is difficult to access health resources. This Telemedicine associated platform implements a multi-disciplinary approach to presenting content, trying to overcome resource constraints at the site where the patients are, focusing on the analysis of the situation in which it is located. The application is ideal in situations such as humanitarian disasters (e.g. natural disasters, wars) where it is necessary that health care professionals make screening of the injured on the spot, creating its clinical picture and sending it to facilities that provide health care.

Osmosis - Medical Education

The inter-professional education is the gold standard for Pedagogy in training in areas related to the provision of health care, supporting a set of collaborative practices between professionals ready to develop their capabilities. Collaborative platforms associated with education, particularly in the health sector, allow students/collaborators to get hands-on practice in the specialty they will develop, while they are still studying [37]. An example of collaborative learning platform in Health care is the Osmosis

collaborative platform was developed at John Hopkins School Institute of Medicine in January 2012, is accessed via browser or mobile devices, it is used for teaching contents linked to various health sectors and is used by approximately 20,000 Medical students, has a set of more than 5,000 questions on many different areas of health. Students through this application can respond to custom quizzes on health areas that most interest them. Students can submit their academic plan of disciplines, as well as their workload and examination dates, and the platform calculates which are the most important topics and questions for study to the forthcoming examination.

MCT - Diabetes - Diabetes control

It is widely recognized that the doctor-patient dialogue is critical to successful treatment and patient care. However, the success of the patient treatment not only depend on the doctor's communication skills, but also depends on interactions and cooperation between the parties. This collaborative effort, good interpersonal skills, medical decisions and open exchange of information, all of which is facilitated by the more informal environment created [32]. The collaborative platform MCT-Diabetes was developed by Georgetown University Medical Center so patients with diabetes can control their glucose levels (diabetes) and so they can be tracked and monitored by the health care professionals who are responsible for providing them with medical care. This platform is used through a browser and uses communications over the Internet. The platform allows the patient to decide which health professionals and family members may have access to their levels of triglycerides in the blood and allows communication between all participants through the platform. Patients who do not allow access to this data by health professionals, can print reports and graphs generated by the collaborative platform and show later in medical appointments.

HiperClinica - Study and Research in Cardiology

The HiperClinica collaborative platform is a platform that is used on the Internet and runs on a browser, developed by the Bahia Federal University Hospital in Brazil, with the intention to be used by students, doctors, teachers and nurses of the Cardiology specialty, being classified as a collaborative learning platform. This platform provides textual and visual information used during the discussion of technical sessions between doctors and teachers of the institution in question. The platform allows for discussions of relevant clinical cases of patients who are manifesting the most diverse cardiac conditions, in order to study these clinical cases and to provide the appearance of solutions for these cardiovascular conditions. In relation to clinical cases of patients, the application provides information on: medical history (including information that is not related to their cardiovascular status); laboratory tests; electrocardiograms; X-rays; additional tests; echocardiography, scintigraphy, catheterization, therapeutic behavior, summary of the case and bibliography.

Mediwikis - Medical content Wiki

The platforms known as Wikis are seen as potentially powerful to promote collaborative document management, since they offer the opportunity to students cooperate in the production of knowledge [38]. The Mediwikis collaborative platform was developed at Newcastle University Medical School Institute, is freely accessible and can be accessed through a web browser, and provides content relating to several areas of Health. This platform works similarly to what happens with Wikipedia, meaning that any registered individual can create publications within the Health areas

available, can edit existing publications made available by other collaborators and, in addition, also allows for comments to available publications on the platform.

4 Final Considerations

The use of collaborative platforms enhances the capabilities of the Human being, making it more efficient when collaborating with others. In the health care area, the adoption of ICT, as a support to medical activities, is already happening for some time through various forms, including new techniques and methods of delivering health care services, such as Telemedicine. Collaborative platforms, in addition to incorporating cross-cutting capabilities to any IT platform, may also be used for teaching medical practices, managing humanitarian crises (given the importance of registering injury types and with this give a better support to the patient screening process), or as a means of dissemination of knowledge to the general public. Additionally, these platforms can also be used by healthcare professionals to monitor patients with various health problems, as heart and lung issues, diabetes, among others. The application of collaborative platforms enables closer relationships between patients and physicians, hence increasing the satisfaction of health professionals and the respective promoters of these services associated with them.

The knowledge acquired from this exploratory study will serve as a basis for future work based on three pillars, culminating in a functional prototype of a CSCW platform that will support the University of Trás-os-Montes e Alto Douro Nursing School and the Veterinary Hospital of Vila Real. This platform will be specified in order to support the students learning in both the academic and internship contexts, aggregating planning scales and distribution of tasks combined with a sharing system for collaborative knowledge which takes into account the inherent evaluation of skills.

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How Ill is Online Health Care? An Overview on the Iberia Peninsula Health Care Institutions Websites Accessibility Levels

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Abstract. The current urge on using Internet for both social and professional tasks, alongside with the existence of over 80 million European citizens with some sort of disability as led to the need for an accessible Web [1]. Given, the also increasing thrive for searching the web for health related information and the assumption of heath care institutions as the creators of this type of information, a research study was developed in order to evaluate the accessibility levels of the Iberian health care institutions. From this study, that used ACESSWEB as the evaluation platform, it was possible to perceive that none of the evaluated websites was WCAG 2.0 compliant and that, despite the poor results, Spanish websites presented more accessibility concerns than the Portuguese. Hence, the situation is critical and a significant effort must be done in order to allow citizens with disabilities to have access to the much needed health related information.

Keywords: eHealth, Iberian Peninsula; Health Care; Web Accessibility; ACESSWEB.

1 Introduction

The advances on Web technologies, mainly perceivable by the urge to use Internet to access information and to interact with others in a social or professional manner, and to use Web applications and systems that provide user directed services, one can easily acknowledge the need for all Web content to become accessible to all users, including those with some sort of disability [2][3]. Despite the inherent social and ethical concern towards Web accessibility, it is mostly regarded as a technical issue associated with Web platforms programming and, as a result, perceived as something whose solution includes very complex redesign and reprogramming operations that require experts on the topics and encompass a very significant cost to organizations [4].

The health topic as long been in the center of discussion when focusing the use of information and communication technologies in the various areas of society [5], and particularly the health care institutions websites are reaching very considerable levels of importance, given the increased use of these platforms, by both patients (customers)

and health related professionals, as a mean to access resources and information that in other way would be very difficult to attain [6]. Current literature does not provide for an in-depth analysis to the Web accessibility levels of the health care institutions websites, nor provides a methodology for accessing this indicator. With the current work we aim on presenting a methodology focused on website evaluation against WCAG 2.0 and delivering the results on a Web accessibility evaluation process supported by the referred methodology and that used the Iberian health care institutions as its target group.

2 Web Accessibility Background

2.1 Accessibility Applied to Web Environments

As acknowledged by the European Union Agency for Fundamental Rights [1], currently there are over 80 million European citizens with disabilities that need to be granted the right to be fully integrated within society and to use and access all available ICT (Information and Communication Technologies) supported content, including the one that is only available online. The ability of a given Web content to be accessible to all users, including those with some sort of disability, is the exact conceptualization of Web accessibility [3].

In order to achieve an acceptable level of accessibility, websites must follow the guidelines defined by the World Wide Web Consortium (W3C), according to which all Web content must be entirely perceivable, easy to operate, simple to understand and robust enough to be compatible with several agents and assistive technologies [7]. Hence, for Web platform developers and Web content creators to be able to achieve acceptable levels of accessibility, they may choose from two separate approaches. The first available path is considered as more functional given that it focuses its attention on users' limitations and on the viable solutions that can present an answer to those limitations. The second approach is a more technical one, given that it concentrates its efforts on the existing Web technologies uses and customizations as a path to decrease the impact of the obstacles that difficult users correct interaction with existing Web content [8][9].

2.2 Health Care Institutions Online Presence

Health care institutions websites are a crucial key-point on the institutions strategy towards reducing the gap between themselves and their patients. From an overall perspective one can deduce that a hospital website will increase the institutions chances on seizing their potential customers (patients) attention towards the offered services [10].

According to Hwang, McMillan and Lee [11], when a corporation assumes a public presence on the Internet, this should represent a strategic approach directed at communicating with their audiences, spreading their corporate image and, in parallel,

displaying their services. When analyzing this issue from a health care institutions perspective, it is clear that a website it not critical in order for the institution to operate. However, the rate at which patients are gaining abilities and access to a more dynamic, interactive and social Web, they are also developing a new need towards understanding not only how to identify certain symptoms associated with some health issue, but also understand what their hospital has to offer in terms of services and available experts and also, how and when a given health problem can be treated and what might be its impact on the patient's life [10][12].

In the same line, and assuming de Haydu, Eleswarapu, Dabaja and Duke [13] research, the existence of websites associated with health care institutions should serve as the basis to a reliable source of information directed at increase the patients (and their loved ones) knowledge regarding their diagnose and inherent treatment. Despite this, there are still several hospitals who continue to implement policies only directed at delivering to the public a good medical service, diminishing the attention given to create and provide useful and accurate health information, thus improving their communication with the public, and allowing all citizens (including those with some sort of disability), to receive some initial diagnosis and have their doubts taken [14]. Schenker and London [15] argue that the availability of a website that provides insides on a given hospital quality ratings, its treatment policies, specialties and protocols, and its patient decision aid mechanisms, will have a very significant impact on the patient decision towards seeking care or undergo a given medical procedure [16]. Thus, and complying with Raji, Mahmud, Tap and Abubakar [14], in order to be useful to their patients, hospitals websites should assume themselves as easy to use, aesthetically attractive and, most of all, rich in accurate and direct health information.

Hence, considering the normal requirement for a hospital website as its ability to engage patients and allowing them to research health related literature, track health status and medical tests results, make appointments and communicate with health services providers [17][18], it is clear that the referred websites must be easy to use and accessible to all. A straightforward engaging of both patients and their families to health related information and Web based systems will act as a trigger to not only an increase in the overall health care services performance, but also to the establishment of better and more solid relationships between medical experts and patients [19]. The importance of hospital websites quality, ease of use and accessibility has been in the agenda of several authors, who argue that, despite the notorious efforts in bringing the institutions to the Web, there is still a long way to go in order for the referred websites to be easily usable and accessed by all [18][20][21].

The aim of the present study is to explore the accessibility issue of Portuguese and Spanish health care institutions websites by undertaking an evaluative study directed at examining their compliance with W3C Web Content Accessibility Guidelines – WCAG 2.0, and through this achieve a common indicator – Web Accessibility Score – that determines how close from being accessible to its users a given website is.

3 Measuring Accessibility from Health Care Institutions Websites

Aiming at achieving a perception on the accessibility levels of the Iberian health care institutions websites, a research project was designed in a way that from an initial list of institutions websites, an evaluation procedure was executed and the achieved results were discussed until reaching assertive conclusions.

3.1 Evaluation Methodology

The evaluation procedure mentioned above was composed by three different stages: an initial stage where the evaluation target group was defined and analyzed, an intermediate stage where all the target group members' websites were evaluated against WCAG 2.0, and a final stage where the achieved results were treated, analyzed and discussed.

Considering the interesting results presented by the Iberian Peninsula in terms of Internet use and, assuming that the Iberian citizens are very prone to use the Web as a means to attain information and communicate, a decision was made to perceive weather Iberian health care institutions websites were accessible to all Iberian citizens. To do so, a Web accessibility evaluation platform called ACESSWEB was used given its ability to automatically evaluate the full extension of a website against WCAG 2.0 and present the evaluation results in a structured, simple and very usable manner. The ACESSWEB platform has the ability to not only perform Web accessibility evaluations to multiple websites simultaneously, but also has the capacity to process and display the evaluations results in a structured manner. In order for the results analysis to be significantly easier and rapid, the ACESSWEB also allows for users to create their own data analysis schemas and inherent visual dashboards [22].

3.2 Evaluation Target Group Analysis

For the present research project, whose main goal is to present an updated perspective on the Web accessibility levels of Iberia Peninsula health care institutions, an initial effort was made in order to collect, from the various governmental organizations, the details associated with these institutions (name, address, nature and website URL). From this initial effort a list of 1098 institutions was created. When performing a deeper scrutiny to these institutions, 519 of them were public institutions and the remaining 579 had a private nature. In Figure 1 it is possible to perceive the regions, within the Iberia Peninsula, where the referred institutions have their legal headquarters.

Despite our initial target group composition of 1098 institutions, after an initial analysis we reached a final level of only 697 institutions with an online and active website (Figure 2). From this analysis it was also possible to acknowledge that over 140 institutions share the same website, and that even though we are living in a "digital society" almost 250 institutions do not have a website or have one that was offline when we performed the evaluation procedure.

Figure 1 - Geographic distribution of all the analyzed Iberian health care institutions.

From the 579 private institutions that composed the initial target group, over 70% of them had a website that could be evaluated. On the opposite side, from the initial 519 public health care institutions inherent to the target group, only 53% of them could be evaluated.
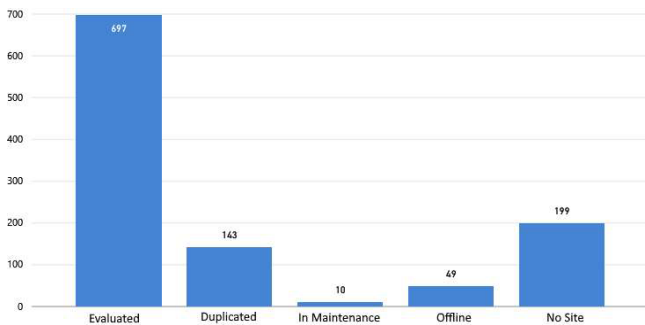
Figure 2 - Evaluation target group analysis from an Iberian Peninsula Perspective.

4   Results Analysis and Discussion

4.1   Achieved Results

The evaluation procedure was executed with the support of ACESSWEB Web accessibility evaluation platform, which allows for a bulk evaluation of groups of websites against WCAG 2.0. With this in mind, and according to Figure 3, the first task to be performed was transforming the list of health care institutions into a tabular set of records that could be fed to ACESSWEB diagnostic system, which consequently performed the evaluation of those websites. The evaluation raw results were reported by the data visualization service where, through the development of several analytical dashboards, it was possible to comprehend the knowledge extracted from the evaluation

procedure. As an initial consideration it was very interesting to acknowledge that during the evaluation process more than 2.9 million elements (tables, images, html elements, etc.) were evaluated against WCAG 2.0, what brings at light an average of over 2700 elements per website. With this in mind, it was also very important to highlight that the average number of identified WCAG 2.0 errors per website was about: 460 errors for WCAG 2.0 level A errors, 93 for WCAG 2.0 level AA errors and 167 for WCAG 2.0 level AAA errors.
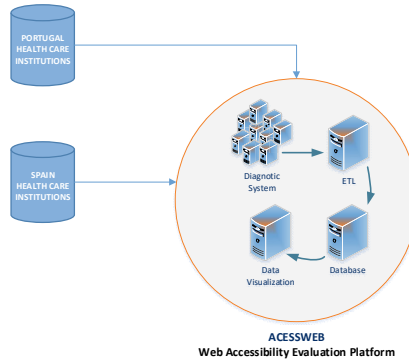
Figure 3 - Evaluation procedure illustration. Adapted from [22].

As Figure 4 mentions, the Web accessibility errors distribution is very similar for both Spain and Portugal, with Portugal leading by a close distance on this category. As a direct result of these errors, none of the evaluated websites from both Spain and Portugal were compliant with WCAG 2.0, thus none of them was totally accessible.
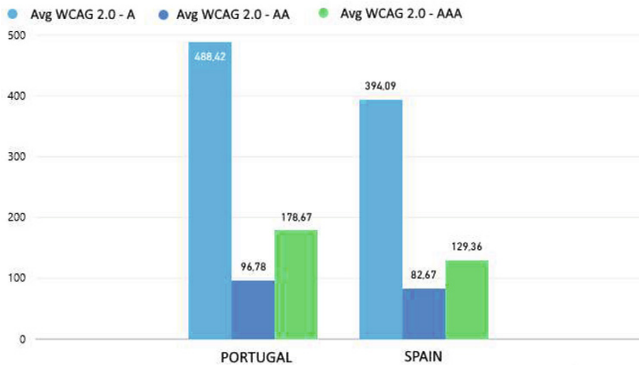
Figure 4 - Average number of detected WCAG 2.0 errors for both Portugal and Spain.

Given the impossibility to closely analyze a WCAG 2.0 compliant website in order to understand how it is built and how it presents its content, authors decided to follow Gonçalves, Martins, Branco, Pereira, Rocha and Peixoto [22] and Kamoun and Almourad [23] approaches, and use a Web accessibility score as the indicator that allows some comparison between all the evaluated websites and that can bring some

awareness to the research topic. In this case, the referred score is a simple indicator that relates the number of accessibility errors with the number of evaluated elements ($\frac{\sum Errors}{\sum Elements}$). In Figure 5 one can visualize the distribution of the project target group according to their Web accessibility score.
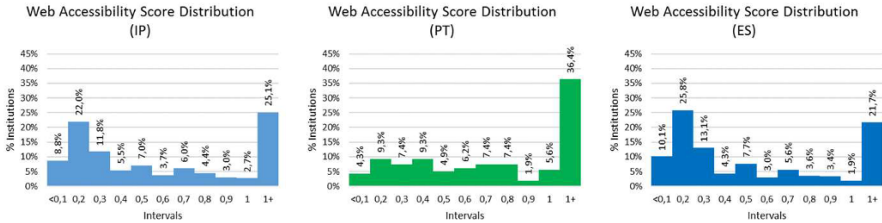
Figure 5 – Web accessibility score for the Iberia Peninsula (IP), for Portugal (PT) and for Spain (ES).

Aiming on bringing a much deeper insight on this issue, the mentioned distribution was made not only from an Iberian perspective but also from a country point of view.

4.2 Results Discussion

When observing the achieved results, and despite the approached topic (Web accessibility) to be considered as of most importance by, not only the scientific community, but also by government, health care institutions still miss on the goal of having websites accessible to all citizens (patients), hence limiting access to a set of very important health related information by those with some sort of disability. The achieved results show that from the initial 1098 health care institutions almost 200 of them do not have an available website for the public to visit, what indicates that a very important share of the institutions does not believe on the benefits of having an online presence that, at the very least, allows patients to have access to descriptions of the set of services and experts provided by the institutions. On the other hand, it also very interesting to understand that under 2% of the institutions had a registered Web domain that is offline.

Given the proven validity of ACESSWEB evaluation platform in what concerns the evaluation of websites against WCAG 2.0, a decision was made to use this platform as the diagnostic tool for evaluating the 697 heath care institutions websites. After reaching the results from the evaluation there was a need to develop a set of analytical dashboards that allowed, in first hand, to perceive that the average number of accessibility errors was significant in each of the evaluated websites, hence reaching a global average of WCAG 2.0 errors for the Iberia Peninsula that represents an almost inexistent concern towards developing accessible Web content. If this situation may not be subject to an extra unease for the privately held institutions, this is not true to the public ones, given the existence of legal regulations according to which the websites of

public institutions should, at the very least, comply with W3C "WCAG 2.0 Level A" criteria.

Even though the critical situation in what concerns the access to Iberian health care institutions websites, when observing the accessibility score achieved by the evaluated websites from a global perspective, these indicators tend to ensure that the evaluated websites are converging into a positive situation in terms of accessibility given that its overall values are becoming closer to 0 (indicating that the number of errors is much smaller than the number of evaluated elements). However, as Figure 5 clearly indicates, this Iberian perspective is decisively influenced by the Spanish institutions websites, that present better results than the ones presented by the Portuguese institutions who present more than 1 error per each evaluated website element in more than 35% of the sample.

5 Conclusions

5.1 Health Care Institutions Implications

Currently there is a very high demand for online health related information. As health care institutions start to increase their online presence in order to foster the establishment of trust relations with their patients, business managers should endure on a dual sided perspective. In one hand managers should trigger the creation of high quality health related information and highly interactive online services and, on the other hand, they should create policies and strategies towards the creation (and subsequent) maintenance of websites accessible to all, including those with some sort of disability. The existence of poor accessibility compliance with international guidelines immediately creates a misalignment between health care institutions and patients, particularly with those most impelled to consume information resources without having to physically grab them. When considering the existing studies concerning both the directions that a health care institution website should follow and the value inherent to each patient (social, financial, etc.), one can easily conclude that by not presenting accessible websites, health care institutions neglecting people with disabilities and decreasing their chances to transform these users/citizens/patients financial value into business value.

5.2 Final Considerations

Web accessibility is a topic of most relevance for our society and for all of our institutions, not only due to the ethical and moral concerns, but also due to the economic impact that disabled citizens have on their countries' economies. This situation, together with the current need for information regarding disease symptoms, treatments and health care techniques and expert services, makes it extremely important for the websites of those with the majority of the responsibility for creating such information (i.e.: health care institutions), to be fully accessible to all. Given the existence of about

10% of Iberian citizens with some sort of disability, a decision was made to perform a study on the accessibility levels presented by the Iberia Peninsula health care institutions. With this work, 1098 institutions from both Portugal and Spain were analyzed and, despite our best efforts, from this initial group on 697 of them had an online website that could be evaluated. The Web accessibility evaluation was conducted through the use of ACESSWEB websites evaluation platform, whose evaluation results allowed to perceive that the situation of the Iberian health care institutions websites is extremely concerning and that a considerable effort towards improving the current status of things must be done.

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Part V
Communication and Journalism in Online Social Networks

Iberian Local Online Media as a Space of Sociability in the Network Society

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Abstract. The evolution of the "network society" over the past five years has resulted in the proliferation of the proximity of online media in the communications ecosystem of the Iberian Peninsula. Portuguese and Spanish hyperlocal media has created a local supply of initiatives involving communities which are promoted with the intention of being present in the network society and, at the same time, existing in the spheres of communication of leading social networks. Although most hyperlocal online media is not part of media groups or cross-border organizations, the fact is they apply fairly similar criteria when designing their strategies for social networks. The analysis of a web-native and hyperlocal media outlet in Portugal and two in Spain (one in Galicia and another in Madrid) shows how proximity is an incentive for renewed forms of technologically mediated communication in local communities.

Keywords: hyperlocal media, hyperlocal journalism, social networks, network society

1 Introduction

Forms of relationships and communications between the different social actors have evolved in recent decades into structures which are more connected, and in which the Internet and new ICT technologies are assumed to create new channels, the experimentation of codes and the configuration of new communications dynamics. This transformation also extends to media, developing online editions of different models to build a complex communications ecosystem in which online media [1] become informative spaces of reference.

In Spain and Portugal, the countries within the Iberian framework of this study, the evolution of the online media industry began over two decades ago. The first Spanish online newspaper appeared in 1994, such as the online publication of the *Boletín Oficial del Estado* and the cultural magazine *El Temps* [2]. A year later, the *Jornal de Notícias* inaugurated online media in Portugal [3].

These twenty years of online journalism in Spain and Portugal place us in a context in which new forms of social and community interaction surrounding the media enable the profitability of new business models, more collaborative and productive structures and greater thematic and geographic specialization. Among the current trends in the development of online media, the growth of hyperlocal media is particularly important. This creates communications spaces in the most immediate area of communities, where social relations between actors are produced both within and outside of the network society itself.

2   Theoretical approaches

2.1 Approach to Hyperlocal Online Media

Hyperlocal online media is a recent phenomenon with its roots in the United States, which has been growing with a strong journalistic basis since 2009 [4]. Such media is edited from the new perspective of hyperlocal journalism, characterized by its geographical orientation and its commitment to the community [5], giving citizens the opportunity to express themselves and create bonds of identity in a globalized cultural context [6].

Among the authors who have defined hyperlocal information and media, Donna Shaw [7] describes these as news websites dedicated to "little stories" pertaining to a particular neighborhood or interest group within a very specific geographical area. Mark Gaser [8] adds that their growth occurs due to the low cost of online publication, which enables the creation of independent hyperlocal news sites with the goal of serving communities neglected by traditional media, thereby fulfilling a vital democratic function. This is echoed by Stone and Miler [9]. To the same end, Crucianelli [10] highlights the variety of sources within hyperlocal media, which accords greater prominence to neighbors and little-explored digital sources.

In addition to these concepts, Flores Vivar [4] explains that the term "hyperlocal" also refers to the combined use of technological applications and GPS through mobile devices, applied to local websites to deliver relevant content not only for a community, but also for any particular individual belonging to it.

Based upon their review of the various uses of this concept, Metzgar, Kurpius and Rowley [11] define hyperlocal media as "geographically-based, community-oriented, original-news reporting organizations indigenous to the web and intended to fill perceived gaps in coverage of an issue or region and to promote civic engagement". The main characteristic of such media is identified by these authors as the proximity of its orientation and its operation in a geographically defined area where news events and audiences coincide. This area can range from a small neighborhood to a city or region [11].

Hyperlocal media is also characterized by a clear community-orientation in the geographic area in which it operates. Although opportunities and the market also determine their agenda, such media seeks to inform about all that affects and worries the community. It covers the spaces forgotten by traditional local media.

The accuracy and usefulness of its coverage evokes the engagement of citizens, who are committed and involved in democratic discussions affecting the future of their community. Moreover, such audience engagement often turns them into the media's, adopting different roles in terms of citizen journalism that, according to Firmstone and Coleman [12], can be those of producers, contributors, sources or participants.

Finally, hyperlocal online media is characterized by its state of being web-native, that is "media formats that exist only on the Internet and media entities whose first distribution channel is the Internet" [13]. The lack of a printed or audiovisual matrix and a recognized business model constitute an economic weakness of such media, which requires them to experience new forms and sources of financing [14]. In web-natives, business and production structures are smaller and more flexible, following less hierarchical and more decentralized models, concentrating the whole production process in the hands of a small group of professionals and a network of collaborators [14].

2.2 Network Society and New Forms of Community Relations in the Context of Proximity

Hyperlocal media plays an important role in advancing social cohesion within the community in which it operates. Following Arias, [15], such online media offers new possibilities and forms of dialogue, encourages users to take action, builds trusted networks, reinforces a sense of identity and creates spaces for civic communication, social and cultural participation.

Forms of communication and community involvement observed in hyperlocal online media arise from the structures of the network society itself, built on information networks based on Internet technology. Castells [16] points out some changes in the socialization of communities, such as the absence of physical boundaries for creating networking affinities, a strengthening of the bonds of physical relationships, the ease with which weak community-based weak are created, as well as the ability to build links between select people through searches.

In addition, the author notes that the stronger physical social networks are, the greater the use of the Internet and its strength. Applied to the hyperlocal community and social movements, the Internet facilitates community mobilization projects which are more flexible, enduring, coordinated and focused on clear objectives based on shared values.

In this context of proximity and the network society, the ties between citizens and journalists are narrowed because the journalist is another member of the community [15]. In the social practice of hyperlocal journalism, actors multiply and develop individual or collective strategies and actions to control both media discourse and community discourse [17].

The opportunity for citizens to participate in local democracy as consumers and producers of information is much higher in hyperlocal online media than in traditional local media. Social networks are consolidating a communications ecology in which the traditional division between institutions, journalists and citizens is no longer centralized, linear or easily controlled because of the ease with which all kinds of messages and audiovisual content can be spread [17].

2.3   Social Networks as a Consolidated Space of Encounters between the Media and Consumers

Social networks are already taken to be areas of convergence and interaction between the media and audiences. Online media designs dissemination strategies through its particular tools and applications. Such media outlets enhance their presence on Facebook and Twitter in order to spread their information, opening up spaces for readers to discuss the news and creating message boards or inboxes to enable the receipt and sharing of texts prepared by citizens [18].

From the perspective of users, social networks allow citizens to be self-reliant on their consumption of proximate information. Thus, they hope that through searching, dissemination and the filtering of news in their social networks, all relevant news items in their community will reach them [19].

According to data from IAB Spain [20], 82% of Spanish Internet users use social networks, which in absolute terms amounts to 14 million users. Commenting on the news is ranked sixth among their more common activities. Taking into account solely Internet use related to news consumption, data from the Digital News Report [21] reveals that Facebook is the most popular social network, used by 52% of users in Spain. WhatsApp is used by 27% to comment on and share news items, making it the second largest social platform in this regard. Twitter and YouTube tie for third place, used by 22% of users to consume, distribute and interact around the news.

In Portugal, the INE [22] also reveals the extensive use of social networks by up to 72% of Internet users. In terms of the consumption of news, OberCom results [23] show that social networks are highly valued as news sources. They constitute the second most used channel, sought out by 66.2% of users, ahead of other traditional sources like printed newspapers. The networks most used to search for and access information are Facebook (98.7%), YouTube (37.6%) and Twitter (7%).

3 Objectives and Methodology

The main objective of this research project is to study the function of hyperlocal online media as a space for the community's socialization on the Internet. More specifically, it seeks to discover the presence and content distribution strategies of the media within mainstream social networks, as well as their capacity to achieve the engagement of users, in the Iberian context of Spain and Portugal.

The selection of the study's objectives is based on exploratory research concerning the situation of active hyperlocal online media in the Iberian Peninsula. Based on the initiatives identified, three hyperlocal media outlets were chosen for in-depth study:

- *Somos Malasaña* (http://www.somosmalasana.com/): selected for being an online media outlet in the Spanish capital and one of the first hyperlocal initiatives in the country, covering the geographical area of Malasaña in Madrid. It maintains active social profiles on Facebook, Twitter and Google+.
- *O Corvo* (http://ocorvo.pt/): chosen for pertaining to the Portuguese capital and operating in the geographical area of the city of Lisbon. It maintains active profiles on Facebook, Twitter and Vimeo.
- *Pontevedra Viva* (http://pontevedraviva.com/): chosen as it constitutes a space of convergence between the two countries due to linguistic (Galician and Portuguese) and cultural proximity. It also operates in an intermediate geographic area between rural neighborhoods and the city, that is, both within the municipality and the region of which it forms part. It maintains active social profiles both on Facebook and Twitter.

The research is limited to the active profiles of these media outlets on Facebook and Twitter, as these are used by all the three publications. The analysis undertaken with respect to these networks is quantitative and descriptive, using free software tools to provide an overview of social media analytics. To extract data from Facebook, Netvizz V.125 has been used. Tweetchup was employed to analyze Twitter profiles. To select the aforementioned publications for examination from the entirety of the media's vast output, a multistage cluster sampling was conducted between the 22nd of October and the 13th of November, 2015. Data was collected on a daily basis on the following dates: October 22nd, 23rd, 24th, 26th, 27th and 28th and November 8th, 9th, 10th, 11th, 12th and 13th.

The interpretation has been oriented along to axes of community presence in online media networks, the publication and dissemination of content, and the engagement/conversation between users and the media. A content analysis was undertaken of the five Facebook posts and Tweets with the highest levels of participation in each publication. The main goals and linguistic functions were analyzed following the methodological objectives outlined by Bonini and Sellas [24]. The type of content and the comments were studied following the analytical approach of the Pew Research Center for the study of local news [25].

4 Results

4.1 Community Presence through Social Networks

While the three online media outlets studied have active profiles on both Facebook and Twitter, their weight and importance in the community varies significantly. Weighting the number of followers of each publication within each social network by the number of inhabitants of the geographical area in which they operate, a comparable percentage was obtained of the physical community of online media users which is also present in social networks.

Somos Malasaña receives 55.05% on Facebook and 47.75% on Twitter, followed by *Pontevedra Viva* with 3.93% and 2.95%, respectively, and *O Corvo*, receiving 1.54% on Facebook and 0.04% on Twitter. Significantly in this case, the more hyperlocal the publication, the greater the presence of the community, offering better results in the context of neighborhoods as opposed to municipalities/regions or cities.

4.2 Publication and Distribution Strategies in Social Networks

The multistage sampling conducted over the aforementioned days identified a total of 225 Facebook posts (69 for *Somos Malasaña*, 14 for *O Corvo* and 142 for *Pontevedra Viva*) and 395 tweets (112 for *Somos Malasaña*, 12 for *O Corvo* and 271 for *Pontevedra Viva*). The volume of content published can be summarized in the daily average of posts and tweets. *Somos Malasaña* registered an average of 6 daily posts on Facebook and 9 tweets; Lisbon's *O Corvo* published only one post and one tweet; and *Pontevedra Viva* had an average of 12 posts and 23 tweets.

In terms of overall content, almost all items published are links to online media information (99% of Facebook posts and 93% of tweets). By contrast, only 5% link to text publications, 4% to photos and 0.4% to videos. This reveals that the main use of social networks is as another channel for distribution and attracting web-traffic, leaving little room for other formats more suitable to real participation and dialogue with users.

4.3 Engagement and Conversation with Users

Via their social media platforms, online media publications create a space where readers can participate to varying degrees. On Facebook, the main indicators of such engagement are the number of "likes" a post receives, how many times a post is shared and how many comments it attracts. On Twitter, engagement is apparent in the number of times tweet is listed as a "favorite" and how many times it is re-tweeted.

The publication data shows the intention of online media to promote a space for interaction with the community, and indicators of users' participation the interest that content holds for them. *Somos Malasaña* registers an average of 28 likes, 9 shares and 4 comments per post and 17 favorites and 9 re-tweets per tweet. *O Corvo* registers 25 likes, 17 shares and 2 comments on average per post, and 0 favorites and 0.2 re-tweets per tweet. Lastly, *Pontevedra Viva* registers 28 likes, 20 shares and 4 comments per post, and 2 favorites and 1 re-tweet per tweet. However, it is not enough to merely take note of a phenomenon of active and reciprocal listening, necessary for dialogue and community socialization through online media social networks.

It is, therefore, interesting to observe indicators such as the percentage of comments which reply to other posts on Facebook, as well as the amount of re-tweets, mentions and replies to other Twitter users. In the case of *Somos Malasaña*, 27% of Facebook comments are responses, and 25% of tweets are re-tweets, with 5.4% of responses and users mentioned in 100% of tweets. With respect to *O Corvo,* 12.5% of comments on Facebook are responses, while on Twitter no re-tweets, responses or users mentioned are registered. Finally, in terms of *Pontevedra Viva*, 41% of Facebook comments are responses, whereas on Twitter only 0.4% of tweets are re-tweets, 0.7% are responses and users are mentioned in 45.4% of tweets.

4.4 Publications with the Highest Levels of Participation

The content analysis of the five posts and tweets with the highest rate of participation for each publication is summarized in the aggregate data of the 15 posts and 12 tweets analyzed in total (*O Corvo* only registered two tweets with some form of participation).

In terms of the language used, 100% of the items published on Facebook and Twitter display a referential function which corresponds to informative action. Only 6% of posts and 34% of tweets reveal an expressive function, especially relevant in information on sports. In relation to the objectives pursued, 100% of the posts and tweets seek to spread the news from the media and redirect traffic to their websites. On Twitter, 20% of tweets also advertise external cultural events.

The functions of language and the objectives detected are reinforced by the content type of the items analyzed. All posts and tweets contain a link to online media content, accompanied by a short introductory text (except the posts of *O Corvo*). Hashtags are used in only 7% of posts and 25% of tweets. Mentions are only present on Twitter, in 50% of items published. The widespread presence of links to media content reinforces the referential function and the purpose of disseminating information. Moreover, the low levels of mentions and hashtag-use reveal the limited interest of the media in participating in conversations, listening to or engaging in dialogue with users in the community.

Analysis of the 15 selected items published by the three publications on Facebook reveals a total of 253 comments (82 for *Somos Malasaña*, 21 for *O Corvo* and 150 for *Pontevedra Viva*). Noting the number of key comments and responses generated, a complimentary percentage is visible in the case of *Somos Malasaña* and *Pontevedra Viva*, with 60% comprising key comments and 40% responses. By contrast, *O Corvo* does not register any responses. All these conversations occur on the same day on which a post or tweet was published, with over 90% of the comments appearing within 24 hours of the original post or tweet.

In terms of the type of user-generated content within the comments, 92% only contain text, in 4% of cases text is accompanied by links, and 2% only consist of links. A minor number of comments which combine text with mentions, photos and videos were also registered. With respect to the links recorded, in the case of *Somos Malasaña* comments are made by the publication itself linking to its own related news stories. *O Corvo*'s links are also to the stories by the newspaper, albeit these are linked to by users. By contrast, in the case of *Pontevedra Viva* links are provided by users and link to other Facebook pages and other news media sites.

Concerning users who comment on posts or tweets, a significant percentage of users appear to comment repeatedly, especially within the responses and conversations created around a published item. In the case of *Somos Malasaña*, 20% of users report an average of 2.4 comments, whereas only 12% of *O Corvo's* users comment more than once and reveal an average of 3 inputs. 35% of *Pontevedra Viva*'s users leave an average of 3.8 comments each.

5   Conclusion

The analysis of the three selected hyperlocal online media outlets allows for the comparison of their presence and strategies on social networks, and highlights the strengths and weaknesses of each. *Somos Malasaña* displays greater integration of the community in its network space, has greater experience with different forms of publishing content, and presents stronger indicators reflecting participation and conversation on Twitter. On the other hand, *Pontevedra Viva* is by far the newspaper which publishes more content on its social networks and elicits more conversation on Facebook. By contrast, Lisbon's hyperlocal *O Corvo* does not appear to pursue a strategy of continually publishing items on its social media profiles, offers nearly identical posts on Facebook and Twitter, and generates virtually no participation or conversation on the latter network.

Extrapolating these results to hyperlocal online media in the Iberian context more broadly, it is possible to confirm the important presence of such media outlets within mainstream social networks. So too is it apparent that they pursue content publication strategies which facilitate the integration and participation of community users in the

social media platforms. However, publication formats vary little and the greater part thereof are composed of links. Although participation indicators reveal that published content reaches and raises the interest of readers, the closest forms of conversation between them and media outlets, such as via comments, shares or re-tweets, remain a rarity.

Finally, data on conversational indicators between the media and users are markedly low, reflecting the limited attention which the media pay towards contributions from the community, thus preventing a real exchange of ideas. However, the analysis of comments by readers on Facebook shows that the spaces created by the media within social networks offer a site to foster conversation between community members.

In conclusion, we deduce that there is a real need to rethink the space offered by social networks. It is imperative to stop managing these as channels which redirect users to online media, and rather to establish them as a place for listening to and engaging in dialogue with communities and users. Hyperlocal online media may be developing similar strategies to those adopted by major media and communications groups, despite having far fewer economic resources. Nevertheless, this shouldn't prompt them to miss the most important resource them have as hyperlocal entities, namely the knowledge and cooperation of citizens whose social potential as a community is enhanced in the proximity of the network society.

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The Use of Social Networks in Interactive Documentary

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Abstract. Interactive documentary is an interactive non-fiction genre, within digital storytelling, that is developed in the diversification period in the digital context and, particularly, on the Internet. The digital convergence of media favors the creation of complex products, characterized by navigation and interaction, as well as new audiences' participation. Social networks open ways for promotion, contribution and personalization of interactive documentary. In this research, we have made a selection of significant projects from the period 2010-2015 and coming from all over the world, in which the development of the genre and the use of social networks have been analyzed.

Keywords: interactive documentary, interactive non-fiction, digital storytelling, social networks, communication.

1 Introduction

The aim of this research is to describe how social networking sites connect with interactive documentary, a booming genre in the digital panorama. There are also some interesting points about production and development of interactive documentary worldwide.

1.1 Documentary and traditional categorization

Firstly, we are getting into a subject supported by two pillars: conventional documentary, also called audiovisual or cinematographic, and interactive media, that represents every platform related to electronic devices and, specially, those developed on the Internet.

Documentary is even becoming more similar to fictional narratives and considering that technology has changed into a more open context, it is still valid that interactive documentary keeps a direct link with reality and tries to give a new point of view to the audience. In that way, Arnau Gifreu takes the multi-perspective definition given by Bill Nichols to refer to documentary as a "mutanting nature as social construction" [6].

Documentary was additionally covered by authors such as Michael Renov or Erik Barnouw, who suggested traditional categorizations besides Nichols. We have considered the categories that Nichols [13] established to speak about representation

of reality in our analysis: poetic, expository, observational, participatory, reflexive and performative.

However, there are some other genres of audiovisual non-fiction, apart from common cinematographic documentary, that extend the current field and recognize the complex and open context.

1.2 Interactive media and technological convergence

Since the appearance of information technology in the 21st century, there has been an evident evolution in many industries and social areas. The World Wide Web caused a transformation in how we are informed and entertained. Several changes have taken place in our society, such as the development of the hypertext, the popularization of mobile devices and the success of social networking sites.

Until the current situation of digital media, different technologies appeared for spreading culture, actually the Internet was a meaningful advance. In this context, in which the user is producer and consumer at the same time and has a lot of tools that allow him to be heard, interactive documentary is growing.

Technological convergence concerns the whole structure, consequently the audience is being affected. Social networking is the issue that interests us because it is bringing real life to the Internet, therefore, new communities and types of relationships have emerged. Furthermore, this phenomenon is present in interactive documentary.

1.3 Hybridization

Convergence appears on numerous screens (television, Internet, mobile devices, etc.) producing new cultural products for the net characterized by hipertextuality, multimediality, interactivity, memory, instantaneity, customization and ubiquity [3]. Within these new proposals that are not only attached to only one medium, we find transmedia storytelling according to Henry Jenkins [9] and Carlos Scolari [17] and a wide field of interactive non-fiction genres where we can find interactive feature, inside cyberjournalism, interactive essay close to cultural promotion and interactive documentary. In addition, as part of this hybridization, storytelling is reaching all kinds of situations at the moment [16].

2 Interactive documentary

The concept of interactive documentary is unfocused and complex due to its recent appearance and different terminological variations from authors that have written about this subject. In the interactive context, the director of the documentary loses some control of the narrative discourse, favoring user interpretation. Within the diversity of terminology, these terms must be outlined: interactive documentary, multimedia documentary, i-doc, web documentary, webdoc, *docuweb*, living

documentary and walk-in documentary. We choose interactive documentary, considering its extended use and open definition.

Even though authors such as Aston & Gaudenzi [1], Favero [4], Gaudenzi [5], Harvey [8], León & Negredo [10], Liuzzi [11], Nash [12] or Porto Renó [14, 15] have worked around the definition, Arnau Gifreu suggests one supported in three aspects: open and complex concept, ambivalence between cinematographic and interactive field and identification as a discourse related to reality. "Interactive online/offline applications, carried out with the intention to represent reality with their own mechanisms from conventional documentaries –modes of representing reality–, and other new, which we will call navigation and interaction modalities, depending on the degree of participation under consideration" [7].

2.1 Categorization of interactive documentary

Beside some features such as loss of control by the author, being an interactive non-fiction genre, based on real facts or circumstances, using hypertext for non-linearity and medium or strong interactivity, according to Berenguer's classification [2], interactive documentary is categorized depending on modalities of navigation and interaction, defined by Gifreu [6].

There are different ways to navigate into the content in a non-linear mode: fragmented, timeline, spatial, testimonial, ramificated, hypertextual, preferential, audiovisual, sound and simulated-immersive. In relation to how the user interacts with the story, there are also some modalities: social or 2.0, generative-contributive and physical-experienced.

In addition, interactive documentary is classified by the representation of reality and the analysis proposed by Gifreu also examines the production, the content, the structure and the relationship between author, text and user. This model was employed in our research to analyze the sample.

2.2 State of the art

The current situation supposes a wide diversity of actors, so it is required to consider them in order to acquire a global knowledge. In the first place, we must point out the production developed by the National Film Board of Canada, as part of the government, because they are promoting interactive documentaries and achieving success in main events. In France we have identified a significant association between Arte, a Franco-German channel, and Upian, a multimedia studio. All over the world, there are other relevant producers like Honkytonk Films, Submarine Channel, VPRO or Helios Design Labs. In Spain there is also some activity from producers such as Barret Films, Mondrian Lab or Yolaperdono. Even public television, RTVE, develops interactive projects in the Audiovisual Innovation Lab. In addition, we must highlight the career of some professionals such as Florian Thalhofer, Samuel Bollendorff or Katerina Cizek, due to their important contribution.

Secondly, the conversation about this genre strengthens and favors its growth. Main references are: i-Docs Conference (United Kingdom), InterDocsBarcelona

(Spain) beside WebDox (Belgium), IDFA DocLab (Holland) and other initiatives around digital storytelling and journalism.

Considering that there are not specific awards for interactive documentary, other contests are including it, such as IDFA, Sheffield Doc/Fest, FIGRA, Sundance, Tribeca, World Press Photo, Visa pour l'image, Prix Europa and Emmy Awards.

Relating to research, the work of Arnau Gifreu should be noted, as author of several publications, as well as Sandra Gaudenzi, Denis Porto Renó, Mandy Rose, Julia Scott-Stevenson, Judith Aston, Paolo Favero, Kate Nash, Valentina Moreno and Carles Sora.

3 Methodology

To begin with the analysis of interactive documentary, we established a limited universe for a global evaluation, which ended with a list of 136 projects considering: categorization as interactive documentary, production from the period 2010-2015 and country of origin.

As a result of discretionary sampling, with the condition of having at least one award, and quota sampling, that guarantee representatives from all the period except for the current year, we prepared a brief research sample for a deeper examination.

3.1 Research sample

The sample we analyzed in more detail was composed of 10 interactive documentaries that we list further below. The research focused on features such as production strategies, structure, navigation, interaction or representation of reality, according to the model proposed by Gifreu [6].

The list of interactive documentaries analyzed is: *Prison Valley* (2010), *Out My Window* (2010), *One Millionth Tower* (2011), *Insitu* (2011), *Bear 71* (2012), *Alma, A Tale of Violence* (2012), *Hollow* (2013), *A Short History of the Highrise* (2013), *The And* (2014) and *V.O.S.E.* (2014).

4 Results

Interactive documentary is going through a diversification period and there is not just one definition. This genre is on the convergence between cinema and interactive media, sometimes next to news or video games. In the analysis we discovered some general trends concerning the 136 documentaries and more specific features focusing on our research sample.

4.1 Global production

There are several countries of origin, though the main production is located in France (20.59%), United States (19.85%) and Canada (12.50%). Other countries like Spain, Holland or Germany are over 3%. Furthermore, international coproductions represent a 12.50% of the global sample with France and Canada at the head. The most repeated association is between Arte and the National Film Board of Canada, which are also the most productive companies.

Paying attention to productions by year, we can differentiate three phases: firstly, 2010 has 13 projects; secondly, 2011-2012 have an average of 22.5 projects; and finally, 2013-2014 have an average of 33.5. Without considering 2015 because it is the current year, a continuing growth has been detected .

The creation of interactive documentaries is supported by important technological advances, for instance, with the standardization of HTML5 or due to the existence of software such as Klynt, Korsakow or Mozilla Popcorn that make it easier.

The web is the main platform to distribute interactive documentaries, but there are some multi-platform, crossmedia and transmedia proposals, such as *Prison Valley* and *Alma, A Tale of Violence*, which employ other extra formats like app, book or TV.

4.2 Navigation and interaction representing reality

As a result of combining several modes of navigation and interaction, interactive documentaries tend to be complex products. They use between two and nine modes, in different degrees. The most common are fragmented, audiovisual, testimonial and hypertextual; also social and generative at a lower level of development. *Prison Valley* and *Hollow* are the most complete documentaries at this point.

In consequence, interactivity implies participation, non-linearity and more personal user experiences; as well as navigation supposes different structures, itineraries and points of view. Cession of the author control and contribution to extend the story are essential ideas in these narratives.

In addition, the documentaries that were analyzed use between three and fives modes to represent reality. The most usual are reflexive, observational and participatory. Those that combine more modes are *Hollow* and *A Short History of the Highrise*.

4.3 Focusing on social networks

On the one hand, we have analyzed how social networking sites interact with interactive documentaries that define the research sample. We conclude that only two of ten projects from the sample have a development deeper than the others. Half of the documentaries have official accounts in the most common social networks, principally Facebook and Twitter, and in some cases they are still updated. The main use of social media related to this genre is promoting the project and publishing news about it, also to keep in contact with users and sharing content within the documentary.

For instance, *Prison Valley* utilizes Facebook as login for the user and this method allows to save the user progress, discuss online in the chat or in the forums about different topics and characters. *Hollow* introduces Instagram to show pictures with #hollerhome tag and Twitter to display the latest tweets about #derecho and #storm, both of them inside the story. Of course, *Prison Valley* and *Hollow* have maintained until now their official profiles in Facebook and Twitter.

On the other hand, we have made an exploration of significant cases that use social networks in the whole selection from the period 2010-2015 and it should be noted that there are some documentaries with different and interesting implementations of them.

Firstly, projects like *18 Days in Egypt* and *Las Sinsombrero* permit the user to participate sending a photo or video from social networking sites. Secondly, *Goa Hippy Tribe* and *Fort McMoney* include the Facebook login to save your progress, to access to additional content that is added to your "backpack", to chat or write a comment online and also to answer surveys in the story. Thirdly, *Do Not Track* and *In Limbo* are getting closer to personalization in interactive documentary. What they are doing is asking for permission to access the user's accounts in different sites such as Facebook, Twitter, Instagram, LinkedIn or Gmail and show some information as part of the story. In consequence the user enjoys an improved experience in which he is involved. Finally, *Malvinas30* is named a transmedia production and was developed in Twitter, using @Malvinas30 and @SoldadoM30 to reproduce The Falklands War in first person 30 years later. They also utilize Foursquare for geolocation.

5   Conclusion

Interactive documentary, as an interactive non-fiction genre, is built on different modes of navigation and interaction and it combines several modes to represent reality. Furthermore, subjects are diverse: social topics, urban cultures and personal stories are recurrent. It can be distributed by more than one platform, although the Web is the most common. Letting the user take control, allowing to participate and personalizing the experience are functions associated with interactive documentaries.

As a result of our research, we can say that interactive documentary is growing from three production centres located in France, United States and Canada, beside a relevant international coproduction and minor contributions from many other countries.

These complex products are using social networks with five purposes. In the first place, they are being used to promote the documentaries and publish some news or announcements about the production. In the second place, these tools are utilized to show content from them inside the documentary. Social networks also make possible the contribution of users to extend the story with their own points of view, by sending comments, pictures or videos and sharing the project. In addition, these sites can be the platform to reproduce a story through profiles, for instance, in Facebook or Twitter, where users can interact directly with characters. Lastly, social networks are being used to personalize the user experience including some personal data from the accounts he authorizes within the documentary.

To sum up the situation, we are face to face with an interesting genre with a prosperous future. Interactive documentary is using new ways to approach reality, such as social networks, which have many possibilities to continue developing and improving the user experience. Other fields in which this genre can grow are live performance, VR, gamification, education and journalism.

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Study of Political Campaign Ads from Ecuador Employing Heart Rate Variability (HRV)

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Abstract. This work analyzes the impact derived from viewing different political ads (with positive and negative emotional content), belonging to the campaigns of the main candidates to presidential elections of the Republic of Ecuador, celebrated on February 13rd, 2013. To perform this task, a sample of 20 Ecuadorian University students was considered, and the Heart Rate Variability (HRV) of each of the participants was measured when viewing the different electoral ads. The results obtained were analyzed considering the ideology indicated by the students in a former questionnaire. The investigation shows a perspective of neurosciences applied to social sciences, employing tools commonly used in health sciences to measure perception. The results obtained do not show clear variations in the HRV indexes related to viewing the political ads. However, noticeable differences were observed when students were divided into several groups, according to their political ideology.

Keywords: Political advertising, Electoral spots, Heart Rate Variability (HRV).

1 Introduction

1.1 Electoral Spots and negative political advertising

Some basic aspects that guarantee the success of the politic campaigns are the messages (written, oral and audiovisuals), sent to the potential voters. The importance of these campaigns and their influence over the electorate is crucial. A large number of studies analyzing the television impact in different electoral situations can be found in the literature. Results indicate this effect is determined by the tone of the advertisements and the features of the voters [1], [2], [3].

Several authors explain the preference of the voters for audiovisual formats. In this sense, electoral spots are fundamental pieces, since they include, in a short period of time (30-60 seconds) a high amount of information. This is indicated, for example, by Berrocal [4].

Diamond and Bates [5], explain that a third part of a 30-minutes television speech is missed by the audience. However, if the duration of the spot is between 30-60 seconds, no information is missed. Furthermore, individuals can retain between 80-

85% of the visual information of an electoral spot [6]. If the spectator does not pay attention to the spot within the first seven seconds, the spot will fail [7].

The success or failure of an audiovisual spot will depend on the correct agreement between three basic elements [8]: oral (what is spoken or written in the screen), visual (color, perspective, symbols, icons) and audio (voice, songs and music).

Related to the classification of electoral ads, three categories are usually employed: positive, negative and comparative ads. The first group emphasizes the merits that the candidate represents. The second group includes ads that incorporate the weakness of the opponents; and the comparative spots compare both aspects [9].

This negative advertising has been defined by Mark [10], as the actions performed by a candidate to win an electoral process, consists of attacking his/her opponents, instead of highlighting his/her own virtues. The same author distinguishes between negative and dirty campaigns, indicating that the first group is a distorted but real accusation, while the second is based on lies.

Geer [11] analyzed negative advertising in presidential elections of the United States, defining negativity as any criticism from one candidate to another, during a specific campaign. Recent studies include in this definition any type of criticisms and attacks among candidates. On the opposite side, Sigelman and Kugler [12] consider only personal aspects as negative attacks.

Johnson-Cartee and Copeland [13] identify three models of negative argument: 1. Direct attacks, against either a candidate or political party, 2. Direct comparison with an adversary, in those aspects where the candidate is better than the others, and trying to visualize the opponents' limitations, 3. Implicit comparisons in which the opponent is not directly concerned.

It is always interesting to analyze the effect of the electoral spots over the different political parties of the individuals sharing the same principles, as well as of people of different ideology.

When the influence of the electoral spots over the potential voters is studied, it should be considered that each person would process the information in a different way, according to his/her political ideology. In this way, a selective processing of information will be performed.

In fact, this is an important point, since the attention will vary depending not only on the politic ideology, but also on the emotional content of the message to be transmitted in the spot. Recent studies have demonstrated that, in general, population ignores the electoral ads belonging to candidates that represent ideologies that are opposite to their own principles. This means that population ignores political information that can interfere, in a negative sense, with their own ideology [14].

1.2   Emotions and Heart Rate Variability (HRV)

The heart rate can be defined as the number of heart beats by unit of time. It is generally measured in beats per minute. The heart rate is not constant; it varies to adapt to different internal and external stress factors. The heart rate variability (HRV) refers to the alterations, beat to beat, in the heart rhythm. The HRV is the result of balancing the influence between the parasympathetic system (heart rate acceleration) and the sympathetic system (heart rate deceleration) [15]. The study of the HRV

alterations is employed as a noninvasive measure of the status of the cardiovascular system. It can be performed employing a heart rate analysis in both time domain and frequency domain, or even employing nonlinear analysis techniques.

One of the most extended techniques is spectral analysis, which provides a quantitative analysis and evaluation of the neurovegetative system. The low frequency components (LF), with frequencies ranging from 0.04 to 0.15 Hz, are influenced by both the sympathetic and the parasympathetic systems. The high frequency components (HF) contain frequencies higher than 0.15 Hz, and represent the parasympathetic tone, related to the respiratory rhythm [16]. Apart from the LF and HF parameters, other extended spectral index is the ratio LF/HF, employed to measure the balance between both sympathetic and parasympathetic systems.

Until now, HRV analysis has been applied to study the risk of patients suffering from diverse pathologies: diabetes, cardiac transplant, fetal distress, hypertension, congestive heart failure, or cardiomyopathy, among others. It has also been recently applied in the field of psychiatry (schizophrenia, bipolar disorder anxiety) [17]. The HRV analysis related to emotional response is a recent field of study.

It is well-known that the peripheral nervous system prepares the body to perform several actions [18]. These actions can be a response to determined external stimuli (such as image or video visualization), and that cause the appearance of diverse responses. Different response patterns of the peripheral nervous system (such as the heart rate patterns, dermic conductance or facial electromyography) should be affected by different inputs corresponding to emotional reactions. An example of this can be viewing electoral spots [14].

HRV could be employed as a useful measure to analyze the emotional regulation and reactions, and to study differences in the response patterns of the neurovegetative system. For example, the variations suffered by people of different politic ideologies could be analyzed employing spectral parameters, such as the HRV indexes.

In a recent work [19], HRV was analyzed when some volunteers are viewing the electoral ads of the last elections in Galicia (Spain). The simple size was not enough to obtain statistically significant data, but result could indicate that the HRV values in voters with extreme ideologies are lower than in the case of voters with moderate ideology. However, the LF/HF ratio was higher in the first group, which points out a displacement to the sympathetic tone.

The research in the emotion field has taking advantage of diverse sets and standardized materials to cause emotions in laboratory contexts. One of the most extended is the IAPS (International Affective Picture Systems) [20], a collection of more than 1000 photographs with different, quantified emotional content of the mental disorders present as a common feature the alteration of an emotional aspect. The IAPS collection has been employed in a large number of studies related to psychiatric pathologies (schizophrenia, depression, anxiety disorders). For example, the psychophysiological response of patients suffering from schizophrenia who were viewing IAPS images was analyzed, and compared with the response of control subjects [21]. Heart rate, dermic conductance and respiratory rate were measured. Results indicate that patients suffering from schizophrenia significantly increased HR, compared to controls, only when they were viewing positive emotional content images. This can indicate that only positive, nice images affect the physiological responsitivity in schizophrenic patients.

2   Objectives and Methodology

2.1 Objectives

The objective of this research was to analyze the emotional response of a set of individuals while they were watching a set of electoral spots. To perform this analysis, some HRV indexes were measured. This general objective was subdivided into four specific objectives:

1. To check for possible differences in HRV indexes between men and women when watching all the six electoral spots.
2. To compare the HRV indexes when watching the official spots of the two main candidates (Rafael Correa of "Alianza País" and Guillermo Lasso of the "CREA" party) and the rest that could qualify as negative spots (two against Guillermo Lasso and two against Rafael Correa, of the latter, one direct and another implicit).
3. To compare the HRV indexes by dividing the sample according to their ideology, among students who declare themselves as supporters of both right-wing and left-wing ideology parties.
4. To analyze if there is correlation between HRV indexes and liking declared by students with the political leaders, with a leading role in the videos.

2.2 Sample and Questionnaire

The sample was composed of twenty students from the Universidad Técnica del Norte (UTN), located in the town of Ibarra, Imbabura, Ecuador. They were students undertaking degrees in Public Relations (15 students: 10 men and 5 women), and Management and Social Development (5 males). Their ages were between 19 and 26.

To ascertain the political orientation of each student, they were asked to indicate where they felt more comfortable, between the far-left (responses of 4 students), the center-left (2 students), liberal right (13 students) and the conservative right (1 student).

Similarly, to confirm the answers to the previous question about their political identification, they were asked to indicate the position, on a 1-10 scale, where they were best identified, being 1 the leftmost position and 10 the righter position.

Finally, they were asked about their degree of affinity and/or sympathy with the political leaders appearing in the electoral spots. They had to mark their affinity on a 1-5 scale, being 1 the lowest affinity and, 5 the highest.

2.3 Features of the Electoral Spots

Six electoral spots were showed to the students. Two of them corresponded to the official campaigns of President and candidate Rafael Correa, from "Alianza País"

(spot called "The Bicycle"[1], (58 seconds long) and Guillermo Lasso, belonging to the opposition party "CREA", spot called "Here comes the other Ecuador"[2], (30 seconds long). The other four are of negative publicity about both candidates, two of them against Lasso: "Here comes the other Ecuador / reply"[3] (30 seconds long), made on the basis of the official Lasso's video, and "the Feriatta"[4], (3.29 seconds long) and two against Correa , "The Blablableada Revolution"[5], (2.17 seconds long), and "Migrants"[6], (0.43 seconds long). From this group of negative publicity, the first three are of direct attack and the latter ("migrants") are of implicit criticism.

2.4 Heart Rate Recording and Measure of its Variability

In addition to the data obtained through the formularies that each participant should fill in, it was necessary to record the heart rate signal of all participants, while watching the electoral spots. To measure the heart rate, a Polar 'WearLink' chest strap with Bluetooth was used.
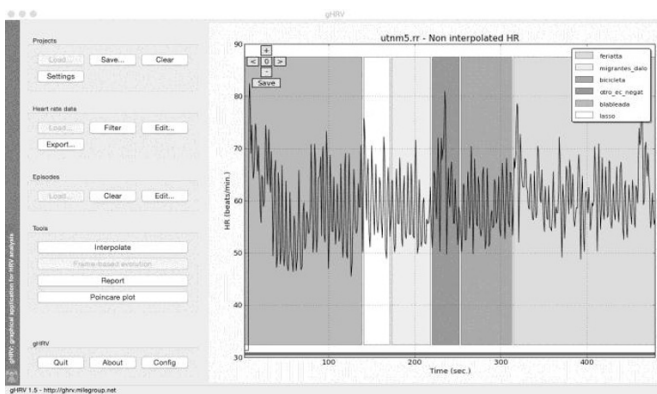
Fig. 1. Example of a hear rate record processed with the gHRV tool

Each participant placed the sensor described above, to the chest, then stood in front of the laptop, and proceeded the viewing of the electoral spots (in random order for each participant). During viewing the heart rate was recorded with VARVI tool (Heart Rate Variability analysis in response to Visual Stimuli), a free software tool developed to facilitate the analysis of HRV in response to different visual stimuli. It can be downloaded for free (http://varvi.milegroup.net).

While the student was viewing the spots, the program communicated with the sensor to get the heart rate data and store them in a file, and labeling the different intervals corresponding to the six spots. After each acquisition, two files were

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[1] https://www.youtube.com/watch?v=xNGWTtRRGjg
[2] https://www.youtube.com/watch?v=TSEVJqG17So
[3] https://www.youtube.com/watch?v=WmaS_Qj-Zis
[4] https://www.youtube.com/watch?v=PyoXbovJwBI
[5] https://www.youtube.com/watch?v=5CgQ5R3h-1c
[6] https://www.youtube.com/watch?v=ySc78jL4X6w

obtained. The first contained the heart rate data, and the second included the tags and time intervals corresponding to each electoral spot. An example of one of this heart rate records is shown in Figure 1.

Once all the records were obtained, processing and spectral analysis were performed. For this task, the RHRV package, developed using the R language (http://www.r-project.org), was used [22]. After removing artifacts a cubic spline interpolation at 4 Hz was applied. Over this equally space hear rate the spectral power was estimated using the STFT (Short Time Fourier Transform). Finally, power in the LF and HF bands and LF/HF ratio were calculated.

As a result, a table with the average values of the HRV, LF, HF and LF/HF indexes was collected. These values were obtained for each record and for each electoral spot, that is, 24 values for each individual. Using the data of this table, different studies were performed. They will be described in the next section.

3   Results

In this Section, before verifying if the main goals of the study were reached, global patterns for HRV in the whole sample were analyzed. In this way, HRV spectral indexes were calculated for all the population of the study, when they were viewing the different electoral spots. No significant differences were found in any HRV index.

Next, some HRV indexes were analyzed to check if the specific objectives of the paper were achieved. The results obtained will be described in the next paragraphs.
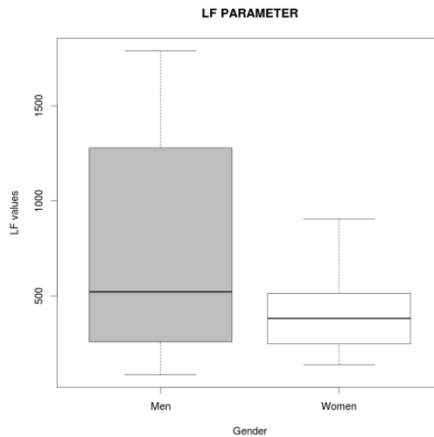
Fig. 2. Comparison of the LF parameter for both men and women

3.1 Gender Analysis

 Scientific works showing differences in HRV indexes between women and men can be found in the literature [23]. In this work, we have previously verified this results,

since the existence of these differences can be help to better understand the other analyses.

First, the average value for the four indexes (LF, HF, LF/HF and HRV) was calculated for all the participants in the study. Significant differences were found between genders. In particular, men presented higher values for HRV, LF and the LF/HF ratio. Figure 2 shows an example of the LF values corresponding to both men and women.

Next to the global analysis, the comparison was repeated for each gender, for the 6 electoral spots included in the study, to analyze if significant differences appear when viewing the spots. No differences were found.

3.2 Comparison of the Official and Negative Spots

To achieve the second goal of this work, the HRV obtained for the official videos of the two main candidates (Rafael Correa and Guillermo Lasso) and the negative spots (two corresponding to implicit criticisms and two of explicit criticisms) were also compared in this study. No noticeable differences have been detected.

Considering the differences between genders previously described, the study was repeated for both men and women separately. The results were similar, and no differences were obtained in the values of the spectral parameters.

3.3 Ideology Analysis

As stated before, participants had to fill in a questionnaire and questions related to their political identification. They had to indicate on a 1-10 scale the political option where they felt best identified, being 1 the leftmost position and 10 the righter position. The responses of the participants were considered to analyze the ideology. To perform this task, students were divided into two groups. Students with a political identification value ranging from 1 to 4 were considered as belonging to left-wing ideology (5 students), being the right-wing subjects those with a response between 7 and 10 (10 participants). The rest of students, with intermediate values in their political identification (5-6), were discarded.

In this study, the greatest differences were found in the HRV indexes when the participants were viewing the electoral spots. The LF values were higher for the left-wing ideology students, than for the right-wing ideology ones, when viewing all the spots, with the only exception of the spot of negative publicity against Guillermo Lasso ("Here comes the other Ecuador / Reply"). The HF values were greater for right-wing students for the majority of the spots, apart from the spot of negative publicity against Rafael Correa ("Migrants" or "The other bike"). Related to the LF/HF ration, students with left-wing ideology presented higher values than the right-wing students. This difference is even more evident when viewing the official spots from Correa ("The bicycle") and Lasso ("Here comes the other Ecuador ").
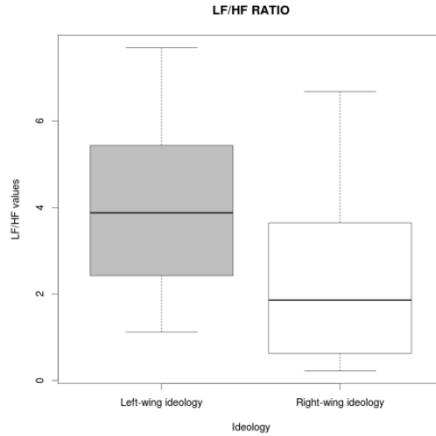
Fig. 3. LF/HF ratio for students of left-wing and right-wing ideologies

Figure 3 shows the LF/HF ratio for the left-wing ideology students, versus the right-wing ideology participants. Differences can be observed. As it is showed in Figure 4, these differences become even greater when the official spots are viewed.
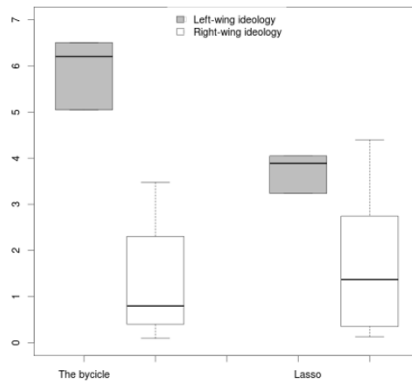
Fig. 4. LF/HF ratio by ideology for the official spots of Correa and Lasso

3.4 Analysis by Friendliness of Candidates

In this later analysis, we tried to find a relationship between HRV indexes and the liking of students for the candidates. After analyzing the responses of students about their identification with the various candidates, we noted that in many cases the opinions were so similar that did not allow us to establish groups. We selected the 4 candidates in which the variation of opinions was wide enough to differentiate two

groups. We added the score given to all of them (range 4-20) and divided the 20 students into two groups, one with students that showed greater liking for them (score 9-12, 8 people) and those who showed less sympathy (score 4-8, 12 people). For this comparison, we selected the spot called "The Feriatta", because it contains an explicit criticism against capitalism and banking.

From the four HRV indexes analyzed, only the LF/HF ratio shows significant differences. The group of students with higher scores also showed higher values for the LF/HF ratio.

4   Discussion and Conclusions

The analysis on the 20 Ecuadorian University students to observe their HRV indexes when watching some electoral spots, and their correlation with the declared ideology, do not show results statistically significant. This can be due to the reduced small sample size employed in the study. However, some interesting differences appear.

There were no differences were observed in the perception of the spots related with the gender. Neither correlation seems to exist between sympathy shown by the students for each of the political leaders, and the HRV values when viewing the spots.

Also, there were no significant differences were observed when comparing the official spots of Rafael Correa and Guillermo Lasso against those of criticism and negative publicity (explicit and implicit), although in the study by ideology, some differences were obtained between negative and positive spots, even although they were not significant.

The most significant differences appeared in the analysis by ideology. Students who declare themselves as supporters of right-wing ideology have a greater variability at high frequencies, and more reduced values at low frequencies. Differences in the measurement of perception conditioned by ideology were already observed in a previous experiment on electoral spots viewing [19], in the sense that the electorate that showed radical political ideologies has higher HRV than people whose political ideology is more moderate.

However, the truth is that a larger sample of evidence would be needed, to check possible variations in the impact of negative political advertising as opposed to positive one, and to see if the different reactions depending on the ideology declared by participants remains or even is accentuated.

It is also difficult to interpret the reason of some changes in the detected cardiac parameters, since this would require combining these results with other tools or techniques, such as qualitative analysis (interviews, focus groups), in addition to the questionnaire applied to all of students.

The contrast between these results and others that can be performed would certainly help to provide new and better evidence.

Furthermore, beyond the details of this specific experiment, we consider the relevance and suitability of the use of the tools and techniques of neuroscience applied to social sciences, as well as the combination of both in the study of human behavior and social relations, beyond the field of health and medicine, for future research, exceeding the initial exploratory approaches.

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Contents in the television of Ecuador.
Incidence of the digital transition and the regulation

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Abstract. In the television of Ecuador a commercial model has predominated. It has not allowed the production of national content, situation that in recent years has changed thanks to the transition to Terrestrial Digital Television and the implementation of the Communications Law that promotes, both technically and legally, the domestic production to meet the demand for quality content. In addition, the digital phenomenon and the regulation in communication would allow to meet the right to communication. The research presents the changes in the composition of content of private television of Ecuador between 2010 and 2015; and the findings of media actors. The effectiveness and exploitation of technological and legal changes will depend on the ability of agreements between companies, society and the government.

Keywords: Television digital; audiovisual regulation; TV content; Audiovisual production; Audiences

1 Introduction

In 2013, Ecuador began the regular broadcasting of digital terrestrial television (DTT) based on the Brazilian-type ISDB-T standard, that same year the Communications Law was approved, that pretends to influence the effective exercise to the right of the communication. In this new framework, DTT would contribute to the promotion and development of a range of programs with better quality of picture and sound, allowing the availability of more frequencies thanks to the digital dividend.

The analogue blackout is scheduled for December 31, 2018, however there remain uncertainties about growth prospects and the supposed benefits that will go along with the DTT [1] because the digital television affects the model of production and the business of content providers [2] opening the market to new operators to democratize access to information, although the process may derive in concentration and loss of diversity like it happened in Spain [3].

Without proper safeguards the implantation of the DTT can cause restriction of the political and social pluralism expanding the number of channels without qualifying the content or not allowing diversification of formats, programs, and actors in the system. Beyond the technological aspirations, it should not be forgotten that the contents are true axis of the digitalization of television [4].

International experiences as Freeview that provide DTT in the UK suggest a line of development that would likely set the course of the sector in the coming years and that demands more interactivity and diversity of the offer. Otherwise, the idea of DTT as innovation can be questioned by not improving the choices offered either through the channels of cable, satellite or IPTV [5].

To consolidate a system of commercialized television is obvious that in Ecuador, it can replicate the tendency to exclude a significant portion of the population that depends on the open television signal [6]. The transition to the DTT requires an increase of hours to meet specific niche audience, but the structure and resulting offer does not guarantee a diversification of the sector. The key to the transformation of the audiovisual ecosystem depends on the diversity of access, content and services open to the public that really meet the needs of users [7].

"Digital technology has allowed the reduction in size and cost of information and communication equipment; It shortened the time required to collect, edit, compile, store and retrieve content "[8] but it does not mean that the demands attributed to the technological modernization process are made.

Thus, the Communications Law of Ecuador, *in spanish Ley Orgánica de Cominucación de Ecuador* (LOC) aims to develop, protect and regulate, at the administrative level, the exercise of communication rights constitutionally established. For that, Article 60 provides that television content is classified as: informative, opinion, formative / educational / cultural, entertainment, sports; and advertising; and Article 97 states that the audiovisual media, whose signal is of domestic origin, would give in a progressive way at least 60% of its daily programming in the schedule suitable for all ages, the spread of content in domestic production, including 10% of independent production.

The Technical Committee for the Implementation of DTT (CITDT) of Ecuador reported in March 2012 that in the emission of the television stations foreign productions are favored [9], which recommended the dubbing of content, change of formats, recording in HD, light, scenery and even makeup to enhance national audiovisual production and have sufficient hours of programming under the new regulatory framework [1].

In this first analysis of the impact of the new public policy in communication, it is evidenced the need to know what the composition of content on the Ecuadorian television and determine, prospectively, if it is able to meet the legal standard required by the LOC, in order to seize the opportunities of the digital transition guaranteeing the rights of the audience.

According to analysis applied in other Latin American countries, it is known that television reproduces logics of market that dominate foreign contents with little room for local production content, which negatively affects the development of the national audiovisual industry [10].

The hypotheses of the research are: 1) The offer of contents of Ecuadorian television is not balanced in relation to the classification that disposes the LOC; 2) The proportion of own production of the Ecuadorian private and confiscated television stationsis[1] is less than 50% of the total hours broadcasted and must improve fundamentally in contents of fiction.

2 Methodology

The methodology is qualitative and quantitative. Statistics published by the International Center for Advanced Studies in Communications for Latin America (CIESPAL) were reviewed, as well as the reports of 2011, 2012, 2013 and 2014 of the Latin American Observatory of Television Fiction (OBITEL) and data from the Group of Contents of the Inter institutional Technical Committee for the introduction of the DTT. The statistics correspond to private and confiscated television stations, the information of public television "Ecuador TV" is not included because the orientation and funding are different than the purposes of commercial television. Furthermore, important informants representing private and state media were consulted to determine the willingness to comply with the regulations of the LOC.

It also quantified the time transmitted in private and confiscated television stations, in January 2015, between 6:00 am and 18:00, because the 60% of content suitable for all audiences to be met by national stations corresponds to this schedule.

3 Results

According to hours of content to be broadcasted on Ecuadorian television (Table 1) there is a clear imbalance in favor of entertainment, about two thirds are soap operas, movies, contests, reality shows, cartoons and children's programs, among others; third of hours shown between 2010 and 2013, are occupied by different genres of entertainment.

Table 1. Contents in open Television, according to LOC

Genres	2010	2011	2012	2013	Media
Informative	18,0%	17,4%	19,5%	23,6%	19,5%
Of opinion	3,0%	2,6%	5,2%	4.4%	3,8%
Formative / educative / cultural	2,9%	0,6%	2,9%	5,5%	3,0%
Entertainment	67,8%	67,8%	61,6%	53.4%	62,7%
Sports	5,9%	8,0%	6,0%	6.1%	6,5%
Advertising	2,5%	3,6%	4,8%	7,0%	4,5%
Total	100,0%	100,0%	100,0%	100,0%	100,0%

Source: Compiled from reports OBITEL 2011, 2012, 2013 , 2014

The origin of programming (Table 2) from Monday through Friday is mostly national, weekends are foreign, local production of large operators is mainly news and sports or entertainment shows [1]. The composition of the programming, despite their high rating, does not meet the expectations that households have [11].

Ecuavisa, TC Televisión and Canal Uno lead the production of national content but the last two transmit the most game, entertainment and sports shows. The numbers for domestic fiction production are minimal (Table 3), nine out of ten premiered fiction contents are of foreign origin.

Table 2. Origin of programming 2015

Station	Shedule	Monday - Friday		Saturday - Sunday	
		Nat.	Foreign	Nat.	Foreign
Gama TV	6:00 – 18:00	46%	54%	52%	48%
Teleamazonas	6:00 – 18:00	72%	28%	33%	67%
RTS	6:00 – 18:00	63%	37%	29%	71%
Ecuavisa	6:00 – 18:00	79%	21%	60%	40%
TC Televisión	6:00 – 18:00	78%	22%	50%	50%
Canal UNO	6:00 – 18:00	50%	50%	63%	37%
Average		65%	35%	48%	52%

Source: Compiled from programming schedules to January 2015

Table 3. Origin of fiction premieres

Years	Variables	Ecuador	International*	Totals
	Hours	305:09	2288:17	2593:26
2010	%	11,8	88,2	100,0
	Hours	189:00	3060:00	3249:00
2011	%	5,8	94,2	100,0
	Hours	234:00	2686:45	2920:45
2012	%	8,0	92,0	100,0
	Hours	530:24	3314:02	3844:26
2013	%	13,8	86,2	100,0

*2010 and 2011 correspond to Latin America; 2012 and 2013 correspond to Iberoamerica
Source: Compiled from reports OBITEL 2011, 2012, 2013

The high costs of production to feed the program schedule tend to impose the criterion of favoring the "productions based on contests, talk shows, music, and content of low complexity of production, among others. Additionally, the cost of producing a soap opera in the country is higher than buying a foreign one" [1]. A problem identified by independent producers is the lack of resources to produce quality. Although there are qualified staff, the general environmental conditions are not adequate, especially for the low financial capacity of audiovisual production and the radio and television companies that prevent from modifying the dominant tendency in the national audiovisual structure.

In the interviews done, it was established that some stations seek to ensure programming that reaches the percentage set in the LOC. In his argument the interviewees underline that the national levels are not the taste or habits of the public, claiming that audiences are still not used to seeing national television, or even they underestimate the local content, so it will be difficult to meet the demands of a new regulatory framework.

The interviewees point as an urgent solution; putting together a competitive and balanced program schedule with new offer of native programming. That is the case of, for example, the RTU station, which has local production and purchases content. The channel is broadcast the percentage of production required by the LOC, covering spaces with domestic production, but it has not yet invested in equipment for quality programs at an international level. The opinion of the technicians from RTU is there

is not enough Ecuadorian production to meet the proportion, either trained staff or a national system for the dramatic production.

The proportion of 60% of national production in the usual emissions, media of higher capacity may do it, but it is possible that small media do not meet the standards established in the Law. An opportunity to do so, recognized by the heads of media interviewed, is the specialized educational television and university production. Most interviewees acknowledge that the information and cultural programming produced by institutions of higher education, among others, can have a major role in the new audiovisual ecosystem, as long as schools take a proactive role of professional quality audiovisual production.

The tendency in Ecuador is that the channels broadcast in high definition, which involves technical quality of content. To ensure a sufficient service for the multiplication of channels provided with DTT, the Group Contents of CITDT works with the ministries of Education, Culture and the National Film Board of Ecuador to make a national repository of educational, cultural and health production available to the operators.

4 Discussion and conclusions

The offer of Ecuadorian television is unbalanced in relation to the classification of content disposed by the LOC. There is a much higher portion of entertainment at the expense of genres that could help the development of the community. Ecuadorian television, viewed from its contents, it is not plural and democratic. This situation requires changes that in front of the implementation of DTT will demand that the work in multidisciplinary teams is oriented to various genres and topics.

Television does not respond to social demands, a situation that would lead to the analogue blackout takes place in adverse conditions, from the point of view of the needs of viewers, especially if we consider the economic structures of the existing operators in the audiovisual market.

The proportion of the own production of the private and confiscated Ecuadorian television stations, in January 2015 is on average 56%. Some stations meet the proportion disposed by the LOC: 60%, but their production do not cover all genres, revealing a high degree of homogeneity in the offer.

The production of fiction, important in the demand for new content, such as soap operas, is basically foreign, resulting that only 10% of all hours broadcasted is of Ecuadorian origin. Market rationality prevails, despite the legislative change in programming policy. Facing an uncertain scenario and the lack of clarity regarding the business model in emerging screens and incipient consumption practices like the Internet, national operators tend to seek competition by reducing production costs, which eventually means less fiction, more content of syndication and dominance of the foreign product.

Ecuadorian television model, whose origin is historically commercial, favors unrelated contents to national realities, it clearly imposes the domain of the audiovisual environment of potential audiovisual of the region like Mexico.

The alternative to this dependence appears to be in the agreements between local authorities, regional and the state to link the entertainment industry and the educational system, and, therefore to fulfill the existing audiovisual lack. In this

sense, it is vital the role of the media that are called to meet the demands of the public with quality and specialized content [12].

National audiences expect that there will be changes in the contents of information, education, and culture. But it's worth mentioning that the potential new entrants to the industry, the role of internet and mobile communication devices or second screens imply a change of what we call broadcast TV to a complex environment and probably unbalanced because by incorporating other services and digital content many sectors of the population may be marginalized.

Finally, the analysis of the interviews show that all stations are working to meet national production percentage, but they should improve the relation by genres because the highest proportion in television are entertainment content. There are opportunities for independent producers to develop content in genres such as education, culture and political information.

The first hypothesis is accepted: The offer of contents of Ecuadorian television is not balanced in relation to the classification that disposes the LOC. But it should be noted that new actors such as educational institutions or groups as CIESPAL can fuel the demand for quality that the manufacturers of the media try to transform the structure of the existing programming. The second hypothesis is rejected to the data in Chart 2

The conformation of a national repository of content that responds to the plan of the Group of Contents CITDT, may favor the operators with a bank of cultural, educational, health and technology programs to renew and diversify programming.

The future scenario is an open field of opportunities and challenges. Some willingness and commitment is found in Ecuador to meet the LOC but there is a lack of policies to guide and encourage coordinated actions by companies and new actors in the communication system. The effectiveness and use of current technological and legal changes will depend mainly on the ability of agreements between companies, society and government. The LOC is only the first step.

4.1 Footnotes

[1]In Ecuador, there are still bided television stations Gama TV and TC Television, which belonged to the owners of failed banks in the national financial crisis of 1999. As a result of this economic crisis, the stations were confiscated by the state in return of guarantee deposits. TV stations with national coverage are seven: four private (RTC, Ecuavisa, Teleamazonas and Canal UNO), a public (Ecuador TV) and the two confiscated ones.

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Looking for a place in social media without getting trapped in networks

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Abstract. Journalism today is looking for new ways to ensure its survival in a context of reconfiguration of media and communication processes. It tests several options, even it is aware that it is at risk of being trapped in some dimensions of the digital world. As the change progresses, there arise renewed proposals, placed between traditional and huge technological companies and social networks (namely, Google and Facebook), which appear as symptoms of a new era. And, while we wait for the hypothetical arrival of that improved background, both media and journalism look for their own room in social networks (from journalism in streaming to slow journalism). Their main goal is to experiment and to ensure their role in the networked society[1].

Keywords: Journalism, media trends, social networks, Networked Society.

1 Introduction

As the construction of the new era of the Information and Knowledge Society advances, within a changing and retrievable background, the media ecosystem offers a new scene. At present, journalism remains as a social communication technique whose main goal is to provide citizens with useful information for daily life. While there are many developments in communication service (mobile communication,

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mobile broadband) and the Internet penetration have been steadily [1]2, the uses and consumptions of information change, since news have also done it, due to the emergence of mobile communications and the new social dimension (social networks environment) [2]. Social networking sites become the nerve centre of communication processes.

The above-mentioned report [3] places social networks as the second leading media among the Internet users under 35 –in Spain-, only behind traditional television. Platforms like Twitter and Facebook have exceeded printed press as the main information source, even users between 35 and 44. Trends indicate a progressive increase of social networks as information source during the course of this year, confirmed in the successive updates of this report. Also, it should be noted that, in Spain, some studies estimate at about 82 per cent the web users from 18-55 consuming social networks, which represents more than 14 million users [4]. According to another work, the estimated number at the end of 2014 was over 17 million users [5]. Being Facebook, Google+, and Twitter the most employed networks.

The data regarding the number social network users around the world have led the media, both digital and traditional, to design strategies to meet their new challenges, which not only include being and participating in social networks, but also looking for formulas to maximise their social media activity. The main goal of the media is to search for an space in which generate, through journalistic messages, users flows from social networks and; but, at the same time, they are trying to be able to act without getting trapped by the main companies created around these successful networks.

The main media and many journalists occupying positions of responsibility in cybermedia claim that, in the current setting, it is impossible to live on the margins of social networks but, at the same time, they are looking for strategies in order to maintain the essential elements of journalism [6].

2   Theoretical approaches

The phenomenon of social networking, journalism and the media has been in the spotlight of many scientific work of our academic environment: many papers on digital networks management are compiled in two notebooks from the *Revista Latina de Comunicación* [7]*,* as well as some sociological analysis on networks [8]; many aspects that link networks and journalism [9]; and research on the way journalists use social networks [10]. At international level, it should be highlighted the work of the Reuters Institute, in which many international scholars participate, and the Latin-American studies from Alejandro Rost [11], European researchers as Kaplan y

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2 A team coordinated by Alberto Ureña and integrated by Elena Valdecasa, María Pilar Ballestero and Olga Ureña has produced the report of the *Observatorio Nacional de las Telecomunicaciones y la Sociedad de la Información*.

Haenlein [12], and North-American scholars [13] on the use of Facebook, among others.

The main researchers working on social networks have been united in stating that this phenomenon has a great power on present societies. Their works note that the virtual world represents another step forward on the road of technological, social, and economic changes that are transforming the interactions between humans [14]. This involves changes in the communication processes and in journalism itself.   The popularity of these networks, their incidence on news consumption, and the number of users continue to grow in 2015 [15][3].

This is interesting for our analysis, since the change process in journalism, its deep transformation [16], and the result of the development of the present information technologies, have given rise to a complex communication environment. It is a highly dynamic scene that is feedback by a heavy scheme of interconnected nodes, which instantly update web contents [17]. Understanding the role journalism is looking for in the new scenario, requires the analysis on the boundaries of journalism in the networked society [18], which seek to establish the reference frameworks for journalism in the networked society and in the social networking space.

3   New challenges

The rise of social networks and the changes in the news consumption makes unavoidable the debate on the boundaries of journalism in the new setting, and the way of addressing the new challenges. There is no question that the digital scenario has opened up new opportunities for journalism that, via its professional culture developed for more than a century, can create contents with features of the new technological environment.

Multimedia [19], interactivity [20], participation [21]; customization [22]; memory or documentation [23], mobility and the use of new formats [24], are some of the main dimensions that should be considered by the new media.

In order to provide opportunities for the development of the defining features of cybermedia, the major networks are offering innovative resources and initiatives for the media. For example, in May 2015, some media started to publish contents directly on Facebook thank to its service Instant Articles; and, in October 2015, Google presented its project to accelerate the mobile web with many newspapers, including the Spanish El País[4]. This rapprochement between news companies and social networks has opened up a renewed path to intervene in the networked scenario,

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[3] Studies carried out by the Pew Research Center in 2015 are available in: http://www.pewresearch.org/topics/social-networking/. The study on the social use of media (2005-2015) is of particular relevance with respect to the evolution of the media and social networks (Social Media Usage: 2005-2015).

[4] El País reported on the project with a piece of news in which assured that digital press reinvent itself with a new open and universal format. Accessible on: http://tecnologia.elpais.com/tecnologia/2015/10/06/actualidad/1444160150_620828.html. Consulted: 5[th] November 2015.

especially in connection with the use and consumption of information from mobile devices.

While awaiting concrete projects and results of these channels for collaboration, it seems that a new phase begins, in which the benefits of media being present in social networks will have to be analysed. What is for sure is that the media doing journalism will continue to provide various proposals, going from live news –both native digital media and traditional media-, to the so-called "slow journalism" or in-depth journalism, with long pieces and careful stories.

From the journalistic field, there is a deep conviction that the future of the profession is based on telling good stories [25] with the current technologies and for connected citizens, who have access to messages from a wide range of sources and need to have the best information possible to take daily decisions.

Good non-fiction stories continue to confirm the central core of journalism, but the challenge today is to get clear and effective pieces, using all the available technologies and resources. The application of some of the current technologies, formats, platforms, broadcast channels and receiving devices, has to be at the service of that goal, since the essence of journalism still lies in what is happening.

Nevertheless, the debate is still opened and it appears that there will be a coexistence of diverse initiatives: hyperlocal and global media, both with sustainable enterprises. In both cases, the boundaries of journalism, the participation in social networks, and the new ways of telling non-fiction stories are some of the main debates of professional associations, the media, as well as some journalists and researchers from the field of Communication Science.

4   Windows in social networks

The presence in social networks (RRSS) is common to the vast majority of journalistic initiatives on the network. An analysis on the use of social networks by the main Spanish media shows the strategies of media for getting closer to their publics, as well as the users engagement through their participation in RRSS. To carry out this study, a sample of the 30 main media has been selected: the ten newspapers with the largest number of readers (Marca, El País, As, El Mundo, La Vanguardia, La Voz de Galicia, Mundo Deportivo, El Periódico, ABC and Sport); the ten radio broadcasters with the largest number of listeners (Ser, Onda Cero, Cope, RNE, Rac1, Catalunya Radio, esRadio, Canal Sur Radio, Radio Euskadi and Radio Galega); and the ten television channels with the largest audience share (Telecinco, Antena3, TV3, Aragón TV, La1 of RTVE, TVG, Canal Sur, EITB2, La Sexta and Cuatro), according to the consumption data of the EGM and Kantar Media –first semester 2015-. On each of these cases, there has been a monitoring of the presence of the medium –its main brand- in the most popular social networks: Facebook, Twitter, Google+ and Youtube. Also, it has been opened the option "another networks" in order to explore the specific offers of each medium in emergent RRSS, but finally it has not been considered because only a few media were using RRSS as Instagram or Pinterest.

The positioning strategies in social networks of the observed media are not entirely homogeneous and differences depend, basically, on the support. The data obtained[5] show that the Spanish press and television present a clear trend towards two social networks: Facebook and Twitter. The total of selected media has a strategic visibility endorsed by the number of users and the largest number of followers is located on Facebook (the press has 4.977.131 followers and the television has 19.083.218). The main bet of the radio is Twitter, since all the stations have a specific #hashtag, but not all of them have accounts on Facebook. Broadcasters such as Rac1, Canal Sur Radio and Radio Euskadi do not have their own profile. The visibility strategy of the radio also coincides with the attitude of the public, since the RRSS with the largest number of users is Twitter in those stations with profile and #hashtag (1.930.782 users have the radio on this social network and 728.911 users have it on Facebook).

There are also strategic differences regarding concentration and diversification of the media of the sample set with more than one profile on Facebook (13 for the different editions and many specific accounts such as Voz Natura). The spread of #hashtag on Twitter is the most common factor of the analysed media (El País has 49 secondary accounts, El Mundo 61, ABC 32 , Cadena Ser 101, Onda Cero 77 and La Sexta 69). But there are many media that opts for regrouping and concentration in one brand (that is the case of the newspaper Sport, of the radio stations Cope, esRadio, Radio Euskadi and Radio Galega, as well as the TVG).

Also, data reveal that the strategic power of media in social networks is more pronounced in the consolidated networks, and is reduced in the emergent ones, such as Instagram and Pinterest. This last network is only used by 6 of the 30 analysed media (Marca, ABC, El Periódico, RNE, La1 de RTVE and Antena3).

Figure 1 and tables 1, 2, 3 and 4 show the total number of followers of the 30 analysed media and a breakdown of each social network:

Fig. 1. Social networks users (RRSS) by medium.
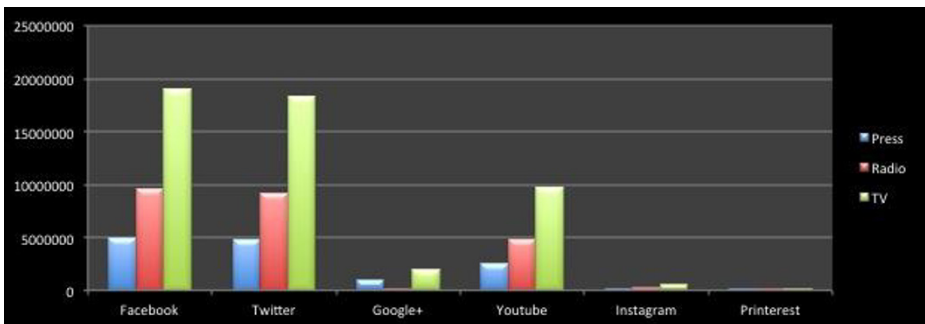
Table1. Social networks users (RRSS) in press.
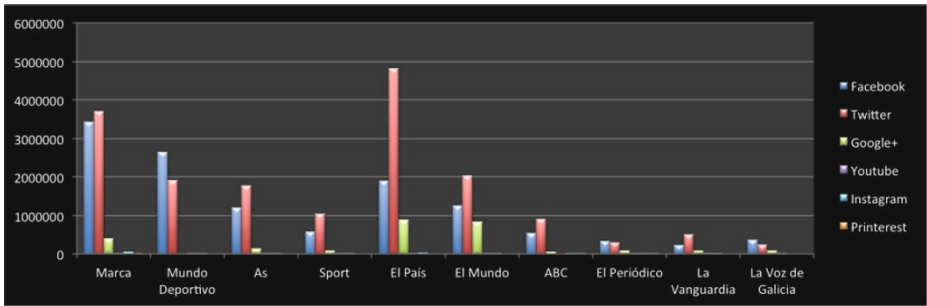
Table 2. Social networks users (RRSS) in the radio.
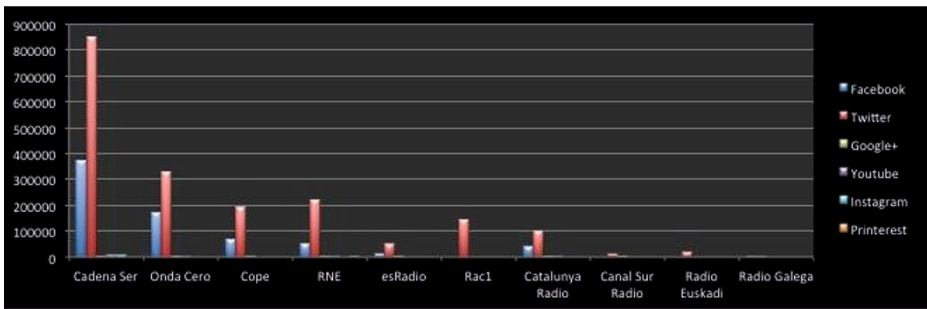
Table 3. Social networks users (RRSS) in TV.
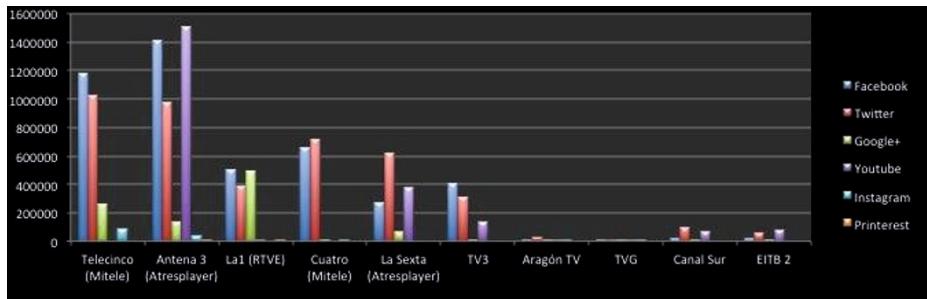
Considering social networks, convergence is more evident in press, while the radio offer is not still adapted to the new scenario. This phenomenon can be mainly seen in the use of networks where pictures play the main role: if almost 100% of printed media has their own YouTube channel and an open account on Instagram (only ABC is not present in YouTube and La Voz de Galicia does not have Instagram), radio stations still live on the margins of these two RRSS: only Cadena Ser, Onda Cero and Catalunya Radio are active in YouTube, and the only broadcaster with Instagram is Cadena Ser (373.529 followers in Facebook, 852.000 in Twitter, 4.108 in Google+, 10.405 in YouTube and 9.851 in Instagram).

5 Conclusion

At present, the media developing journalism and professional groups are united by their common interest in the search for new paths for its survival within a process of reconfiguration of the media scene. This shared desire is manifested in the products essays and the intervention formulas in the communication background, in order to meet the challenges of the Information and Knowledge Society. In particular, these challenges are related to the evolution of mobile communications and the widespread use of social networks in communication processes.

Both media and journalists agree that, in the third decade of the third millennium, they cannot be on the fringes of social networks, but at the same time, are aware of the risk of getting trapped in some dimensions of the conversational process of the digital streets. Hence their shy partnership agreements with the main social networks for experimenting renewed communication formulas in the networked society.

As the change process and the reconfiguration in the media scene advance, renewed proposals emerge in traditional industries and the main technological companies and social networks (especially, Google and Facebook). These initiatives seem to be symptoms of a new era for the content industry. For the time being, the goal is to test and open new paths to ensure the survival of journalism within a scenario in which communication is ubiquitous.

From this analysis it was firstly shown that the connection, conversation, and participation strategy, which strengthens the "social version" of traditional media, is still concentrated on a double scene of fortitude and leadership: Facebook and Twitter. Nevertheless, the strategic weight of these two networks is different depending on the medium: while the press and television find the support of their users on Facebook, the radio has Twitter as its main ally in the digital context. But there is a lack of homogeneity in the use of social networks is. Mass media does not have the same strategies when begging for concentration or diversity of accounts and profiles –the main brand or opening various specific accounts depending on the section and program-; and the convergence levels applied to RRSS where pictures are at the fore (press and radio). Meanwhile, newspapers are beginning to offer new video and photography services via YouTube channels and Instagram accounts. On the contrary, radio stations are resistant to experiment with image resources and do not have visibility on these networks.

This work confirms the trend of the high level of users engagement with the media through, essentially, Facebook (33.608.998), but also the emergence of Instagram (976.462), where there are innovative experiences and professional profiles in the field of journalism.

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Competing Tourist Destinations and their Positioning on the Social Medium *Facebook:* Ecuador, Colombia and Peru

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Abstract. Today's tourist industry is characterised by its increasingly profitable and competitive nature, forcing destinations to seek forms of differentiation in order to attract greater numbers of tourists. However, this is challenging task, and tourism promoters and managers are required to plan and design effective marketing strategies tailored to communicate and highlight the tourist attractions of their destinations. In this sense, adapting to the new scenario created by social media has revolutionized communication. Destinations are now required to make full use of the advantages these communication tools offer. The aim of this research is to analyse the tourist positioning of Ecuador, Colombia and Peru on the social medium   *Facebook.* The conclusions indicate that the countries analysed should improve their optimisation strategies in order to take full advantage of the interactive potential Facebook offers, thereby optimising their future position as tourist destinations.

Keywords: Tourist destination, Promotion, Positioning, Social Medium, *Facebook.*

1 Introduction

Tourist destinations compete for differentiation, and in this sense promoters and managers are required to design suitable communication strategies, tailored to securing strategic positions in the tourist's mind in order to secure higher visitor numbers as well as increased revenue and investment for the country in question, with the corresponding positive impact on its economy.

In order to achieve this, it is vital to realise that times have changed; the incursion of Information and Communication Technologies (ICTs) has radically altered the way

travellers access information, plan their trips and share their experiences [1] [2] [3]. It has also led to a change in the pattern of both tourist supply and demand.

In terms of supply, social media, as online platforms for the dissemination of content and communicating and sharing information, have revolutionized the way tourist destinations are promoted.

Trends among tourists have also changed with regards to demand. They are now better-informed and more easily-influenced, unquestionably due to the impact of social media, which has converted Internet users into authentic protagonists, as their opinions and recommendations are extremely useful in obtaining more detailed information as to preferred tourist destinations and thereby contribute to the decision to choose one destination over another.   In the light of this changing scenario, this study analyses the case of three destinations in South America and which compete with one another in order to differentiate themselves and attract the greatest number of tourists: Ecuador, Colombia and Peru. They all have two things in common: a coastline and mountains, and therefore sun and sand and inland tourism form the basis for the most appealing products for visitors.

This study aims to determine their position on one of the most popular social media - Facebook – in order to discover whether they are making optimum use of this tool. Should this prove not to be the case, it will also define those aspects that must be reconsidered in order to enhance this position.

2   Tourist Destinations and Promotion on Social Media

According to Bigné [4], a tourist destination is a combination of tourist products capable of offering tourists an integrated experience […], which can be subjectively interpreted by consumers in accordance with their travel itinerary, cultural knowledge, reason for travel, level of education and prior experience.

Ejarque [5] defines it as a series of resources that are sufficiently attractive to induce travellers to make the necessary efforts to travel there. From a demand perspective, Bull [6] classifies it as the city, region or country visitors travel to, considering it to be their main objective, therefore offering a vision of a precisely defined geographical area.

In terms of supply, a tourist destination comprises a set of tourism facilities and services made up of multiple attributes that together generate its appeal [7]. These attributes include historic sites, beaches, mountain ranges, parks, landscapes, etc. In other words, all the services and facilities that satisfy tourists' needs when travelling.

The definitions given above reveal some of the defining characteristics of a destination and the reasons for the tourists' choice, focusing in particular on attributes associated with subjectivity, experiences, efforts, objectives, etc. This implies that each destination is open to multiple interpretations by visitors, which will vary in accordance with the type of tourism they are seeking, their expectations and previous experiences, etc. In short, the tourist destination is a series of factors that facilitate a tourist experience in a certain place and satisfies tourists' needs.

It is therefore essential for tourism promoters and managers to dedicate time and effort to planning communication strategies in line with the nature of the destination

they represent. Furthermore, they must be aware that online promotion, including the use of social media, currently plays a crucial role, as it allows for more interactive communication with consumers. Social media platforms have thus become a new means for the dissemination and promotion of tourist destinations. Recent studies have shown the rising numbers of visitors that generate content on 2.0 platforms and use the information available in these media when planning their trips.

A social medium is understood to be a group of people with some type of shared interests who communicate online, where participants may or may not know one another personally, and where the network also allows for the sharing of knowledge and experiences through the use of Internet-based applications [8].

The use of social media by tourist organisations and destinations provides them with a greater insight into travellers' needs and preferences. Social media have therefore become an endless source of information, converting them into an essential tool for countries. In this sense, Kang and Schuett [9], Munar and Steen [10] and Hudson and Thal [11] claim that a significant part of the image today's consumers have of a destination, together with their assessment of it and decision to visit, is constructed via the Internet and the social media in particular.

As Mich and Baggio [12] have stated, *Facebook* is currently the most popular social medium [13] [14]. Indeed, it is positioned as the principal tool in the online tourist industry and is the most popular with tourists at all stages of the travel experience: before, during and after their trip.

3   Competing Tourist Destinations: Ecuador, Colombia and Peru

The scope of this study extends to three countries situated in the West of South America. They compete with one another in the tourism industry, and all three have sufficient tourism attractions, including coastal and mountain destinations, to be able to position themselves at the forefront of the industry. Furthermore, their governments undertake specific actions aimed at taking advantage of the resources that identify, differentiate and distinguish these destinations. Below is a brief description of the characteristics of these destinations.

Table 1. Destinations

ECUADOR	
Official Name	Republic of Ecuador.
Located	Located in the Northwest of South America and bordering with Colombia, Peru and the Pacific Ocean.
Altitude/Extension	Extension 270.670 km^2 with an altitude of 2850 meters.
Climate	The climate is tropical, with temperatures of 50°F to 70°F in the mountains, 60°F to 80°F on the coast. In the rain forest the weather is constant: rainy, humid and warm. The Galapagos Islands: sunny between December and May although the temperature drops from June to November.
Population	14,483,499.

Economic Activity	Oil makes up 40% of all exports, in addition to bananas, flowers, cocoa, shrimps, sugar cane, rice, cotton, corn, palmitos, coffee, wood and tourism.
Places of Interest	Quito is called 'the Face of God' Guayaquil is known as 'the Pearl of the Pacific; Cuenca is the third largest region and the Galapagos Islands have a large number of endemic species.
Language	Spanish.
Observations	Home to the UNESCO Qhapaq Ñan World Heritage Site.

COLOMBIA

Official Name	Republic of Colombia
Located	It is located at the northern end of South America, bordering to the north with the Republic of Panama and the Caribbean Sea, to the East with the republics of Venezuela and Brazil, to the south by the republics of Peru and Ecuador, and to the west by the Pacific Ocean.
Altitude/Extension	Extension 2,070,408 km^2 with an altitude of 3,350 meters.
Climate	A warm climate with average temperatures of around 75.2ºF which covers 80% of the extension of the country.
Population	47,662,000.
Economic Activity	Oil and coal production, production of gold, emerald, silver and platinum, flowers, coffee, sugar cane, bananas, textiles, food, beverages, automobiles, rubber, hospitality and tourism.
Places of Interest	The historic city of Cartegena has been declared a UNESCO World Heritage Site; St. Martha for having in a single destination: Sierra Nevada mountain range, rain forest and coast. San Andrés boasts the finest beaches in the country.
Language	Spanish.
Observations	Home to the UNESCO Qhapaq Ñan World Heritage Site.

PERU

Official Name	Republic of Peru
Located	Peru is located in the western part of South America. Its territory borders with Ecuador and Colombia to the north, with Brazil and Bolivia to the east, Chile to the south and the Pacific Ocean to the west.
Altitude/Extension	Extension 1,285,215.6 km2 with an altitude of 2,500 meters.
Climate	The rain forest is humid and tropical, with high precipitation levels. The climate in the mountains is dry and temperate, with major variations in temperatures during the course of the day. The north coast enjoys year-round sunshine, whilst on the central and southern coasts temperatures are mild.
Population	31,151,643.
Economic Activity	Primary Sector: Agriculture, Livestock Breeding , Fishing and Mining; Secondary Sector: Industry Tertiary Sector: Transport, Trade, Communications and Tourism.
Places of Interest	The Inca Trail, of the historic city of Cusco Machu Picchu or the Sacred City of the Incas and the Capital Lima.
Language	Spanish and Quechua.
Observations	Home to the UNESCO Qhapaq Ñan World Heritage Site.

Source: Authors' own from tourist destination websites

4 Methodology

The online tool *LikeAlyzer* (http://www.likealyzer.com/) was used to analyse the position of Ecuador, Colombia and Peru as tourist destinations on the social medium *Facebook*. This decision was made for several reasons: firstly it allows for the measurement of the parameters of interest for the purpose of this study; secondly it analyses fan page efficiency; furthermore, it contributes to detecting problems and providing solutions; and lastly, it is available free of charge.

The procedure was based on identifying those government organisations that use Facebook to promote tourism, and secondly, on the observation of the corresponding fanpages in order to analyse the following parameters: Content, Interactivity and Visibility. It must be stated that the choice of these parameters is in line with a study carried out by Huertas, Setó and Míguez [15]. It was carried out between 13th October and 13th November 2015.

The aspects analysed in each item are listed below:

Content: Post format (photographs, videos, links, status, etc.); Post rate and Information type (suggestions, complaints, questions, acknowledgements, etc.)

Interactivity: Loyalty or engagement; User reactions and Fans' publications

Visibility: Number of followers or fans; Number of 'Likes'; Shares (the number of times a post has been shared); Post length; Timing (the time of day when most posts are uploaded); Hashtags and Favourite sites

Table 2. Domain registration and Fan page

Tourist Destinations	Url	Fan page
Ecuador	www.turismo.gob.ec	https://www.facebook.com /MinisterioTurismoEcuador
Colombia	www.mincit.gov.co/	https://www.facebook.com /MincomercioCo
Peru	www.mincetur.gob.pe/	https://www.facebook.com /minceturperu

Source: Authors' own from tourist destination websites

5 Results: Content, Interactivity and Visibility

This section discusses the results obtained from the measurements of the parameters Content, Interactivity and Visibility.

Content should centre much of the tourist destinations' efforts to attract customers, and therefore fanpages should be the object of continuous updates. However, once the customers' attention has been caught, it is essential to work to maintain it and generate competitive advantages that will boost their loyalty and the destination's positioning.

The first results regarding the content of the *Facebook* pages analysed correspond to the item 'post format' and its influence. An initial approach confirms that images/photographs are the most uniformly and generalised means used to boost content visibility.

As shown in Table 3, Peru, which only employs 2 formats (photographs and videos) in order to disseminate its content, uses photographs for the vast majority of its posts (83.3%), compared with 79.2% in the case of Ecuador and Colombia, which use a wider variety of formats (photographs, videos and links).

In all three cases this type of post is the most common, although other formats such as videos and links also play an important role in disseminating content. However, in this study they do not have a particular impact.

Regarding 'post rate' (Table 3), Ecuador lies ahead of its competitors with an average of 19.86 posts per day. This would be extremely effective if the destination used this high rate to interact with its fans. However, the posts would appear to be of little interest, as the amount of feedback is low. In the other two cases, Colombia, with an average of 1.24 posts per day, effectively encourages user interaction, whilst Peru, with an average of 3.32 publications, also fails to generate sufficient response as it is unsuccessful in generating interest in its site.

Table 3. Posts per type, per day and rate

	ECUADOR	COLOMBIA	PERU
	Posts	per type	rate*
Photos	79.2%	79.2%	83.3%
Video	12.5%	8.3%	16.7%
Link	8.3%	12.5%	---
Status	---	---	---
Others	---	---	---
Posts per day			
	19.86	1.24	3.32

* At the time of analysis 13/11/2015. Source: Authors' own from *Likealyzer*

Finally, the analysis of 'information type' revealed that although acknowledgements, suggestions and comments were made, in all three cases the number of questions asked was very low. This prevents the pages from motivating their fans, fomenting visibility or obtaining key responses that may prove crucial in determining a destination's sales and marketing strategy.

The Interactivity parameter considered the degree of 'loyalty or engagement' (see Table 4), which measures reactions, 'Likes', comments and shares. In order to calculate engagement, *LikeAlyzer* divides the PTAT (*People Talking About This*) by the number of 'Likes'. According to this tool, in order to be successful on Facebook, the result must be higher than 7%.

A comparison of the number of people that react to the daily posts and the degree of engagement generated reveals that a high number of 'Likes', albeit not in all cases, leads to a higher degree of engagement. Therefore, Peru, which has more than 200,000 fans, only manages to generate a reaction of 2.84% (5,676 people) to its mere three posts a day, whilst Colombia, which has far fewer fans (22,406), manages 2.54% with a single post per day. In the case of Ecuador, which has 59,986 fans, the degree of engagement is over 3%, with its almost 60,000 fans reacting to its 19 posts per day.

However, it is true that the ratio is extremely low in relation to the number of posts, leading us to reflect that in addition to the actual number, it is also essential to monitor fans' reaction and their interaction with them.

Table 4. Fans, Post per day, PTAT and Engagement

	ECUADOR	COLOMBIA	PERU
Fans*	59,986	22,406	200,126
Post per day*	19.86	1.24	3.32
PTAT**	1,850	568	676
Engagement	3.08%	2.54%	2.84%

* At the time of analysis 13/11/2015; ** People talking about this of the last month. Source: Authors' own from *Likealyzer*

A further item that allows for the measurement of interactivity is users reactions or responses in relation to the types of posts published. Analysing the post types and comparing them with the reactions they produce provides the 'response rate'.

Figure 1. Page's top posts. Top 5 Posts. From 13/10/2015 to 13/11/2015
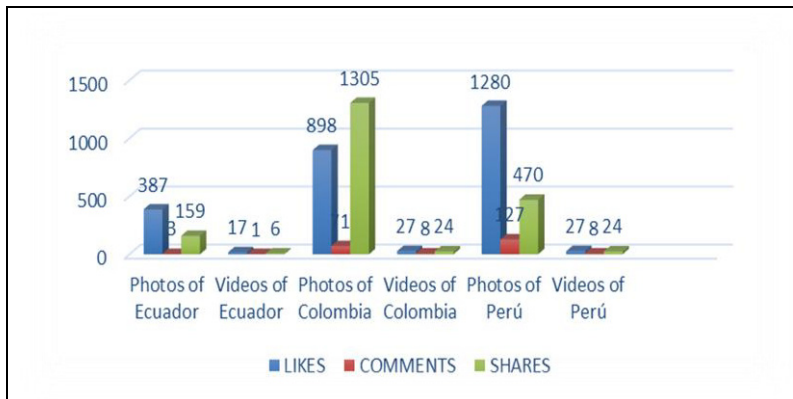
Source: Authors' own from *Likealyzer*

As shown in Figure 1, posts featuring photographs and videos are the most successful, generating the greatest number of responses and therefore interaction, especially 'Likes' followed by shares and lastly comments. There is a sole exception to this trend: four photographs published by Colombia over the last month and that have been shared 1,305 times and received 898 likes. In all cases the best reactions are generated by photographs posted during the following time bands: Ecuador between 3 p.m. and 6 p.m. (GMT); Colombia between 12 midnight and 3 a.m. (GMT); and Peru between 12 noon and 5 p.m. (GMT).

The final parameter analysed are the 'fans' posts on each fanpage' and the responses made by community managers. All destinations should encourage people to interact with them, enabling their fans to upload posts on their pages. However, neither

Colombia or Peru allow access to their profiles, preventing a two-way flow of communication and thereby making interactivity and visibility far more complex and much less effective. The opposite is true in the case of Ecuador, which does allow its fans to post, although surprisingly it fails to respond to their comments. Indeed, the almost 60,000 followers of this fan page that tend to post comments particularly between 12 midnight and 2 a.m. (GMT), and especially on Fridays, never receive an answer. This side of communication is therefore neglected, which may eventually cause users to stop visiting the page.

In the case of Visibility, a series of parameters were analysed to determine the best ways to boost their presence on the Internet. In this sense, the 'number of fans' is the most significant criterion. Table 5 shows that Peru, with 200,126 fans, is the destination that generates the greatest amount of interest, followed, albeit at a considerable distance, by Ecuador with 59,986 and Colombia with 22,406. The results obtained by Peru are significant because the high number of fans indicates that much more could be done to position this country as a successful tourist destination.

The average number of 'Likes' comments or shares each post generates is another indicator that provides useful information in terms of visibility. Although Peru obtains a higher average (218) than the other two countries, particularly with the photographs posted between 12 noon and 3 p.m. (GMT), it could activate an even higher number of followers by launching updates and events of interest. Also worthy of note is the poor result obtained by Ecuador (an average of 33), considering that it has almost 60,000 fans and 20 posts per day. These results indicate that the posts fail to hold any particular appeal and generate practically no visibility.

Other aspects that contribute to measuring visibility are timing, post length, the hashtags used in the posts or the favourite sites for interaction.

Timing refers to the period of the day when the posts are most effective and motivate more followers. In this case, it must be noted that none of the destinations analysed achieve a satisfactory degree of coordination, although Ecuador and Peru come close. The analysis of another item, 'post length', reveals that in the case of all three destinations the number of characters varies between 100 and 500. This is highly valued by the fans, generating more and better quality interaction.   Finally, the results obtained from the analysis of the hashtags and favourite sites indicate that all three destinations make use of the former, as it provides them with greater visibility on other social media such as *Twitter*. As for the latter, and although all three countries interact with more than 10 sites, Ecuador and Peru stand out due to the appropriateness of their choice of sites they regularly relate to, as they are closely linked to the world of travel and leisure, thereby boosting their visibility as destinations.

Table 5. Fans, post per day, likes, comments & Shares per post

	ECUADOR	COLOMBIA	PERU
Fans*	59,986	22,406	200,126
Post per day*	19.86	1.24	3.32
Likes**, Comments &Shares	33	120	218
Timing	Way off	Off	Way off
Length of posts***	Between 100/500	Between 100/500	Between 100/500
Hashtags	Using	Using	Using
Pages liked	Yes >10	Yes >10	Yes >10

* At the time of analysis 13/11/2015; **rate per post; *** characters. Source: Authors' own from *Likealyzer*

6 Conclusions

Early 21st century trends in travel and tourism reveal an increasingly competitive market in which two-way communication, proactive promotion, interaction with customers and enhanced visibility are all capable of generating major competitive advantages. If, in addition to this, we add the development and application of information technologies, we are faced with a situation whereby tourist destinations are required to come up with increasingly aggressive and efficient strategies in order to attract tourism consumers.

In the light of this scenario, social media are playing an increasingly central role in terms of their contribution to the promotion and marketing of tourist destinations by favouring contact with tourists, sharing content and boosting visibility and virality.

In relation to this, the analysis of the fanpages of Ecuador, Colombia and Peru as competing tourist destinations has provided the following results:

In terms of the content the fanpages generate through their post formats, the results indicate that there is considerable room for improvement, as only three formats are used: photography, which generates the highest degree of interaction, videos and links. This points to the need for greater variety and dialogue in order to create more interesting and attractive sites which in turn would boost engagement, loyalty and interactivity.

With regards to interactivity, it must be stated that generating a large number of posts does not always lead to increased engagement, and therefore the destinations would be advised to monitor their posts more closely, thereby boosting interactivity. Indeed, the relevance of the role played by social media in improving customer relations and therefore the degree of engagement has been proved [16]. Consequently, any attempts to increase the number of 'Likes' could include adopting the following strategies: direct conversations with consumers; the organization of events, competitions or promotions; encouraging and rewarding loyalty; or encouraging users to collaborate with the generation of content.

The data obtained from the final item analysed, visibility, should lead destinations to reflect on the fact that although the number of fans is naturally a key factor in

generating this parameter, they should also seek to improve each customer's participation and conversion rates. The analysis showed that the timing of the posts is a crucial element in securing a minimum degree of interaction and scope for the communications posted. In this sense, none of the three destinations achieve a perfect degree of coordination, and their presence can therefore be considered lacking in effectiveness.

In relation to the information obtained and the fanpage data analysed, we can conclude that the concept of the social medium Facebook as a tool for communication and sales does not appear to have been sufficiently thought out. Likewise, it can be seen that although all three destinations occupy a significant position in South America's tourist industry, the strategies applied lack clearly laid-out objectives, leading to a low degree of operational effectiveness and lost opportunities.

The recommendation would be for all three destinations to establish more effective marketing strategies for application on the social media, in which planning must play a vital role, as well as the identification of specific, measurable, feasible and realistic objectives of a fixed duration.

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The Importance of Social Capital in Higher Education. A Study of the Facebook Fan Pages

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Abstract. The objective of this paper is to analyze the importance of social media in improving knowledge exchange, which may be reflected in improving the quality of higher education institutions. For this purpose, we study the relevance of three Spanish universities in Facebook. Although the importance of Facebook has been demonstrated in education, very few researches provide concrete evidence on its use as a mean of communication. Findings reveal that Facebook has an important role in terms of Social Capital by identifying communication strategies in order to achieve a higher efficiency, brand image and reputation.

Keywords: Higher Education, Social Capital, knowledge, network, Facebook.

1 Introduction

The globalization of the world has produced a series of worldwide changes where knowledge becomes a crucial element in the company. These changes are creating a new generation of knowledge enables the development of competences required by companies to survive in a competitive context [1]. In this context, the value of a business is directly related to intangible assets rather than physical assets, such as: company image, customer loyalty, employee satisfaction, innovation, organizational culture, staff with appropriate skills, etc. [2]. All these intangible assets are commonly named Intellectual Capital and has become the most valuable resource for companies to improve their competitive advantage and key determinant in the process of value creation [3].

The origin of Intellectual Capital is placed in the early 90s when a group of firms such as Skandia, Dow Chemicals and Canadian Imperial Bank use this concept to make reference to all intangible assets. These pioneers firms developed their respective Intellectual Capital Models that represented the first assumptions and principles of the Intellectual Capital theory [4]. Since then, many definitions of the Intellectual Capital have proliferated, but all of these have common characteristics: the accumulation of knowledge and the capacity of these intangible assets to generate value for the organization.

In the knowledge-based approach, most papers establish that Intellectual Capital it is integrated by three main components: Human Capital, Structural Capital and Social Capital [5]. Human Capital is defined as the knowledge that each worker possesses, develops and accumulates, it's a knowledge mix that employees have with respect to

their work, skills, leadership skills, capacity to assume risks and give solution to problems [6]. Structural Capital is the institutionalized knowledge and codified experience held and used through databases, patents, manuals, structures, systems and processes and Social Capital is the result of the organization's relationships with its stakeholders, which encourage the exchange of knowledge among different networks [7].

There is increasing consensus among social sciences disciplines about the importance of social capital concept. They suggested that the present and future of business survival lies in networks of relationships among individual and organizations rather than traditional modes of competition [8] [9]. This is particularly important in knowledge-intensive sector such as high technology industries or universities. Research on networks is increasingly focused on understanding how the social context in which firms are embedded influences their behavior in terms of knowledge exchange, as can be seen from the extensive research available [10] [11].Nevertheless, social capital has been explored the least in the Intellectual Capital literature [12], that is why in this paper we look in more detail at the role of social capital in universities and more specifically we adopt a network approach based on the relevance of universities web sites in Facebook, as a form of social status or reputation .

We carry out our empirical study in three universities of Spain. Two of them are considered as the most important Spanish universities in rankings and the third one is the university which we belong to.

The objectives of the study are to:

• Show the web performance of the universities studied and its situation in the Webometric ranking in the following items: presence, impact, openness and excellence.

• Identify web contents of the Facebook pages through post per type, post per day and type of information as photos and videos shared by the institutions analyzed or the number of links they are using.

• Identify the interactivity of the Facebook pages associated with the engagement and the web user response.

• Identify the visibility of the Facebook pages analyzed. For that purpose we considered the number of "likes" and the average of likes, comments and shares values.

2 Theoretical Framework

The most important higher education institutions argue that new relationships are needed in order to achieve the purpose of globalization and improve their internationalization. This new context is having implications for the Higher Education as a whole. The characteristics of social relationships and the networks these result in, can influence the ability of Universities to access, transfer, absorb and apply knowledge [13].

To date research community has established that users of information prefer other colleagues, friends or family members as their preferred source of information [14]. This new form of information has led in the setting up of webs of relationships to access information from one another [15]. These new relationship are called "social media",

that is, forms of electronic communication (as Web sites for social networking) through which users create online communities to share information, ideas.

Researchers have been examining the role that social media plays as an important item of Social capital in university. Some of the studies have highlighted in the University students' use of Social Networking System (SNS), in particular, in learning outcomes of SNS in the higher education classroom [16] [17]. Selwyn argued that exist three interrelated concepts should motivate the use of social media in higher education: the changing nature of the new student (highly connected and creative); the changing relationship that university learner has with transmission of knowledge and the importance of "user driven" education [18] [19].

Another research line about this topic is its use for marketing purposes. Stockey [20], surveyed 30 universities which use Facebook, twitter and Youtube with the objective of study 7 items; engagement, listening, relationships, trust, authenticity, visibility and branding. The conclusions showed that the engagement was lacking despite the high presence of social media in their platforms. Hand (2011) in his research about "Canada: Social Media on Campus and Its Discontents" [21] has found that the use of social media to communicate with students promote transparency. Sturgeon and Walker [22] found that even though the beginning of using Facebook was "to keep an eye" on their children or other family members, the result was that they saw its academic benefits.

Facebook is one of the most frequently visited among social networking sites. It was developed during the 2004 as a Harvard-only social network site, but it has expanded rapidly from its original site to the entire world getting a great numbers of registered users. Although the importance of Facebook has been demonstrated in education [23], it isn't still seen as a professional social network [24]. That is the reason why in this paper we´ll focus in the characteristics of Facebook pages in three universities of Spain.

One of these is the highest-ranked Spanish university "University of Barcelona". This University was established in 1450, which makes it one of the oldest higher education institutions in the world. The University of Barcelona is placed at 166th in the 2015/16 QS World University Rankings.

The second of these is a much younger institution "Universidad Autónoma de Madrid". It was established in 1968, and it's currently ranked at 186th place in the QS World University Rankings and 9th in the QS Top 50 under 50 de 2015.

The last one is the university we belong to "University of A Coruña". In the 2015 edition the University of A Coruña occupies the position number 999 in the Center for World University Rankings (CWUR) and the 40th for the 71 Spanish universities analyzed (public and private).

3 Methodology

Before showing the results of our Fanpage analysis, it may be useful to review the results of these three university in the Webometrics Ranking. This ranking is designed in such a way as provide a good indicator of social universities capital. In this ranking it is considered both official publications and informal internal communication, which can be relieved by the intensity and type of activity of the university on the web.

The Webometrics ranking is built as follows:

Activity (50%) and it´s composed of three items:

Presence (1/3). The global volume of contents published on the university web domains as indexed by Google.

Openness (1/3). It takes into account the number of files published in dedicated websites according to the academic search engine Google Scholar.

Excellence (1/3). It takes into account the academic papers published in high impact international journals.

Visibility (50%). The quality of the contents is evaluated through the "impact", counting all the external inlinks that the University webdomain receives from third parties. The link visibility data is collected from the two most important providers of this information: Majestic SEO and ahrefs.

Table 1. Ranking web of universities studied

University	World Rank	Spanish Rank	Presence Rank	Impact Rank	Openness Rank	Excellence Rank
U. of Barcelona	145	3	264	342	125	102
U. Autónoma de Madrid	256	10	486	483	338	218
U. of A Coruña	713	34	847	1055	509	975

Source: Author's own from Webometrics, 2015

For the purpose of our study we used the online LikeAlyzer (http://www.likealyzer.com/). This interface allows us to know aspects related with the effectiveness of a Fanpage and helps to identify problems. In accordance with the research conducted by Huertas, et al. [24], the items analyzed were web contents, level of interactivity and visibility.

4 Findings

The research was carried out between 20 October and 20 November 2015. The aspects relating to each item were:

Web contents: Post per type, post per day and type of information.

Interactivity: Engagement and web user response.

Visibility: Number of "fans", likes and shares (average).

Table 2. Domain registration and Fanpage of universities analyzed

University	url	Fanpage
U. of Barcelona (UB)	http://www.ub.edu	https://www.facebook.com/UniversitatdeBarcelona
U. Autónoma of Madrid (UAM)	http://www.uam.es/	https://www.facebook.com/universidadautonomademadrid
U. of A Coruña (UDC)	http://www.udc.es	https://www.facebook.com/udc.gal

Source: Author's own

4.1 Facebook Contents

Post per type and its influence. The most commonly tops used to encourage the visibility of their contents have been: photos in the case of Barcelona and Madrid and status in Coruña. As the table 3 shows, the most information of Universiy Autónoma of Madrid is provided through images (79.2%), although it's also used the video (16.7%) and links (4.2%). In the case of Unversity of Barcelona, emphasis is placed in photos too (62.5%), but also it was decided to use in a very high percentage links (33.3%). Unlike this trend, the University of A Coruña publish more than half of its posts through "status" (58.3%) what gives it a differentiating factor.

As can be appreciated on Table 3, the wide range of publications is important, this fact provides a greater visibility and keeps their users connected and entertained, which promotes interaction.

Table 3. Posts per type, per day and rate

	BARCELONA	MADRID	CORUÑA
	Posts	**per type**	**rate***
Photos	62.5%	79.2%	29.2%
Video	4.2%	16.7%	---
Link	33.3%	4.2%	12.,5%
Status	---	---	58.3%
Others	---	---	---
Posts per day			
	1.07	2.52	4.02

* At the time of analysis 20/11/2015.
Source: Author's own from LikeAlyzer

Post per day. University of A Coruña with 4.02 post per day overtakes the other two, which enables to interact more effectively with its fans, generate more interest and, therefore, to increase the chances of feedback.

Type of information. Although comments, acknowledgements and indications, have been made, they were very few questions in all cases. It´s important the three universities increase the number of questions in order to activate the web user response leading to greater visibility for their web page and to provide them with answers that may be important on student's perception of their University.

4.2 Facebook Interactivity

Engagement. The Engagement Rate is calculated by taking the total PTAT (people talking about this: likes, comments and shares) and divide by the total number of fans. The result of this rate should be over 7% to succeed in Facebook, from the LikeAlyzer view (Table 4).

Table 4. Fans, Post per day, PTAT and Engagement
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	BARCELONA	MADRID	CORUÑA
Fans*	76,296	55,873	14,636
Post per day*	1.07	2.52	4.02
PTAT**	4,803	1,072	1,165
Engagement	6.3%	1.92%	7.96%

* At the time of analysis 20/11/2015; ** People talking about this of the last month.
Source: Author's own from LikeAlyzer

When comparing the number of people who respond to daily posts with engagement rate we can detect differences between universities. In the case of Barcelona with over 76,000 fans, only get a engagement of 6.3%, while for Coruña with a significantly lower number of fans achieve a rate close 8%. Madrid doesn´t get even a rate engagement of 2% because their nearly 56,000 fans are not responding to post per day. These results lead us to conclude that the number of post per day is not just important, but also to increase the following of those posts and the fans interactivity.

Web user response: when we compare the engagement with the type of post (figure 1), we note than Barcelona and Madrid´s fans seems to responding best to photos, in the case of Coruña photos and links gave the most successful. The best results when your followers seem to be most active are: in Barcelona between 15h – 18h, Madrid between 12h-15h and Coruña between 21h and 24h (GMT in all cases).

Figure 1. Page's top posts. Top 5 Posts. From 20/10/2015 to 20/11/2015

	Photos of Uni. Barcelona	Photos of Uni. Aut. Madrid	Photos of Uni. Coruña	Links of Uni. Coruña
LIKES	3752	452	66	60
COMMENTS	68	11	1	0
SHARES	421	44	200	19
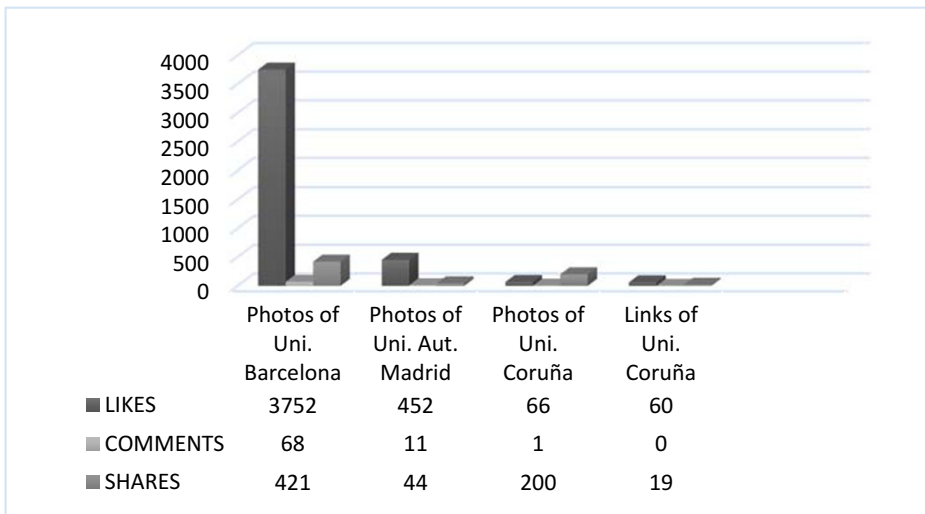
Source: Author's own from LikeAlyzer

4.3 Visibility

This item focuses on those aspects to help improve their presence of Facebook.

Number of fans. It´s the most important aspect of visibility (table 5). Barcelona with 76,296 fans is the most visited page, followed by Madrid with 55,873 fans and Coruña with just 14,636. Special attention should be given to Barcelona with only a post per day has the largest number of fans. If this university rises the number of post per day it´s probably that increase its visibility considerably.

Table 5. Fans, post per day, likes, comments & Shares per post

	BARCELONA	MADRID	CORUÑA
Fans*	76,296	55,873	14,636
Post per day*	1.07	2.52	4.02
Likes**, Comments &Shares	378	39	46

  * At the time of analysis 20/11/2015; **rate per post
Source: Author's own from LikeAlyzer

Likes, comments and shares. The average values of likes, comments and shares by post are other aspects which provide useful information about visibility. In this regard, while Barcelona has achieved better results than the other institutions, it could increase its engaged follower promoting events or initiatives more interesting. It´s striking that Madrid possesses the lowest results in relation to great number of fans and its almost 3 post per day, what it means that its post are very little attractive and consequently its visibility is non-significant.

5 Conclusions

The objective of this paper has been to analyze the importance of social media in three Spanish universities and more specifically the relevance of universities web sites in Facebook, as a form of social capital.
    Previous research has already showed the importance of web universities sites for social networking in order to access and transfer knowledge and to improve their internationalization.
    The results about the Fan pages in the universities studied, confirm that they have a correct variety in their posts, specially photos, videos and links and in the case of University of A Coruña the status is important too. Results also show that fans seems to responding best to photos. As a consequence of these our first recommendation is to increase their use. This is particularly important in the case of University Autónoma of Madrid, as a tool that could generate a greater interaction and visibility.
    On the other hand, it is important to point out that these institutions have focused, almost exclusively, in spreading information rather than receiving information. Our second recommendation is that questions and comments should be asked to fans and

they should be responded more quickly. This is an effective way of achieving a correct engagement rate because fans will appreciate if they can feel part of higher education community

Finally, it is recommended that these universities analyze the profile of their fans, which are their interests-based social media and in particular Facebook, with the intention of increasing their engagement.

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Management of social networks of the audiovisual project "EnchufeTV"

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Abstract. In this research work, the management of the social networks of the transmedia project "EnchufeTV" is analyzed. The methodology is quantitative and qualitative, four monitoring tools of social media ware applied to gather information and collect statistical data between June and July 2015. The research was complemented by interviews to experts in the subject. It can be seen that social media is the ideal platform for new content, viralization and wider dissemination and expansion of the content, although EnchufeTV does not fully exploits the advantages of social media and it does not post in large-scale. It is ratified that projects such as "EnchufeTV" mean a breakthrough in terms of audiovisual content on the Web in Ecuador.

Keywords: Audiovisual embodiment; Social media; Humor; digital TV

1   Introduction

Advances in the Web 2.0 have boosted social networking. From personal communications to virtual communications. Each platform is a set of broad media services and relationships, because these platforms have become multimedia communication processes in a broad sense [1].

Relationships and interactivity generated by social networks have become the object of many organizations that have seen in them a platform to expand and promote their product. Castells [2] defined as a network society a social structure that is composed of activated networks by digital communication technologies and information based on microelectronics. The growth of users in the network could be explained by globalization, but also by the rising of the middle class in Ecuador between 2003 and 2012 which grew a 35% [3].

To Mendieta [4], with social networking audience it does not reduced but it improves the tracking them. In addition, conversations in social networks increase the consumption of live TV, so they are considered as a trading partner. Social networking has changed the consumption of audiovisual material, constituting what is called Social TV, based on communicative interaction, boosting the expectations of the audience and keeping the interest before, during and after the broadcast [5].

The possibilities for interaction and participation in Web 2.0 propose new forms of relationship between media companies and the society, as well as the media presence in social networks to promote their contents. Also, current technology allows to measure and to meet the media audiences' increasingly accurate and complete, thus facilitating the advent of the ideal of the personalized content and the advertising one to one [6].

The media requires new ways of displaying information, that are attractive, useful and personalized. The creation of a new language is not an option but an obligation for sheer survival and competitiveness. Reinvent every day strategic vision and qualified personnel not yet abundant [7]. In this context, the popularity of social networks among the current society makes a clear need to thrive in use and activity [8].

The media is interested in creating their own social network to catch and target population groups that may be of commercial interest. Although they are not considered themselves as a business and seem to suffer from some speculative bubble, what is clear, is that immersion of users in these networks and the time spent in them continue growing [9].

Overcrowding, immediacy and responsiveness have made brands to think that the Internet is a more participatory and proactive context. "It's the Web 2.0 philosophy converted into social space for communication between different users and participants who take advantage of the tools of production and content management to interact and exchange material [10].

In Ecuador, Internet usage grew rapidly in recent years. According to the Ministry of Telecommunications and Information Society, in 2013, 66 of every 100 people used the Internet. These numbers are 11 times higher than in 2006, where they were only 6 out of every 100 users. The number of Facebook users reached 7 million in 2015, of the 2.8 million registered users in 2011. Until December 2014, Internet users in the country reached 13,231,169 [11].

With this background information, it is important to know which image is projected on social networks. "When we monitor them, we refer specifically to know the particulars, views, interactions, scope or impact of a brand, product, service or program" [12].

This research work aims to analyze the management and handling of social networks of the EnchufeTV program, the questions to be asked are: Managing social networking of the EnchufeTV program will benefit its channel? Is there feedback from the Web series in each of its social networks? The research hypotheses are: 1) EnchufeTV does not make proper use and exploitation of social networks; 2) EnchufeTV posts content periodically.

2   Methodology

The methodology is quantitative and qualitative. With Google Trends and SocialMention it is evaluated the positioning in social networks of the EnchufeTV project, date of analysis July 27, 2015. The tool, Follow the hashtag allowed to yield figures around conversations of EnchufeTV in Twitter during the week from the18th to 28th of July, 2015. Finally, with the Fanpage Karma on Facebook the statistics from 21st to 28th of June 2015 were analyzed.

To strengthen the quantitative information, there were made interviews with experts in the   matter: Francisco Campos Freire, professor of the Department of Communication Sciences of the University of Santiago de Compostela; Direito Sabela, a member of the research group Novos Media Santiago de Compostela and Carlos Correa, head of Networking and Planning at the Center for Entrepreneurship Prendho.

3   Results

On July 27, 2015 the positioning in the network of the word EnchufeTV is tabulated. In addition to quantifying the number of entries and access to the comments, a semantic analysis of content was made for a more descriptive assessment of the contents, highlighting the following parameters: 50% strength; sentiment 1:3, 7% passion and 47% reach. The amount of feedback was also obtained during the research in real time that were 2 positive, 5 negative and 99 neutral. In the top words, it can be seen that the 3 greatest impact are related to the EnchufeTV project and its members.

Figure 1. Searches the term EnchufeTV
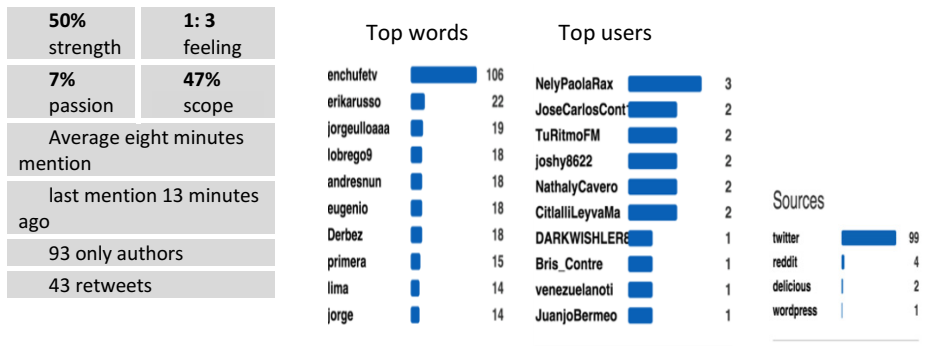
Source: Solialmention

Figure 2 search variables appear over time on EnchufeTV (abscissa axis). The vertical axis represents the frequency with which they have searched globally, with its peak in July 2015, in which EnchufeTV got into a controversial case on its scketch "Trailer del Chavo (La Película)", launched on July 6, 2015. Public opinion and the media echoed the video, generating thousands of positive and negative comments of the audiovisual web project.

Figure 2. Evolution searches for the term EnchufeTV
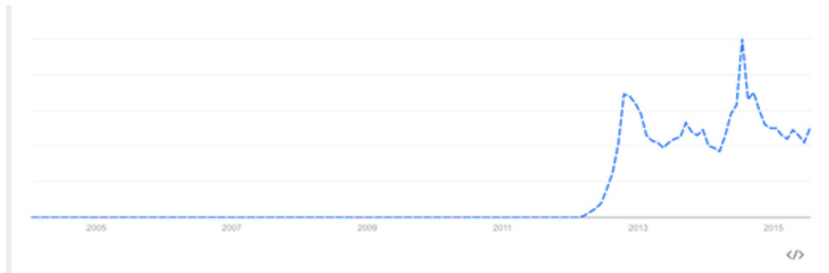
Source: Google Trends

Hashtags make it easier for people to find and follow discussions on trademarks, events and promotions. The tool Follow the Hashtag was chosen for the analysis, useful for understanding conversations in Twitter through useful and coherent graphics through the hashtag EnchufeTV. Figure 3 shows that the day where the hashtag EnchufeTV got a greater scope and impact was the July 24, 2015 at 19:00, reaching the highest point within the research time.

Figure 3. Day of greater scope and impact of the hashtag #EnchufeTV
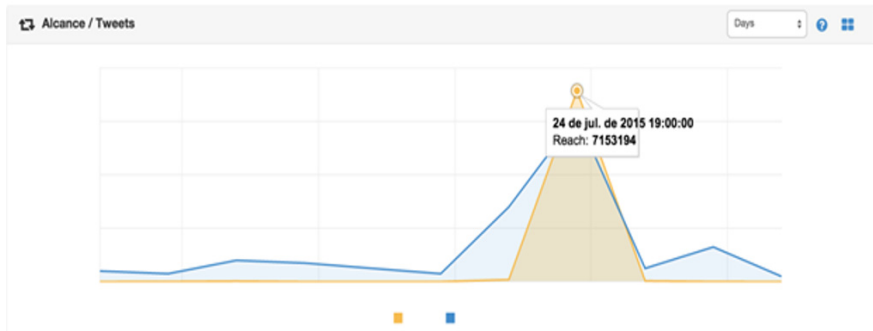
Source: Follow the hashtag

In Figure 4, the daily publications that EnchufeTV made during the investigation period are shown. It is obtained as a result that Friday was the day where most publications were made, with a total of 5. Although the application Fanpage Karma indicates that best results were obtained at other times, on Mondays, Tuesdays and Wednesdays, indicating 3 posts each day. Sunday is the day where fewer publications are made.

Figure 4. Number of daily publications of EnchufeTv in the social network Facebook
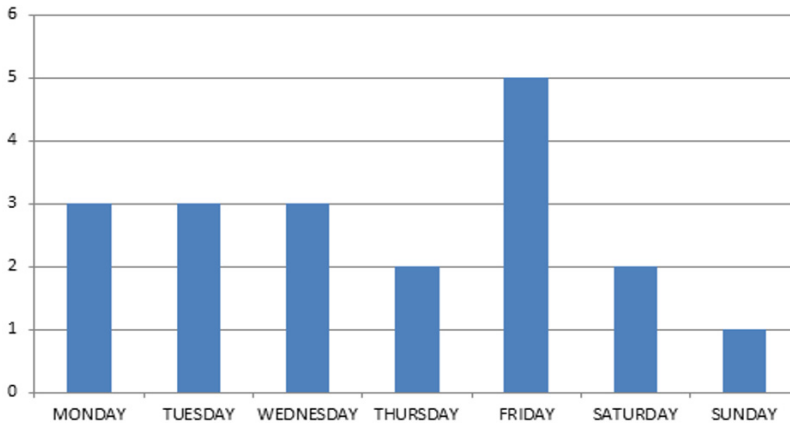
Source: Fanpage Karma

Francisco Camps stressed that the main advantages that provide social networking and digital media are accessibility, the ability to freely reach a lot of people and that basically there is no need for a fee to access to them. "With new technologies networks have expanded their extension, their relationships, and they have formed multiple nodes that are establishing different connections and constitute the most important relationship of technology with social networks".

He says that a great number of audiovisual productions designed exclusively for the Web are starting to be seen, and large productions like Netflix or Amazon are providing such productions. "Distributors content, which originally came from traditional media, are beginning to be digital native producers and it's something that is being imposed".

Sabela Direito said that although social networks were born as a system of exchange of messages between friends and family, they currently have a position that has been growing over time. "Basically, all companies, communication channels and television, social networks are present in the different programs that are broadcasted mainly on Facebook or Twitter, but they are starting to bet for networks that are timidly developing like Instagram or Google+".

Sabela says that in recent years the user has had an evolution to be more active, not as an individual posting things, but as a person who follows the accounts, the content that others post. "People are more active but also more participatory because there is certain feedback established with other users".

Carlos Correa says that some years ago the communication was unidirectional, the media conveyed a message, they also had the power whether to pass or not those issues that were of interest. The company only consumed these contents and did not give them feedback. "With internet we are all potentially content creators, then, we are not just hungry for information, but rather eager for conversation".

He notes that "A cold news, it is not only of interest, but it is now possible to qualify with views, opinions or viewpoints. Thus, the Internet has provided us with a set of tools to generate conversation and broadcast content through audio, video, text or a mixture of all of them".

4   Discussion and conclusions

Social networks provide notable advantages to transmedia projects as EnchufeTV, the immediacy and speed of dissemination of content, exchange of views with those who receive the content, gratuity use and achieve a digital identity on the Web through the audiovisual material produced stand out.

Despite the benefits, according to data obtained through research, EnchufeTV only emphasizes social networks when launching a new production, at which more movement is denoted in the social networking profiles. The rest of the week a low activity regarding to publications and new content is evidenced.

Profiles with decreased activity has not meant an obstacle when attract followers. The different accounts in social networks of EnchufeTV show an increasing trend in the number of followers, denoting that the material published by the Web series is of public interest and captures their attention.

Among social networks, Twitter is perhaps the most dynamic. Search through a hashtag is best reflected an interest or preference. With EnchufeTV, it's observed that the name of the project and its members a representative number of mentions were made through hashtags.

The interaction in social networks between transmedia series and the audience is practically null, it is not even evidenced when promoting a new production. While a new video generates activity by fans through comments, EnchufeTV response to criticism or value judgments, both positive and negative is not shown.

5   Hyphotesis testing

  1)   EnchufeTV does not make proper use and exploitation of social networks.

According to research, this hypothesis is tested. Although EnchufeTV maintains profiles on social media, these are used when a new sketch is issued or a controversial video emerges. There is no interaction with the audience.

  2)   EnchufeTV posts content in large-scale.

This hypothesis is rejected. The transmedia series broadcast content but at very low levels. As it is demonstrated in the analysis of weekly publications of EnchufeTV, the day with the highest number of updates reached a five, a low number for an audiovisual project of this magnitude.

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Leading Ecuadorian Companies in the Wine Tourism Sector and their Positioning on the Social Medium *Facebook*

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Abstract. In recent years wine tourism has contributed to the positive evolution of tourist destinations, providing opportunities for development for local economies through the generation of employment and its multiplying effects on other transversal sectors. Oenology gives tourists the chance to discover more about local culture and enjoy sensorial experiences and sensations whilst indulging in the pleasure of tasting a region's traditional wines. In this sense, and in the specific case of Ecuador, the presence of prestigious wine-making companies with an excellent national and international reputation contribute to boosting wine tourism. Mention must be made of two of the country's leading wine producers: 'Dos Hemisferios', situated in the province of Guayas, in the region of Playas, and the 'Chaupi Estancia Winery', in the province of Pichincha, in Yaruquí. This study aims to identify the positioning of these companies, as representatives of Ecuador's wine industry, on the social medium *Facebook*. The conclusions point to the need to take advantage of the opportunities social media offer today as a communication channel, in order to improve the position of wine tourism in Ecuador.

Key words: Wine Tourism, Social Media, *Facebook*, Positioning, Ecuador

1 Introduction

Although the motivations that drive modern day tourists have changed, and are becoming increasingly diverse and plural, they all share a common need, that of

"living unique experiences". Experiencing sensations, emotions or reliving pleasurable moments are key factors in generating the desire to visit a destination.

Wine tourism is seen as a means of satisfying some of these wishes.

Wine, a natural beverage obtained from the fermentation of grapes, is one of the principal products of gastronomy: not only is it considered a drink of prestige, but it is also widely used in food preparation. The popularity of this resource has led to a growing interest in gastronomy and wine tourism, attributable to a large degree to the promotion campaigns targeting destinations associated with oenology.

With regards to tourist communication, it is important to stress that changes in our environment stemming from the arrival of information and communication technologies (ICTs), in which social media play a crucial role, have led to the inclusion of new promotion strategies in order to reach customers effectively.

In the light of this context, this study aims to analyze the positioning on Facebook of two of Ecuador's leading wineries: 'Dos Hemisferios' and 'Chaupi Estancia Winery'. The choice of these companies as the scope of our study is due to the fact that they are at the forefront of oenology in Ecuador: their wines and brands enjoy an excellent national and international reputation, as proved by the numerous prizes and awards received over the years. Furthermore, both companies offer visitors the chance to tour their vineyards and wineries and taste their wines.

2   Wine Tourism

Wine, like gastronomy, forms an essential part of the culture and history of any region, reflecting its identity and forming an essential part of its heritage [1].

Oenotourism, wine tourism or even vinitourism refers to "consumer behaviour, a strategy for the development of the geographical area and the wine market of that area, and also an opportunity for wineries to promote and sell their products directly to consumers" [2].

As stated by Millán and Dancausa [3] and Molina, Gómez and Estéban [4] in recent years this type of tourism has been the subject of a considerable amount of scientific literature in different countries. This vast amount of literature indicates the tremendous interest generated by this type of tourism. One of the contributing factors is its capacity to revitalize a destination by involving all three sectors of the economy: the primary sector, through vine growing; the secondary sector, through the wine making process; and the tertiary sector, due to the variety of services involved (tourism, gastronomy, the retail trade, etc.).

According to Mowforth [5], if alternative tourism represents all those trips made in order to carry out recreational activities in direct contact with nature, and forms of cultural expression that motivate visitors to discover, enjoy and take part in their conservation, then wine tourism can be included in this classification.

In their study of the motivations and experiences that drive the wine tourist to visit and enjoy a destination, Hall and Sharples [6] consider wine tourism to be "visitation to vineyards, wineries, wine festivals and wine shows for which grape wine regions are the main motivating factor for visitors".

In short, wine tourism attempts to promote the winemaking resources of a specific region through a wide range of wine-based cultural elements, in order to boost the social and economic development of the territory. In this sense, 'Dos Hemisferios' and 'Chaupi Estancia Winery' boast more than sufficient resources in order to contribute to this development.

3 'Dos Hemisferios' and 'Chaupi Estancia Winery': at the forefront of Ecuador's Winemaking Sector

Ecuador is home to a number of leading companies dedicated to the production and sale of wine. The most important of these include 'Dos Hemisferios', 'Chaupi Estancia Winery', 'La Toscana' and 'Vinos Don César' [7].

In the alcoholic beverages market, wine is the third most popular drink amongst middle class Ecuadorians, after beer and whisky[1].

The most popular varieties consumed in the country include Cabernet Sauvignon, Malbec, Syrah, Merlot Tempranillo and Pinot Noir.

For the purpose of this study we have selected just two of the four companies mentioned, due to the reasons described above. Characteristics such as their location, details of their production and sales or the prizes and awards received are given in Table 1.

Table 1. "Dos Hemisferios" and Chaupi Estancia Winery"

	DOS HEMISFERIOS	CHAUPI ESTANCIA WINERY
Location	Guayas (in San Miguel del Morro de Cantón Playas)	Yaruquí (parish in the metropolitan district of Quito)
Production and Sales	National and International	National and International
Types of Wines	White and Red	White and Red
Variety	Caberbet Sauvignon, Malbec, Merlot, Pinot Noir, Shiraz and Chardonnay.	The first was Palomino, originally from Jerez, Spain. Today it has 32.

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[1]http://www.hoy.com.ec/noticias-ecuador/la-importacion-y-el-consumo-de-vino-en-el-ecuador-aumento-496366.html

Brands	Bruma, Del Morro, Enigma, Paradoja and Travesía.	Palomino Fino, Pinot Noir, Meritage "Alyce", "Alyce" Gran Reserva, Chardonnay-Viognie.
Prizes and Awards	Two mentions in 2009 for the best white wine "Enigma 2008" and best red wine "Paradoja 2007". Three silver medals "Enigma 2008", "Bruma Reserva Red 2007" and "Paradoja 2008", in 2009, 2010 and 2011, respectively. Three gold medals "Enigma 2008", in 2009, "Enigma Chardonnay 2008", in 2010 and "Paradoja 2007", in 2010. Grand Gold Medal awarded to "Travesía 2009", in 2011.	Two special mentions at the Decanter World Wine Awards in London.
Wine Tourism	Tours of the vineyards and wine-tasting sessions.	Guided tours of the vineyards, wine-tasting sessions and the possibility of attending cocktail receptions and picnics.

Source: Author's own from Acosta and Monge [7].

4 Online Communication via Social Media in Tourism

Within the field of information and communication technologies (ICTs), the social media have emerged as a new format for the dissemination of tourism companies. Recent studies have pointed to a growing number of tourists that generate content on 2.0 platforms and use the information available on social media when planning their trips.

Among these social media, *Facebook* occupies a dominant position. The most popular social medium of all time, it is positioned at the forefront of the online tourism industry and is used by tourists at all stages of the travel experience [8].

In recent years, advertising investment in these interactive media has increased dramatically, attributable to the rise in the Internet penetration rate among the world's population. In the light of this, Buhalis [9] stressed the need to adapt to these technologies. In the late 90s, he claimed that those companies that failed to establish a presence in the electronic marketplace would face serious short-term disadvantages, characterised by a sharp drop in their market share. Likewise, Álvarez, Benamou,

Fernández and Solé [10]; Heerschap, Ortega, Priem and Offermans, [11]; Theodosiou and Katsikea [12] and Hudson and Thal [13], defend the idea of a clear transformation among sectors due to the Internet and its ongoing evolution, which naturally includes the tourist industry.

From the traveller's perspective, Wichels [14], Lange and Elliot [15] and Llodrá [16], posit that the social media influence tourists' decisions. Wichels [14] draws attention to the fact that the modern day tourist has access to multiple information sources and channels.

In the light of this new scenario, and with regards to tourist promotion, it is essential for companies to adapt their strategies to the new forms of online communication, which pose a series of challenges. At all events, their presence on the social media is crucial.

According to Rodríguez and Sánchez [17], having a *Facebook* profile impacts positively on the positioning of tourist companies, and therefore optimizing their presence on the social media is essential. However, their mere presence is insufficient: what is required is the correct use of these media in order to achieve the desired results. These aspects have proved decisive in our approach to this study.

5 Methodology

The aim of this study is to analyze the Facebook positioning of two winemaking companies: 'Dos Hemisferios' and 'Chaupi Estancia Winery' in order to detect positive and negative aspects of the promotion strategies implemented through this channel and to provide, where appropriate, a series of recommendations that would enable the companies to optimize their presence in online media in order to improve their positioning in the future.

According to Babbie [18], those cases in which the problem is in its preliminary phases, the issue is new and data difficult to obtain are related to research of an exploratory nature. At the same time, we are dealing with two case studies, defined by Serrano [19], situations that aim to acquire knowledge based on individual circumstances. This study is in line with this methodology.

However, this study is also of a qualitative nature as the research tools employed include documentary analysis through the observation of the fanpages at www.facebook.com/vinosdoshemisferios/ and www.facebook.com/ChaupiEstancia.

Fanpage Karma, http://www.fanpagekarma.com/, was used to analyze these fanpages. This is an online tool used for the analysis of social media and the monitoring of networks such as Facebook, Twitter, YouTube, Google+ and Instagram. The study was carried out over a year, from 1/11/2014 to 1/11/2015. The items used in for the fanpage analysis were Visibility and Interactivity.

In terms of *Visibility*, the study was addressed from three perspectives: on the one hand, that defined by Cavalganti and Sobejano [20] as "influence"; namely the number of followers a brand has on the various social media. This is considered to be the most important variable, and is often the only one taken into consideration. This may be a mistake, as the group of fans alone does not mean that the strategy or objectives of a certain fanpage have been met.

In addition to the recognition conferred on the number of fans, Huertas, Setó and Míguez [21] posit that visibility can also be measured in each post, taking into consideration the number of 'Likes', comments and shares.

Finally, another point for consideration is that the number of posts also impacts on the visibility of a page: the higher the number of posts published, the greater the chances of the information reaching more people. According to Internet República [22], the average number of channel updates on Facebook should be between 3 and 5 posts a week, an aspect that has been taken into consideration in our analysis.

As for *Interactivity*, Brodie, Ilic, Juric and Hollebeek [23] see *engagement* as the interaction of experiences between consumers, the brand and other community members. In order to calculate this, Cvijikj and Michahelles [24], Huertas, Setó and Míguez [21], Valerio, Herrera, Herrera and Rodríguez [25] use the following formula:

Engagement = [likes+comments+shared posts/No. fans] x 100.

This parameter provides an insight into the company's communication and interactivity with the users of its virtual community. A high engagement rate indicates that a brand has managed to connect with its Facebook fans. In some cases, it is claimed that the engagement rate should be higher than 7%, as stipulated by the online tool *LikeAlyzer²*; however, other authors and tools such as *Fanpage Karma*, do not establish any minimum score in this respect.

Leung and Bai [26] claim that securing fans' participation in a Facebook page ensures that they are more likely to return to the page in question. In other words, a high engagement rate indicates that the social media activity is being carried out correctly, managing to involve the community members. This item therefore sheds light on the interaction between a page and its fans; in other words, it provides information regarding the number of people that comment on, share or like one of the posts.

6 Results of the Facebook Positioning of 'Dos Hemisferios' and 'Chaupi Estancia Winery'

This section contains the discussion of the results for the analysis of the Visibility and Interactivity items for each of the companies. The *Fanpage Karma* tool was used and the objective was to analyze the companies' position on this social medium.

As the following table shows, there are significant differences between 'Dos Hemisferios' and 'Chaupi Estancia' in terms of *Visibility*, with the former obtaining far higher results than the latter in all cases.

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² http://likealyzer.com/es

Table 2: *Fanpage* feasibility analysis

	Fans	Post	Likes	Comments	Shares
Dos Hemisferios	22,589	462	16,292	732	5,482
Chaupi Estancia	1,679	6	8	0	0

Source: Author's own from *Fanpage Karma*

The number of fans and posts, together with the likes, comments and shares for each post, indicate that 'Dos Hemisferios' is far better positioned on the social medium than 'Chaupi Estancia'.

An analysis of the number of posts reveals that 'Dos Hemisferios' exceeds the minimum number recommended by Internet República [22] of between 3 and 5 posts a week. Indeed, it publishes an average of 9 posts per week, a figure that is higher than the total number of posts published by 'Chaupi Estancia' over the entire year.

In the case of 'Dos Hemisferios', the contents of the posts that generate the greatest visibility are centred on information about the company and the wine products, prize draws, health and wine, the awards received by the brand and the history of wine in Ecuador.

A further aspect worthy of comment is that practically all the posts feature photographs, and the writing style is direct and commercial in tone, employing recurring copy such as "Could we ask for anything more?" in reference to one of its products. As for the times selected for uploading comment, these vary from day to day and do not follow a pre-established pattern.

In the case of 'Chaupi Estancia', the number of posts is extremely low, just six. The analysis of the number of 'Likes', comments and shares shows that the posts fail to generate any reaction from fans. In the light of this, the company would be well-advised to reconsider its strategy. The *Interactivity* analysis provided the following results:

Table 3: Fanpage interactivity analysis

	Engagement
Dos Hemisferios	99%
Chaupi Estancia	0.47%

Source: Author's own from *Fanpage Karma*

The information obtained regarding visibility provided a brief insight into the degree of engagement, and the analysis of the above table confirms the considerable differences that exist between the online promotion of 'Dos Hemisferios' and 'Chaupi Estancia'. The extremely low rate obtained by 'Chaupi Estancia' is attributable to the small number of posts and the low participation rate of its online community, resulting in only a negligible degree of interactivity. Considering the data provided by this parameter, it is clear that 'Dos Hemisferios' does know how to interact with its fans, achieving an engagement rate of almost 100%.

7 Conclusions

Today, consumers lie at the centre of any business, and it is therefore essential to be able to connect with them and build up long-term relationships. For this reason, tourist companies and organizations should make use of those platforms that enable them to contact their clients, realizing that they are seeking interactions and relationships that provide added value. The social media are positioned as the perfect platforms from which to connect with users in a direct and personalised way.

In the light of this situation, the companies analyzed here, both situated at the forefront of the wine tourism sector in Ecuador, must be fully aware of the crucial role social media play as a communication and advertising tool.

The results of this study into the Facebook positioning of 'Dos Hemisferios' and 'Chaupi Estancia Winery' reveal a clear difference between the two companies.

Both reflect the different types of companies we can encounter on the social media. 'Dos Hemisferios' is in line with those companies that choose to adapt to the new communication channels, incorporating them into their everyday business activity, whilst 'Chaupi Estancia', for reasons that are unknown to us, falls into the category of those companies that have to date failed to adapt and take advantage of the opportunities offered by the social media.

In short, in our analysis, 'Dos Hemisferios' obtained good results in terms of its Visibility and Interactivity in the online channel, benefiting from a strong position on Facebook. In contrast, 'Chaupi Estancia' failed to reach anywhere near the same level. The recommendation is therefore for this company to carry out a series of benchmarking studies in order to improve its Visibility and Interactivity and, by extension, its future position on Facebook.

Recommendations to companies wishing to obtain a good online reputation include the following: listening actively to customers, making comments, being accessible by creating communication channels from which to interact with customers, showing empathy and the capacity to listen to and respect consumers' opinions, talking to customers, answering their queries and responding to their opinions, offering an experience that adapts to the brand's objectives, adopting a constructive attitude and analyzing any criticisms in order to learn and grow from them [27]. Apart from these recommendations, we could also add the need to regularly update the online channel, and include visual elements such as photographs and videos offering contents that are both appealing and interesting to users.

In the case of the companies analyzed, awareness of the degree of efficiency of their fanpages is essential, as it will enable them to detect any weaknesses, adopt the necessary measures and thereby contribute to improving their position in the wine tourism sector.

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Innovation as the Key for the Future of Public Service Media

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Abstract. Digitisation has modified the way we use the media and the needs of society, which has led public media to expand the development of their mission with new and improved services. The EU28 State public media are devoting part of their efforts –particularly regarding to the economic part- to innovation and development actions in order to reinforce their position in an increasingly competitive market. This research presents an assessment of the progress in innovation of these corporations until mid-2015, giving particular emphasis to web platforms, apps, smart TV and laboratory of ideas. The methodology to undertake such study is based on the analysis of the departments and reports on innovation and development of every European state public media.

Keywords: Public Service Media, Innovation, Public Service, Digitization, apps, smart TV, web platform, Media Labs.

1 Introduction

As a result of the innovation process in the media scene, the role of public service media (PSM) is being challenged, notably in relation to their scope for action in a new scenario marked by new distribution platforms such as the Internet and mobile platforms.

New services are seen as the natural development of their content offer and, consequently, as the essential funding sources, those that allow them to guarantee their business viability within an increasingly fragmented and competitive space. Once again, commercial companies do not want to compete with public service media since both of them fight for their audiences.

PSM argue that the values and objectives linked to their services have acquired a more relevant dimension in the digital scenario, with the objectives of ensuring the editorial independence against economic and industrial concentration and giving the public a diversified offer as an alternative to the homogenization of programming schedules. Likewise, public service media may also take advantage of the new framework to set high quality standards for the production of content, to defend the status quo of journalism rules, and to ensure the maintenance of pluralism and social representativeness, which are not automatically achieved only by making an abundant

supply. In fact, the new possibilities offered by digital technologies involve, together with the synergies generated by a distribution platform, are seen as an opportunity to establish a better public service and to better carry out their duties [1].

Against this background, and having the intention to justify the way in which a specific offer content or service meets the goals included in the definition of public service media, it came on the scene the public value assessment of content supply, in order to analyse whether or not it should be included. Also, evaluation of concepts such as proportionality, funding and impact on the market are also becoming important. These keys helped to start processes of redefining public service media in Europe and implementing public value tests.

In addition to redefining their commitments, the emergence of a cross-platform media environment, together with the extension of their activities, forced public operators to adapt their internal structure and operational logics. With regard to the organization, the great challenge is to evolve from a production´s vertical structure towards a space in which content and services must be delivered in a wide range of media and platforms [2].

As a result, content and services should be designed and produced considering the potential of cross-media strategies and cross-platform synergies. This evolution requires a change in professional routines and an adaptation of production procedures. Also, the management culture should also be modified in order to take full advantage of structural changes.

2   Innovation and Public Service

Managers of Public Service Media should be aware of the ongoing transformation processes and all the implications for their performance. Also, a multi-platform and cross-media structures should be focused on providing the public with the tools they need and the interaction with political and market players should lead to new attempts, initiatives, and action plans [3].

Commercial media companies want public service media to be subjected to heavy restrictions to restrict their participation in digital activities. Nevertheless, state and supranational policies consider that PSM have the right to present on all the available platforms, since that ensures their universality and the achievement of their public service mission. In this regard, innovation remains the best option to preserve these media.

If public service media are not able to adapt themselves to the evolution of the needs and requests of their public, they will lose their social support and, consequently, their legitimacy as public services [3; 4].

The discussion on adaptation of PSM to the new media scene differs from country to country, and the level of conflict of each case depends on different variables [5]:

- Legal and social status and relevance of public service institutions.
- Size, weight and relevance of PSM operators and their activities within the national market.

- Level of multiplatform expansion of public service operators as compared to commercial players.
- Size and capacity to influence of commercial lobbies.
- Conjuncture of the national market.
- Legal tradition and level of detail of media regulations.
- Institutionalization and development of media accountability.

A discussion on how innovation should be included and performed on PSM, we should take into account the recommendations drafted by the European Commission in its communications on the application of state aid rules to public broadcasters (2001, 2009). According to the EC, four criteria are to be considering when assessing public service media activities:

1. A clear definition of public service, including the kind of services that it should provide.
2. The role of public service operator should be explicitly attributed to a media institution.
3. Public service funding should be proportional to the activities carried out, which need to be clearly related to the defined remit.
4. Regular and efficient monitoring of public service should be implemented.

As a result of these recommendations, many countries such as the United Kingdom, Germany, the Netherlands, Denmark, Sweden, Norway and the Flanders region (Belgium), have addressed the public value tests. Commercial operators argue that accountability operators ex and post will best serve the promotion of innovation, one of the main goals conferred to PSM. In any case, public media should not apply the same criteria, since they are not only focused on a market-based approach. If public and commercial media do not have the same objectives, assessment methodologies must rest on different benchmarks or indicators.

Moreover, if accountability requirements for public media are too restrictive, then PSM will invest greater effort in meeting the need of authorities rather than responding to citizens' demands. However, it should be analysed if these tests have a positive impact on the provision of public service. In fact, PSM can develop a tool for improving the quality and adequacy of their contents and services [6].

In 2014, The European Broadcasting Union published the report *PSM Values Review,* a tool composed by six elements of the mission of public service media in the new digital context: universality, independence, accountability, excellence, diversity and innovation.

In terms of planning and developing innovation, the EBU challenges public service media to ask themselves the following questions: How do you define innovation? What does your mandate/legislation say? How do you evaluate your performance? How do you communicate your performance? What are your best practices and longer-term goals? What do you do to distinguish yourself from your competitors?

3   Research objectives and methodology

This research aims to analyse the level of innovation of the EU28 state public corporations, since it is considered as the key element for the renovation and adaptation process in the digital scenario, in which PSM are required to defend their legitimacy as public operators, a remote mission from their main competitors.

The method employed to know research, development, and innovation initiatives of these media is the content analysis of PSM reports and publications with regard to this issue. Each and every one new product, system and mechanism has been individually assessed.

The present study was carried out in the first half of 2015, and the results were lastly revised in that summer.

4   Results and discussion

The present study on innovation in PSM of the European Union again shows that, at the European level, there are two levels of technological development. There are clear differences between corporations of the so-called leading European states and those Member States that recently joined the Union.

In any case, as it usually happens, it also identifies common innovations in distribution of products and audiovisual services, as shown in Table 1.

Table 1. Common innovations of European public media (2015)

INNOVATION: COMMON SERVICES
1.   Web platform
2.   Live contents
3.   Use of some social networks
4.   Mobile platforms
5.   Customization

Source: prepared by the authors

All the corporations analysed, with the exception of Bulgaria, Croatia, Slovakia, Greece and Hungary, launched web platforms, be it through their own websites or another online addresses. PSM use these services to publish all their contents, and broadcast live, streaming, or podcast. The differences are mainly in the typology of platform, with different design and operability ranges.

From the social TV point of view, all of them have profiles on social networks, being Facebook, Twitter and Google+ the analysed in this report. All this data on technological improvements related to distribution of contents can be consulted on their corporate website.

Finally, the customization of contents has a twofold benefit. On the one hand, this makes it easy for users to access to products in which they are interested. The process is simple: you open an account on the website or platform, indicate your preferences and start enjoying contents and services. In return, PSM receive useful information on

audience´s interests. Hence, PSM use these data for their market studies that result in the creation of products. This system makes possible for PSM to have live information on their different audiences, without waiting for the next day´s audience data.

Besides digital common advances, each corporation is taking their main steps on the innovation and creativity scenario. They have the will to differentiate themselves from competitors and to guarantee their role of public service in an increasingly fragmented and competitive world. The table below compares the most significant differences between operators.

Table 2. Differences in innovation services of European public media (2015)

INNOVATION: DIFFERENCES BETWEEN PSM	
Content	**Distribution**
• Radio broadcasts with image	• Smart TV (HbbTV)
• Lab of ideas an multimedia centre	• Red button
• Tools for testing products	• Second screen
• Collaborative projects between countries	• Smart consoles, glasses and watches

Source: prepared by the authors.

From the content perspective, there are four main lines:

1. *Radio broadcasts with image:* Some of the PSM with public radio services are working to include improvements and to increase their attractiveness to young audiences, far away from traditional media. This is why the ORF from Austria and the RTÉ from Ireland explicitly include the intention of incorporating video an image in radio services.

2. *Lab of ideas, think tanks, and multimedia centres*: A great number of public media are implementing labs of ideas or innovation labs, that is to say, departments responsible for creating new products and services on the basis of audience needs. Also known as multimedia centres, these divisions are mainly focused on the creation of audiovisual contents without forgetting the area of distribution. Corporations that report on their labs of ideas are: RTBF and VRT from Belgium, RTVSLO from Slovenia, RTVE from Spain, ERR from Estonia, FT from France and CT from Czech Republic. The BBC from the United Kingdom is also working on this system, as explained below.

3. *Tools for testing products*: The BBC launched Taster, a mechanism to involve audiences in the assessment of new products and services before their broadcasting. Collaboration of the public is requested, and then there is a selection of people capable of making assessments. This is a pioneering initiative between European PSM, and it is based on collective intelligence, on paying attention to audience, the future consumer of new products.

   It is intrinsically linked to customization. The digital setting walks towards a fragmentation and diversification of public, who will

increasingly access the contents through multiplatform and mobile devices. In this sense, knowing beforehand whether a product is going to work or not how it will turn out becomes an advantage from an economic and productive point of view.

4. *Collaborative projects between countries*: Public media from Greece and Lithuania include two collaborative projects in their innovation strategies. The first one is based on sharing digital contents with Greece related to relationships between these two areas; the second project consists of disseminating through new technologies all the audio files about the relation of Lithuania and the European Union.

    In this context, the RTÉ from Ireland also has a commitment for the internationalization with the launch of a premium services to provide visibility of their contents abroad.

    From the innovation perspective, there are ambitious projects, but they are included in innovation reports since their essence, based on collaboration between countries or with the European Union, are likely to be important creative aspects for European PSM.

From the distribution perspective, there are four identified work lines:

1. *Smart TV (HbbTV):* A large part of the EU28 public service media presents smart TV projects, developed through the international standard HbbTV, which allows the TV consumption of products and services and at the same time offers additional information. PSM that report on this issue are ZDF from Germany, ORF from Austria and RTVE from Spain.

2. Red button: PSM from Spain, Ireland, the Netherlands, Poland, United Kingdom, and Czech Republic dedicate a considerable part of their efforts on innovation to improve the red button of the remote control. Through this service, they offer complementary services to improve users´ experience, with live videos, information, pictures, and even music related to the program they are watching.

3. *Second screen:* Apart from the red button, some of the analysed corporations complement their products through second screen services, that is to say, through the connection between television devices and another device (mobile phone and tablet, for example). The RTP from Portugal is the most active in this regard.

4. *Smart consoles, glasses and watches:* Some PSM, such as the RTBF from Belgium, is experimenting with the launching of products and services to be consumed in smart consoles, glasses, and watches.

Also, there is a third point that affects both contents and distribution:

1. *Redeployment of staff*. The adaptation to the digital setting entails the reorganization of staff from public service media and, consequently, the creation of new departments and divisions that, in turn, should have heads to lead projects. That is why in recent years it is taking place a massive increase of senior appointments to drive the ships of digital innovation.

    This issue is the cornerstone of technological and digital development of corporations. The Irish RTÉ and the English BBC do not forget this aspect,

since they are the most aware of the need to have people trained for driving innovation processes, creating synergies and enhancing competitive differentiation.

5 Conclusion

Nothing will ever be the same again. Traditional broadcasting, as we know it, will continue opening the way to new strategies based on connected TV and second screen, with content broadcasting that will be increasingly complemented by additional services.

1. *Web platform*. Every corporation needs to launch an online platform dedicated exclusively to the provision of live streaming and podcast radio and television content. It is a service that is run separately from the website, whose function is to be a container of news, programming, video and audio services, and corporate information. It should be highlighted the model of BBC iPlayer, an online platform on which the British corporation provides all their video and audio contents and allows users to register, create communities and deepen the customization. The platform interface is characterized by the presentation of videos relating to channels.

2. *Mobile Apps*. Besides corporate platforms for Android and iOS, provision should be made for the possibility of developing free apps targeted at various audiences and specialized in different subjects, from the weather information up to games, as some public media are testing. These services with reduced production costs make the difference for the audience.

3. *Customization*. The possibility of registration on the PSM websites is extremely to access customized services. The creation of personal spaces should be linked to a platform on which users report their interests. Also, PSM should guarantee the opportunity to send comments, share and recommend contents, and encourage the creation of communities related to their products and services.

4. *Radio innovation*. Corporations should study the opportunities for R&D on the radio. That requires an analysis of the projects developed by European corporations, as the Belgian VRT and the Irish RTÉ, with the digital broadcasting of radio programs with image.

5. *Think Tanks or Innovation Labs*. It is important to strengthen the functions of the labs, the germ of truly innovative projects, which place public companies in a strong position compared to their competitors. Further work is needed in this area, as well as in interactive applications for the second screen and the red button service.

6. *Tools for testing products*. It is suitable to analyse the option to test the widespread use of audience test for all kind of new products. In recent years, the BBC has successfully developed its *Taster tool*.

7. *Smart TV*. To enhance the potential of the international standard HbbTV. Audiences are increasingly demanding and want more and better services. Connected TV is the present, so PSM should make special efforts on this issue.

8. *Multi-device reception*. Audiences want to consume products and services of radio

and television in other kind of devices different from computers, mobile phones and tablets. We refer to glasses, watches and consoles. There is not, for now, a widespread trend, but it should be considered due to the fleeting technological developments in recent years.

9. Social networks. It shall be positive to progress on the creation of attractive and dynamic content for social networks. There is a need to develop social media guidelines to advise professionals on the use of social networks, t provide guidance on language and writing publications, interaction, generation of media discussion, participation, feedback control, advertising and legal issues.

10. Reorganization of staff. If PSM want innovation to be successful and fruitful, they need to adapt and train their workers. For this it is essential to develop training programs aimed at certain departments, and to create areas exclusively dedicated to design, develop and test ideas. This shall entail the creation of new departments and leadership roles.

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Data, native advertising and ad blockers revolutionize the media business models

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Abstract. Through the last hundred years, the innovation of media relied on the technologies of distribution and dissemination of contents, that innovation has now moved to business models. Radio and TV borrow the funding model of advertising, initiated by the press, which then pierce the web. Digital technologies impact not only the forms of distribution of content but also its marketing models, monetization and financing as well as strategies and alliances that media organizations must adapt to new competitive scenarios. This article examines the changes brought about by innovation in business models for marketing advertising and in the product or service information both in the press and on traditional television.

Keywords: innovation, business models, Big Data, native and programmatic advertising, ad blockers, pay television.

1 Introduction

The purpose of this communication is to analyze the impact caused by the introduction of broadcast technologies, programming, data analysis and control of advertising, added to the distribution of information and entertainment digital content from the media. We take as references several emerging business models of the press and television. In particular, we focus on the introduction of programmatic and native advertising models as well as the emergence of tools of adverse reaction to those forms of attracting attention and persuasion represented by the so-called advertisement blockers.

We also note note the change and impact that is occurring in the form of commercializing the pay television (from traditional channels and platforms to new aggregators or infomediaries such as Netflix, Amazon and Hulu) and their effects on the economy of the traditional media. The effects of innovation not only affect the traditional media but also the new media because generalist digital social networks (Facebook, Twitter, LinkedIn, etc.) have new competitors (Whatsapp, Snapchat, Line, Viber, etc.) that gather a bigger number of social messaging. Innovation processes are

at an even increasing pace, and life cycles are shorter, both for the services and businesses [1].

The hypothesis with which we work is that innovation in distribution and marketing processes is what will revolutionize and disrupt business models of traditional media. To test this issue a prospective analytical observation of trends documents, databases and operating accounts of major media companies is conducted. Used as primary sources of research reports from Entertainment and Media Outlook PWC (2015-2019) [2], WorldTrendsDatabase WAN-IFRA (2014) [3], EBU EBU, ACT, European Audiovisual Observatory, media groups listed companies and specialized studies on the topics covered by the subject matter. We complement these primary sources with the results of a survey of 350 communication companies in Spain within the Barometer of Communication Management (2015) [4] performed by the XESCOM Network and New Media's Research Group at the University of Santiago de Compostela (Spain).

2   Theoretical approaches

OECD [5] defines innovation as "the introduction of a product (good or service) or process, new or significantly improved, or the incorporation of a new method for marketing or organization, applied to business practices, to work organization or external relations". Innovation, theorized by Shumpeter (1943) [6] as inventive or creative entrepreneurship, may be incremental (continuist) or disruptive (which completely changes the rules of competition of companies and sectors). Traditional companies develop incremental innovation but rarely cause the disruptive, which is more typical of the new competitors, due to the difficulty of adapting to breakthrough business models [7].

The international economic organization mentioned above distinguishes four types of innovation in: product, as the introduction of a new good or service or significantly improved on its characteristics or uses. Process as an implementation of a new method of production or distribution or significantly improved. Marketing, and the implementation of a method that involves significant changes in product design or packaging, placement, promotion or price, and organizational, as the implementation of a new organizational method in business practices, either in production or in external relations, or both at once [5].

The elements of traditional marketing are the four Ps: product, price, promotion and place (distribution). But the current marketing requires more than the four Ps strategies, especially in regard to the value of the product or service and the relations to be established with the target customers. That is why we speak of marketing of the fifth P (the prosumer, a user and consumer at the same time) or the 6 Rs: relationship, retention, profitability, reference, recovery and reactivation. This new dimension of

marketing means putting the receiver of the goods or services in the heart of the strategy process and the business model [8].

The concept of business model is one of the most recurrent in professional and academic descriptions of recent years, as a kind of invocation, which is used when, is not quite known what to do to improve the economic and commercial results. The business model is not the same as the funding model, even if they are directly linked. The first embraces the entire marketing process and the second articulates funding sources, and is also a part of the business model. The business model is the way in which a company seeks to generate revenues and profits, bringing value to one or different customer segments through different flows and networks of relationships [9].

The business model describes the foundations through which an organization creates, captures and provides value [10], [11]. Embraces at least the following nine elements: 1) Markets, customers, segments and target customers. 2) Value proposition and value of the product/service. 3) Channels of distribution, sales and communication. 4) Customer relationship system. 5) Key resources (essential asset of value in the product or service). 6) Key activities for a workable model. 7) Key associations (network of suppliers and partners). 8) Prices and volume of income and prices. 9) Structure and types of costs.

The two business models of traditional media are the sale or lease of the product or service and advertising, which often exploit jointly or independently. Traditional press combines both models, except when it is financed through advertising to be distributed free, as does the general radio and television broadcasting. Also visual media (radiotelevision and film) exploit the payment model combined with different forms of advertising. The advertising model is based on the attention economy [12], which consists in getting measured audience to sell them to advertising brands quantifying the impact of the contact (GRP, gross rating point) as the price. On the Internet that contact is recorded, tracked and analyzed through fingerprint.

The evolution and breakdown of the business models of the media caused throughout history the emergence of various forms of advertising (bartering, product placement, merchandising, sponsorship) and selling the product or service (block sale, subscription, paywall, freemium-premium, pay per view, micropayment, etc.). These new forms of marketing were emerging as the competitiveness of traditional systems started to saturate. Native and programmatic advertising are two recent innovations –the first one, evolutionary and the second, rupturist– of the media market. Both represent alternative paths to other breakthrough innovations caused by advertising blockers and new quantifying systems for audiences.

3   Changing media markets

The sale of half a million copies of newspapers represents 56% of the income of press, which are distributed everyday worldwide through an approximated 12,000 different headings. The press is going through a profound change in its business model. A significant loss of advertising revenue and sales in hard copy has been recorded, due to falling circulation. At the same time, the press is maintaining digital audiences on account of increased online access, especially through mobile devices, according to the World Association of Newspapers [13].
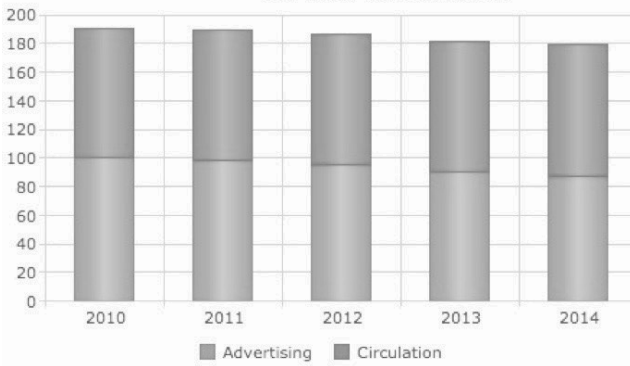
Fig. 1. The evolution of income from press (data in millions of dollars). Source: WorldTrends Data Base de WAN-IFRA, 2015.

Press reached 179.000 billion in 2014 from its printed product (circulation), 87,000 million from advertising and 9,000 million in digital sales. The printing business at global scale still has 93% of all income. But as can be seen in Table 2, the business model of digital media evolves differently than the printed model because sales revenue for digital accesses (paywall) grow more slowly than online advertising, 30% of it comes from mobile phones; which it is estimated to reach 52,000 million in 2017, according to WAN-IFRA [13].
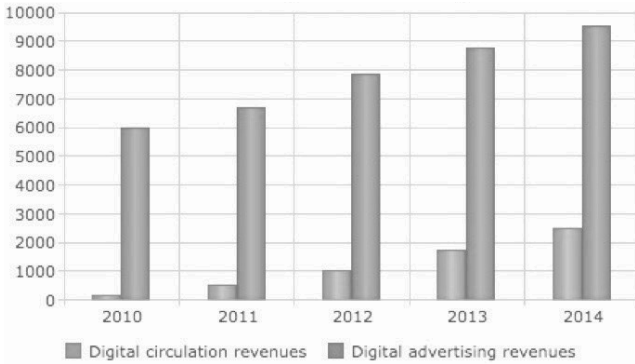
Fig. 2. Incomes from digital press (data in millions of dollars). Source: WAN-INFRA WorldTrends Data Base, 2015.

The evolution of the press distribution is very different within each continent. Circulation increased 16% in Asia, but decreased significantly in the West, between 20% and 10%, respectively, in Europe and Australia as well as in North America. Out of ten printed newspapers with the largest circulation in the world, nine are from Asia. The one that tops the list, The Yomiuri Shimbun, is Japanese (9.1 million copies). There is only one from the United States (USA Today, 4.1 million).
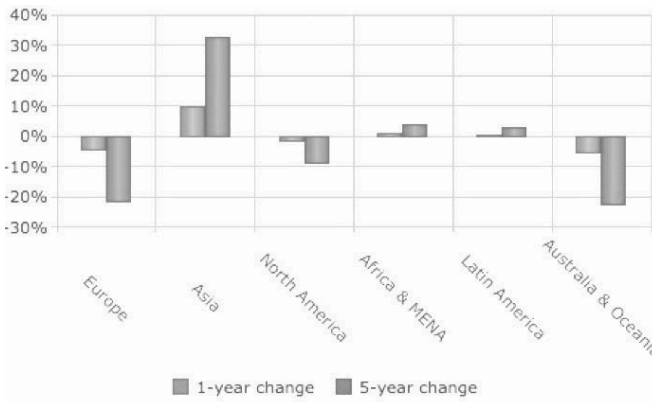
Fig. 3. Global press circulation. Source: WAN-IFRA WorldTrends Data Base, 2015.

Online advertising increased by 20% according to predictions of the Global Entertainment and Media Outlook 2015-2019 PWC´s report while commercial revenues of conventional television slow down and stagnate around 4.1%. It is estimated that in 2019 Internet will overtake television's advertising, and mobile device advertisements will pass that of the traditional screen. The Internet search advertising is expected to grow 35%, from 53,000 million in 2014 to 85,000 million in 2019.
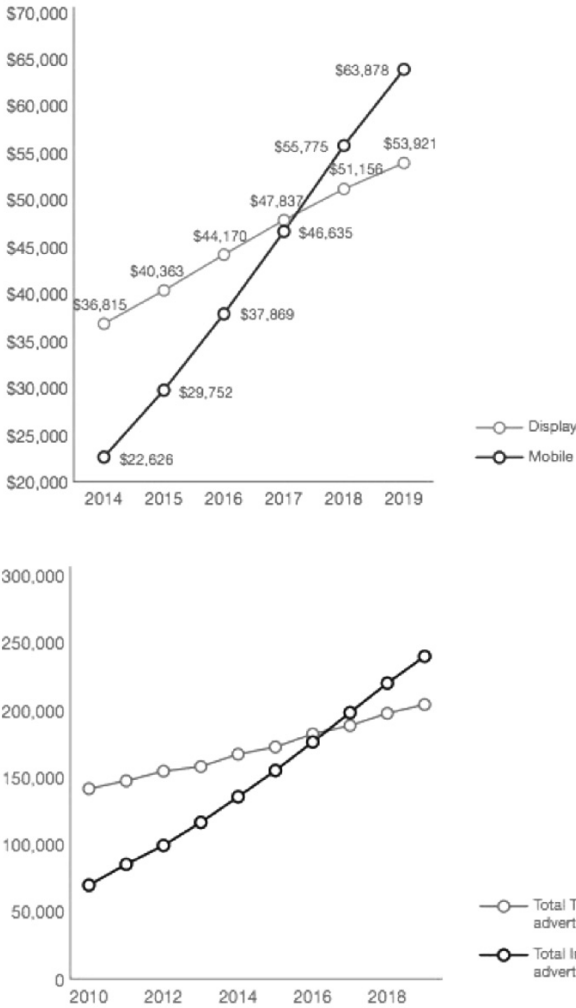
Fig. 4. Advertising on TV, internet and mobile devices. Source: Global Entertainment and Media Outlook 2015-2019 (PWC 2015).

Multiscreen television consumption and multichannel distribution, like the Over-the-top (OTT) system are changing marketing advertising models. Table 5 shows the evolution of the growth of mobile advertising revenues and decrease of linear digital television. Consumption of video on demand, through individualized downloads, disrupts the traditional model advertising, closely related to linear programming of content and advertising measurement of their audiences. The new television is increasing independent of linear programming [14] and the access to devices.
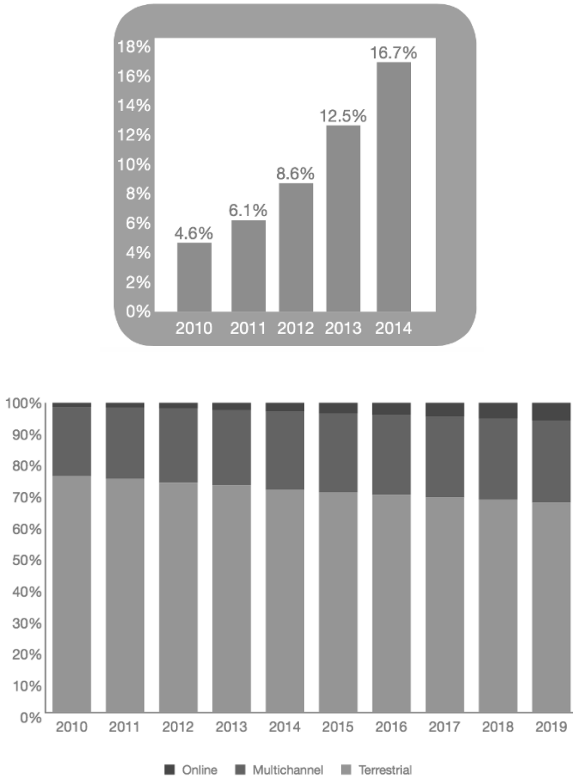
Fig. 5. Evolution of mobile and TV advertising. Source: Global Entertainment and Media Outlook 2015-2019 (PWC 2015).

4   New systems and forms of advertising

The change of the distribution channel on the printed press and radio broadcasting system to the Internet opened the barriers of circulation and access to content, altering the production models, valuation and monetization of audiences. The power control over the content moves from producers programmers to consumers receivers and intermediation platforms from infomediaries. Users gain freedom of use and consumption, giving a part of its fingerprint, in exchange for access to content through infomediaries (Google, Apple, Facebook, Amazon), who take advantage to quantify and monetize their role as gatekeepers. Thus, control of the audience and their data passes from media to Infomediaries; and with it, the new business models.

Programmatic advertising, which is one of those new models, is based on real-time bidding (RTB, Real TimingBidding) of an investment offer of a brand, a change on the demand for best audience data to its planned campaign, between all digital media

connected to the system. It is a captive model of large platforms that have huge robotised inventories of digital audience data from which schedule bids, according to prospects of revenue and audience profiles. According to Magna Global, half of the investments made in the US in 2017 and a third of those in Germany will be of programmatic advertising. This model unleashes a commercial battle between Google, Apple and Facebook for control metrics for users data and the relation with producers of content. There´s also a variation on the calculation systems of Return on Investment (ROI) and Return on Advertising Spending (ROAS).

Facing this programmatic commercial power of GAFAnomics (Google, Apple, Facebook, Amazon) –superpowers that in 2020 may become the first world economic potential [15]– Large movements of rejection and release of power are developed in support of users. The ad blockers are applications developed since 2006 that allow users to skip commercials with the same logic that once many people used VCRs to avoid advertising of linear programming and now do the same by the use of streaming.

Native advertising, a trend emerged from the crisis of the traditional model (saturation and rejection of massive or invasive campaigns, loss of confidence of advertisers, etc), is an euphemistic term used to present it as if it were a journalistic genre or pure entertainment, appealing to capture users' interest and experience. That is why it tries to use the journalistic and fiction genres and apply them to advertising communication, not without strong ethical and deontological tensions with professionals and the social responsibility of enterprises. It's really not a new form because such advertising communications had been traditionally named advertorials. What is new is that intends to ignore or bypass the blocking of conventional advertising.

Other ways of renewing business model of traditional media are intensive use of sponsorship, bartering (payment of production), product placement (introduce advertising within the product) and user data to fund distribution. This is part of what YouTube does, which has become the global television century, displacing CNN to state category. Along the short video format, self-production of users and social network distribution that defines Youtube, the platform models from Netflix, Hulu and Amazon, that are robbing traditional markets to traditional broadcaster from television traditional payment. In the press business, the paywall it tries to gain income through subscriptions and direct sales to digital access, although slows free mass circulation, necessary to offset advertising. Available data from paywall business in digital media ranges from 7% in UK and 14% in Finland, with a global average of 10% [16], [13].

5 Conclusions

New media and business models are extensions and remediation, continuist or breakthrough, from traditional media transformed into social metamedia [17], [18], [19]. Innovation has become the center of competitive strategy, focusing mainly on distribution and marketing processes. Trends determine the specialization and innovation in applications (Periscope, 360, Hyperlapse, augmented and virtual reality); robotics; gamification; disintermediation and P2P; image recognition; metaverses deployment; cognitive and predictive analysis algorithms; and the optimization of tools and application in mobile communications.

The competitive advantage [20] of technological innovation processes of distribution and marketing have conquered the infomediaries and their large platforms, because they have established direct contact with users, turning them prosumers [21], [22]. Traditional media are left, for the time being, with the product and the possibility of innovation on its organization. Although for distribution and marketing the product, traditional media increasingly calls on those that control most of the data. The battle being waged, therefore, it is the data, registration, inventory, measuring, standarization, homologation, analysis, quantification, valuation and monetization.

The next focus of competition in the media sector points to the content and the application of creativity and innovation to experience around the technologies of artificial intelligence [23], [24] and virtual reality [25], [26]. No doubt that the prosumer experience of navigation enriches even more through virtual immersion. It is the competitive landscape in which are also positioning some media and important infomediaries. What remains to be seen is whether these innovations will move immediately to the business models or their evolution will be slower.

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Possibilities and limits of virtual ethnography as a research technique for political and corporate communication

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Abstract. The emergence of virtual environments as a context, as a tool, and as a research objective (in other words, the Internet as a new anthropological space), has led to the adoption of new specific techniques to apprehend these new fields, and not only as sources. Virtual environments are also seeen as universes in which take place communication processes that, without entirely disengage from from those produced in physical settings, have some pecularities that require a new approach methodology. Therefore, this theoretical article is intended to serve as critical review of the virtual ethnography, while analyzing the limits and possibilities of this technique in the fields of political and corporate communication, since this tool can be very useful in this fields.

Keywords: Virtual ethnography – ethnocommunication - political communication – corporate communication.

1 Introduction

1.1. Definition of virtual ethnography

Since the emergence of the concept of virtual ethnography, the main discussion has been focused on its hypothetical autonomy as regards the classical ethnography. In this regard, two opposing trends appeared: those who defend that virtual ethnography has distinctive elements, and those who believe that it is the application of the classic ethnography to a new object of study, the Internet.

This face-to-face has been produced in parallel with the development of two ranges of determinism (technical and social) that tackles the technology impact in social sciences from two opposing perspectives, while theoreticians such as Carmona consider neither technology acts independently from the social to finally mould it, nor the social stands as the head of technological development [1].

In any case, Sören [2] summarizes the ten principles that Hine [3] attributes to virtual ethnography, deriving from reflection on how to deal with the three categories of limitations that affect the cyberspace (changes in the role of time and space, changes in communication, and changes in the role of social media):

1. Understand the Internet as a place to create new communicative spaces of interaction.

2. The Internet as an interconnected communication space with face-to-face interaction and not as an aloof communication space.

3. The evolution from a "multi-located" (i.e., it can be performed in several communities at the same time) to one that sees it as fluid, dynamic and mobile.

4. Due to its fluency, ethnography is reformulated with the subject of study and follows the flow of interactions toward new spaces.

5. This research technique has as challenge the configuration between the virtual and real worlds.

6. The immersion in the context of study is intermittent, as the interaction in these spaces.

7. The bias of virtual ethnography, face with the holistic aspiration of the classical technique.

8. It requires interaction of the researcher with technology through the medium conducting ethnography.

9. Any interaction with informants is valid.

10. It is characterized by a continuous reformulation and adaptation to the virtual environment.

It is, therefore, the response of the ethnographic method to a new reality emerged with the rise of ICT [2], so that it is intended an implication and integration of online and offline life, rather than seeking to work towards a model that highlights the differences between classical and virtual ethnography. As far as we are concerned, it is vital to overcome that opposed vision in benefit of an holistic model that incorporates an overlap and integration of online and offline fields. Doing the opposite means incorporating a barrier from research that does not exist in the empirical ground, where the coexistence and integration of both areas is accepted quite naturally from a theoretical and daily practice point of view.

Thus, instead of begging for a virtual ethnography that, as proposed by Ramírez [4], distinguishes between two areas of study (online ethnography and outline ethnography), we consider it more opportune to approach this new technique from an integral point of view, especially when the influxes of online and offline universes are increasing, and synergies between them discourage a methodology against nature and with borders.

As is to be expected, the advent of a new methodology always implies the emergence, or at least the review, of the support techniques [5], even though in the case of the virtual ethnography there is the circular premise that "devices are not only tools, but mediating elements that change practices, institutions and individuals and have effects on ethnographic practices" [6].

In any case, the essential features of ethnography as a social research technique remain, albeit adapted to the new digital environment [7]: the phenomenological character, the relatively persistent permanence -now reduced- of the ethnographer, the holistic and naturalistic vision -reduced but still an aspiration- and the inductive nature -participant observation is intermittent but remains the base. –

All of this regardless of the diversity of terminology related to this technique [8]: cyber-ethnography, cyberspace ethnography, virtual ethnography, media anthropology, mediated ethnography, and ethnography through the Internet. All of these notions share the object of analysis of this new sociability [9], derived from the Internet as an everyday device that promotes the formation of more or less stable communities, with attention to the new schemes of proposed relations: human-machine, nature-culture and biology / robotic-techno-science [8].

3   Ethnocommunication

Virtual ethnography is a suitable technique to use in a variety of scientific fields, from anthropology to psychology or sociology, to communication, where the ethno-informative practices allow us to analyse interactions with communication purposes -between users, users and media, and users and communication agents-. Therefore, it should be clear that "ethnography as research methodology is not restricted to social

anthropology" [15], while the social and sociological component cannot be disregarded. This technique is focused on the study of social interactions on the Internet, where practices, meanings and cultural identities intermingle through various channels" [9].

Also, this technique should be approached from the perspective of a multi-semiotics ethnography[1] [13], taking into account that it is "one of the most innovative areas of what, in general terms, is known as qualitative research in communication science [...] where it is being produced a disintegration of the observation "place", and it is being strengthened researchers attention to the 'interaction', in the abstract, ubiquitous and decentralized" [10].

From the first time that the concept of "ethnography of communication" was theorized in 1964 in the *American Anthropologist* journal by the socio-linguist Dell Hymes [2], there have been identified a number of trends using this qualitative technique, as Soriano notes [10]:

a) Media-centrist Ethnography: the study of news production processes in newsrooms, especially in the 70s, which represents the beginning of the breakdown of material frontiers of the fieldwork.

b) Relationships between journalists - sources: the study of human relationships between editors and information agents.

c) Audience reception: careful observation of the immediate environment in which micro-social reception processes of the media are produced.

d) Virtual ethnographies, for which practices described in 1.1. may be applied.

In any case, much of the application possibilities of this technique lie, as Sören notes [2b], in social networks and, more particularly, in "understanding the use given to them by individuals" [2b]. For this reason, it is proposed a threefold approach to these environments: as a research tool, due to the high rate of penetration and the high degree of data segmentation; as a data source, both of individuals and their interactions; and as a context where the action happens, "from the everyday life of narratives made by individuals about common events, to more thorough interactions on political issues" [2b].

As it has been shown, the four noted research areas point the role of the media as essential agents in the process, while from our perspective it is crucial to implement virtual ethnography in non-mediated models, precisely under new contexts arising on the net, not only as a communication channel but also as a communicative product itself.

In other words, it is about using this technique in the field of corporate communication, in line with the rise of research in this field, which allows leaving behind methodological proposals focused exclusively on processes in which media are involved.

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[1] It allows new procedures to access to information; consolidates data validation by creating new crossings to compare sources (...); to analyze and interpret information without leaving a textual format, since interviews and conversations are directly written; opens new ways for organizing interpretation and argumentation; and allows cross-referencing and development of links to media (text, picture, video, sound, etc.) in all phases of the investigation [15].

[2] In its beginning, this concept was related with a double anthropological approach to the problems of language: the first is to transcend the fragmented contributions of the disciplines mentioned above [ethno-linguistic, psycholinguistic ...] and move to directly investigate the use of language in situational contexts; and, secondly, you have to move away from the linguistic form as a framework for the community context, investigating communicative areas as a whol, and that any use of channels and codes of communication should be seen as resources applied by members of the community [10].

4   Political and institutional communication

Boundaries between political and institutional communication are not the aim of this research (works on this issue may be found at García Orosa and Vázquez Sande [11] and Vázquez Sande [12], but they are taken as areas of interest in which it is possible to implement virtual ethnography as a technique.

For this purpose, we would probably find ourselves in the land of corporate communication that targets a wider audience, since one of their essential features is that they are targeted to universal rreceivers, delimited by the territorial boundaries of the institution limits, independently that sometimes it can be used segmentation techniques that favour a more effective relationship.

In any case, it seems underniably there is growing interest in political communication around the academia. This is not only reflected in the increase of PhD thesis focused on this discipline, but also in the emergence of research groups with expertise in the field. Simultneously, it is taking place a remarkable professionalization in this domain, which contributes to academic progress in this matter.

Therefore, we consider it appropriate and relevant to analyze what are the possibilities and limits of use of virtual ethnography in the fields of corporate and institutional communication, land with boundaries sometimes blurred, and whose clear distinction may contribute this research technique, characterized by the development and ongoing review of the subject, which also allows it to adapt to changes currently affecting the Spanish political ecosystem.

5   Methodology

Our research is divided into three consecutive parts, mainly using two techniques: bibliographic review and in-depth interviews with experts, with the aim of responding to our two research questions: What are the thematic lines that, within the political and institutional communication, have applied virtual ethnography in the Hispano-American environment? What are the potentials and limits of this technique in both disciplines?

For this purpose, it has been madde thorough review of published research in recent years, combining this technique to each of the two disciplines in search engines and specific platforms that allow us to detect papers, articles and books (and chapters), so that we can get an accurate reflection as faithful as possible.

Subsequently, it is made a reflection on possibilities of virtual ethnography, and the limits that can be imposed as a research technique from the perspective of the socio-political context itself and the uses of the Internet, among other conditions.

Once this work is done, it was conducted a semistructured in-depth interview with the expert Israel Márquez, one of the most authorised spokesmen in Spain regarding the implementation of this technique, in order to outline the conclusions at which we arrived.

6   Results

As it has been explained, the first part of the analysis was a revision of Hispano-American research on our area of interest in which virtual ethnography had been used as a technique. We have used search engines linking "political communication" to "virtual ethnography", and "institutional communication" to "virtual ethnography". This procedure helped us to obtain this exiguous relation:

- "Construcción del candidato -marca en las redes sociales. El uso de Twitter y Facebook en las elecciones a presidente en España, 2011"

(Figueroa, González and Núñez, 2012[3].)

- "Grafitis políticos: pintadas y participación política de los jóvenes" (Reyes and Daza, 2012[4].)
- "Redes sociales virtuales. Más allá de la mediación tecnológica" (García and Uscátegui, 2011[5].)
- "Acción colectiva y movimientos sociales en las redes digitales. Aspectos históricos y metodológicos" (Sádaba, 2012[6].)
- "Jóvenes en la red: ¿hacia un espacio público virtual?" (García, 2012[7].)

As it can be concluded, the small number of investigations, most of them in the Hispano-American context, are so far oriented, almost exclusively, to electoral participation, leaving on the margin a great number of subjects that could use this technique.

And, on that subject, we will discuss other research lines in which virtual ethnography could be used to study issues related to political and corporate communication. Therefore, it is proposed a Decalogue on which we integrate ethnography proposals from the organization and the receptors to which it may be applied the participant observation and semi-structured interviews as key tools of this technique:

1. The motivations of a group of citizens who follow various political or several parties in a particular social network to find out why they are taking that decision, in order to further analyse the relationship established between them, to check whether the information obtained is useful to determine their intention to vote (if what these directly interested sources share a virtual has electoral impact or influence).

2. With a group of informants declaring themselves undecided or abstaining, it could be analysed if the fact of being exposed to political stimuli in social networks (via political parties profiles or accounts on social networks; via content published by the media; and via personal contacts) affects its final decision to vote and, if so, who to vote for.

3. Placing ourselves in an organization ethnography, identify the reasons of the presence or absence of a political party, candidate or institution on emergent social platforms such as Snapchat and Periscope, and establish whether or not the familiarisation with the virtual environment is a push factor pressuring the use of these tools.

4. In the case of specific social networks for party supporters, it could be investigated what kind of reactions cause in the community: if it increases their feeling of belonging by engaging with this tool of internal communication; if it is done as a reflexive action, without getting involved to a greater extent; or if it affects on the way they share content on the virtual community.

5. From the determination of a community of users from a political party or another institution and its rival, it may be analysed how is established the discourse

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[3] Available on the website: http://www.alice-comunicacionpolitica.com/abrir-ponencia.php?f=247-F50000ad22471342180050-ponencia-1.pdf. It should be noted that, while authors affirm that they have used this technique, the research itself seems to be based on a content analysis.

[4] Available on the website: http://ibero-revistas.metabiblioteca.org/index.php/ripsicologia/article/view/240/208

[5] Available on the website: http://www.acorn-redecom.org/papers/2011Gil_Espanol.pdf

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[7] Available on the website: http://catalogo.ulima.edu.pe/conferencias/felafacs2012/eje2/36.pdf

between the two and how that conflict is reflected in this receptors study.

6. Analyse the motivations of participation in a community of active citizens in institutional platforms on websites that collect ideas (i.e., through initiatives such as participatory budgeting) or included as a citizen control, with the aim of establishing models of encouragement to other members group and encourage more dynamic participation from the government administration.

7. In a crisis situation, identify the main sources of information used by citizens, in order to know the role played by digital administration channels. Also, interviews may help to see the causes of these patterns of behaviour and to establish the guidelines for the re-legitimization of the institutional action and, thus, make the entity become a source of reference in these contexts of particular sensitivity.

8. Taking "anonymous" informant profiles on social networks as subjects for the research (i.e., whose features and activity do not allow to verify who is behind in the offline world), and who, nevertheless, have an active participation and interaction with any politician or institution, identify the reasons for this deliberate "anonymity" and study how the behaviour patterns would change in the event of intervention from a "real" profile (that is, when the person is clearly identifiable[8]), while there are studied the relationships with other users between the virtual and real identity.

9. Studying, within a community of informants who access corporate information and relate to the entity through a mobile app, the reasons why they use that formula and analyse the correlation between the use of that tool / channel and the degree of participation and involvement.

10. Analyse professional routines and relationships established in the team of electoral campaigns in the digital realm, even determining how these interactions are played out of the Internet, using a model of mixed ethnography.

As we have seen, it has been suggested an extensive list of research areas that show the diversity of virtual environments in which this technique may be applied (social networks, websites, mobile apps...); publics (captives, unconcerned, undecided...); situations... In short, a wide range of axes on which the virtual ethnography can be used in the field of political and corporate communication, but on the understanding that it is a relative few explored field.

Perhaps the reasons could be related to their limitations, from our perspective, on the use of the virtual ethnography in these two areas, reflecting intrinsic difficulties of the technique itself that increase when applied to these areas due to their particularities. In this sense, we believe it is essential to pay attention to these four factors that, in our view, limit the scope of the virtual ethnography in our areas of interest:

    1. The special secrecy of political parties, which will hamper the development of research within these organizations when blocking the access to ethnographers. If virtual ethnography encounters this difficulty to develop research within the issuer circle, it will be more likely to happen in the case of political parties or politicians themselves.

    They carry out strategic activities in which decisions are restricted to very few people (in some cases, to a leader and his top advisor); so keepers would deny

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[8] Not surprisingly, the subjects "are anonymous and are presented with multiple identities" [15], while one of the strengths of this technique is used, "there are clear advantages to develop ethnography in cyberspace when the subject of study (...) makes anonymity and digital mediation, which allows Internet, a boon for inquiries among these study subjects "[15].

access to ethnographers (and therefore would prevent their immersion in the field to perform a slow, sustained and systematic observation). Also, the researcher would have information and may reveal issues that surely do not concern the centres of power in a more and more competitive context, in which public image is an essential asset, so it is not difficult to guess the reluctance of these organizations to participate in such projects.

2. The changing dynamics on the field of political communication, derived from the professionalization of the sector, of the great advances implemented by academia, of changing contexts that it is living (specially from the electoral point of view in Spain); conflict with one of the essential features of the virtual ethnography, the most time-consuming research technique. It is therefore a high risk of starting a project that could become quickly out-dated, due to the giddy pace of political and corporate areas, since they are subjected to socio-political pressures of multiple contexts.

3. One of the peculiarities of this research technique is the inability to universalize results, since it focuses on the singular and the particular. This factor, together with the cyclical and contingent elements of each campaign and institution, make conclusions to have a reduced and very specific impact, due to the high territorialized component of our fields of study, which contrasts with the analysis of de-territorialized communities, a typical aspect of virtual ethnography, where geography is contingent but not decisive.

4. The difficulty of creating that long lasting trust relationship ("rapport") due to the issues under discussion, probably because of the delay in the implementation of a democratic system in Spain. In the case of a virtual ethnography of receivers, there is a notable reluctance to participate in this research. Something similar happens with virtual ethnographies of organizations where, in addition, the absence of previous similar projects becomes a reason to decide not to collaborate.

5 Discussion and conclusions

The use of virtual ethnography in the field of political and corporate communication is still residual, and not only because it is a recent research technique, but also because there are a number of specific features in both areas that limit the use of this methodological tool. Among them, we refer to the difficulty of generating strong relationships between ethnographers and informants because of the social reluctance to tackle political issues (probably because of a democratic deficit derived from the delay in the consolidation of a democracy in Spain); the secrecy of the organizations because of the high strategic component of institutions and parties; the limitation issues which as particular to establish general guidelines; and the fast pace of change of these institutions (both public and private), which may cause rapid obsolescence for a research technique that, by nature, is the most time-consuming.

Nevertheless, it has been proposed a Decalogue of lines of research in which, in our opinion, the use of virtual ethnography is relevant, since it is a technique that enables us to better meet our objectives. Thus, we have outlined proposals that include both virtual ethnographies of the organization and receivers, integrating initiatives from different virtual environments (social networks, apps, websites ...) and with different study communities.

Therefore, the use of virtual ethnography in the political and corporate communication is a methodological challenge, since there is an almost total lack of background, which shall not preclude the settlement of this technique in this fields, as

it is the only one that allows us to explore areas that so far have not focused the attention of researchers on political and corporate communication.

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Digital convergence in Ecuadorian media: some strengths and weaknesses

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Abstract. Convergence in mass media goes beyond the simple integration of the act of production, the usage of multi-media, and remodeling management. It refers to a multi-dimensional process that affects the technological, business, and professional fields, as well as users of mass media, thereby promoting the integration of tools, spaces, work methods, and previously disaggregated languages. Ecuadorian media began to seek convergence in 1998. This article analyzes the state of the art of digital convergence in Ecuador based on two case studies: *El Telégrafo* and *El Universo*. The conclusions of this study stress the need for information provider companies to assume the challenges that are implied in reaching audiences that are becoming more and more diverse.

Key words: integration of media production, convergence, multimedia, mass communication.

1. Introduction

The evolution of ICTs has led to the transformation of information providers. This is mainly due to the phenomenon of technological convergence. The integration of media production, the new models of production routines and journalist profiles, as well as multi-media phenomena, and new media narratives are key factors of this change. Moreover, the increase of access to the Internet, the development of social networks, the role of users as pro-consumers, plus the growing usage of mobile devices and new trends in publicity make the Internet an important tool in mass media analysis.

Consequently, many media operators have to operate within the framework of innovation and openness. In this way, they can better meet the needs of readers, while also seeking new forms of doing business that facilitate the financial sustainability of media companies [11].

This article presents an analysis of the state of the art of digital convergence in Ecuador that is based on two case studies: the national newspapers *El Telégrafo* (public) and *El Universo* (private). Furthermore, it describes the main characteristics of the new consumers of media in Ecuador, as well as the professional challenges of journalists regarding the process of ICTs, and information provider needs. The main conclusions of this study thus serve as a starting point for a more ample study of digital convergence in Ecuador, which are applicable in other contexts.

2.   Convergence

According to Ester Appelgren, who is quoted by Moreno [9], it is possible that the first introduction of the concept of convergence was developed by Nicholas Negroponte in 1979, i.e. when he introduced the famous model of convergence that was based on three converging industries: television, radio and cinema. The printing and publicity industry and the computer industry of the time were likewise influential. Ecuadorian media, however, began to seek convergence in 1998. This phenomenon influences other important spheres such as the professional training of journalists, and the re-categorization of the profession, which can only be done with the feedback of actual journalists. Ramón Salaverría et al [18] refer to a process that affects various fields:

> A multi-dimensional focus, which is facilitated by the generalized implementation of digital technologies of telecommunication, affects the technological, commercial, professional and editorial aspects of mass media - thereby promoting an integration of tools, spaces, work methods, and previously disaggregated languages. The journalists elaborate contents that are distributed via multiple platforms, e.g. by means of individual languages.

On the other hand, the technological revolution facilitates "enables modern print media producers to take advantage of new media, which facilitate audio-visual publications and which are potentially, interactive" [1].   At the same time, it motivates the planning of various forms of reaching the public, for example, by means of downloading documents, organizing chats, forums, or permanent updating news, or interactive maps to tell stories. The user exclusively accesses the contents that are of interest to them, thereby personalizing the information channel. All this propitiates change in the dissemination of information products, and consequently the informative business [16].

Within the context of digitalization, it is important to know how experts define convergence. Regarding journalistic convergence, Historian Armando Piñeiro [14] states that: "The convergence of the media involves the organization of the new information companies, which arise from the fusion and the purchase of different media by the same business produced in the decade of the 1980s and the 1990s".

With regard to the above, Néstor García Canclini [3] holds the view that: "…today digital convergence is articulating multimedia integration, which enables us to see and to listen on a mobile, palm-held device, or audio iPhones, or see images, written text, and promote the transmission of data, by taking photographs and videos, saving them, communicating with others, and instantly receiving new ideas". This view is not journalistic, but anthropological.

García Canclini speaks of reception, compared with Salaverría, who prefers the term "production".

For Jenkins [7], media convergence is not only based on the inter-connection of distribution channels, platforms and technologies, but covers an entire process of cultural transformation that affects the way in which mass media are used. In this regard, Lisy Navarro [10] states that the "online newspaper will convert into a form

of communication that encapsulates the written press, the simultaneousness of the radio, and television images".

The sociologist Manuel Castells, who is cited in García de Torres and Pou [4], guarantees that there are indices of a strategy of convergence on behalf of Internet and software companies, and that traditional communication media will be affected by an insufficient bandwidth.

We cannot talk about success or failure of media convergence seeing that this will depend on the vision and strategy of the company that adopts it: integration, interactivity and hyper-mediality [6].

3. Methodology

This research examines digital convergence in Ecuadorian media. For this study, we revised existing literature about the topic, i.e. with the aim of determining the trends that characterize this phenomenon in the country, such as emerging contexts for the management of information. Media professionals thus have before them a vast challenge.

Within this context, two case studies were selected that help to map out the characteristics of media convergence in Ecuador, namely two national newspapers: El Universo www.eluniverso.com and El Telégrafo www.eltelegrafo.com.ec.

For both of these newspapers, we revised their webpages, i.e. given that in this work did not analyze contents, but structures and tools. This revision was carried out during a short period of time. We can also add to this visits to the media providers and interviews with content editors to discover the dynamics of both forms of media related to the process of convergence.

The selection criteria of the media are reliant upon the nature of them. *El Universo* is private and *El Telégrafo* is public. Both are circulated nationally and comprise two of the oldest in the country.

The objective is to influence the trend of the work that is managed by public and private media in the country, as well as to determine the strengths and weaknesses of convergence in the technological, commercial and professional fields.

4. Ecuador on the path towards convergence: a general overview

In the first instance, the network was only used to build presence, that is, where there was a complete 'switch' of the contents in the paper version. This milestone was experienced in the nineties. In 1995, the newspaper *Hoy* published its first online edition.

Between 1997 and 2000, we witnessed a standard growth in online newspapers. Conversely, between 2001 and 2005 no data were recorded. Whereas, for 2006, there were 22 newspapers on the Web. This number was mantained until 2008. From that time until today, the number has increased to 10 daily newspapers.

Box 1: **GROWTH OF CYBER-NEWSPAPERS**

YEAR	1997	1998	1999	2000	2006	2007	2008	2009	2010	2011	2012	2013

NUMBER OF DAILES	7	9	10	13	22	22	22	29	30	30	31	32

Source: The author with information from the fourth report about Hispanic dailies on the Internet (1997-2000), WAN (2007), with data from 2006 and WAN (2009), with data from 2008.

In second phase, some changes were produced in the content. Thanks to the inclusion of new technology, the image was being adapted to the new environment.

In 2009, *El Universo*, changed its structure and introduced a new image to its readers. Likewise, *online* newsrooms were organized, which involved hiring a different team to the printed press so that it could organize, prepare and publish information on the *Web*.

The same thing happened to *El Telégrafo*, who while renewing their printed editions and after being seized by the State, implemented their *website* and subsequently the applications for mobile devices.

Currently, a vast number of Ecuadorian dailies implemented a model that was more or less integrated among the digital and printed media production companies. In a certain way, they developed models that were adapted to the reality of the environment- i.e. related to the evolution of ICTs.

5.   Case Studies: El Universo and El Telégrafo

El Universo. Founded by Ismael Pérez Pazmiño, its first publication circulated on September 16, 1921. Several years later, in 1957, it was endowed with the slogan "The biggest national daily".

Its institutional website www.eluniverso.com states that the company has evolved as a result of technological and journalistic changes, which has required alterations in its infrastructure. For this reason, the newspaper has been produced in different locations- each of which is adopted to its time and current situation.

El Universo was put online in 1996. At first, only two people were in charge of updating the *website*. Then, there were four. During that same year, the newspaper had no newsroom. With the passage of time, however, small teams were put together. Since January 2011, journalists from the print and digital version have been working in the same physical space, but without incurring the full adoption of a convergence by the media. The Assistant Editor is currently the link between the two editions.

El Universo has been on the Web for 19 years, and is currently published in three different platforms:

1. Websites.
2. Social networks: Facebook www.facebook.com/eluniversoec: 877,039 likes; Twitter: www.twitter.com/eluniversocom: 1,2 M followers; Instagram: https://instagram.com/eluniversocom: 48.9K followers.

The newsroom is comprised of the following: a content editor or chief editor, an assistant editor, eight digital journalists, two videographers, three we developers, a web-master and responsable for Marketing. To this we can add a technical department

that gives maintenance to all the products of *El Universo*, which comprises seven people, five IT staff, and two designers.

The basic characteristics of digital newspapers –namely multimediality, hyper-textuality and interactivity- are moderately developed in *El Universo*, although there is a need to increase an exclusive section for disseminating information in real time, performing live transmissions from news productions or coverage of other media, and online services.

Moreover, it is evident that planning of content was made by thinking about the print editions and not for them and the online platforms, seeing that a great part of the content that is digitally distributed comes from the print publication, while the material is exclusively made for digital platforms is minimal. So, in 2014, only three videos were highlighted in the report of Accountability of *El Universo*[2].

Regarding the model of interactivity, it is found during the stage of initiation. Fewer tools are provided to the user –social networks, forums, and mobile technology testimony (citizen journalism), which have not been fully exploited. The news, which is what readers need to comment upon, are closed to that possibility. The challenge is to seek, through interactive tools, the greatest journalistic advantage possible, and, of course, to pay careful attention to the audience.

As for the business model of this form of media, which Picard [13] describes as the architecture of the product, its services and information flow are necessary for highlighting some of the factors that have obliged media managers to reformulate the strategies, products, and even the contents of their media, especially since late 2009, i.e. when the Government approved a tax reform that included a 12% tax on a newspaper[3].

There are also other measures such as the establishment of a basic salary for communicators and journalists, requirements for the professionalization of journalists, the banning of advertising of products that are considered harmful (junk food, alcohol and tobacco); and the obligation to publish the number of copies that print media sell. All this represents a major blow to the media industry in the country, which has created forced cutbacks, suppressed certain products (media supplements, magazines, etc.), and reduced the circulation of copies, etc.

El Universo, for example, faced heavy criticism and even legal proceedings initiated in 2011 by President Rafael Correa, which was due to a publication of the erstwhile chief columnist of the newspaper, Emilio Palacio, in a column titled: Say no to lies (No a las mentiras), alluding to the Ecuadorian President.

It should be noted that, traditionally, El Universo, joint-stock company, has been one of the biggest newspaper companies of Ecuador. According to the financial report of the Superintendence of Companies of Ecuador (2013), this media recorded losses greater than $ 2 million and a financial profitability of -0.0701[4].

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[2] Retrieved from: http://www.eluniverso.com/noticias/2015/03/12/nota/4651466/rendicion-cuentas-wwweluniversocom?src=portada on November 15, 2015

[3] Retrieved from: http://www.eluniverso.com/2009/12/04/1/1356/aprobado-iva-papel-periodico.html on November 13, 2015.

[4] Retrieved from: http://www.supercias.gov.ec/consultas/inicio.html?height=578#, on November 14, 2015.

In spite of this, an effort is evidenced by digital publications through its *Web* site, which, according to the ranking www.alexa.com, the *El Universo* website is in seventh place of the most visited sites in the country[5].

This is because 46% of digital users visit the Websites of newspapers, and the newspapers represent 6% of total Internet visits, 0.8% of pages viewed and 1.1% of the total time spent on digital platforms, according to World Press Trends in its report of 2014[6].

Within this context, *El Universo* has made changes to the infrastructure and tries to position themselves on the network either through their website or in their social networks. For this, a description of their activities is included on its webpage, and the potential benefits for users and sources of income of which their budgets are supplemented. The business then begins to become increasingly complex-despite innovation, the main income still comes from the sale of copies and print advertising.

El Telégrafo. Founded in Guayaquil on February 16, 1884. It was given this name because Ecuador had access to the telegraph service that year, and was the first newspaper in the country to use that invention.

In 2007, the newspaper, which was on the verge of bankruptcy, was seized by the Ecuadorian State, and a new phase commenced by becoming the first public newspaper in the country. By 2014, more than 50% of the shares of the company belonged to the National Government at the Ministry of Telecommunications and Information Society.

Its website www.telegrafo.com.ec has an average of 1,057,916 visits per month[7]. During an interview Gissel Hidalgo, editor in charge of the Web, says that the work done by the media is not only directed to the website, but also to mobile devices such as iPhone, Android, or Ipads. In that sense, during the last year 4070 applications were downloaded from *El Telégrafo*, 1,718 of which were performed on iPads and 2352 were performed on Android systems.

Social networks: Facebook: www.facebook.com/diarioeltelegrafo that registers a total of 42.919 "likes"; Twitter: @el_telegrafo with 23K followers; Youtube: www.youtube.com/eltelegrafoec con 1.665 subscribers

In terms of structure, this form of media is distributed as follows: a general editor-in-chief, a web platform editor, newspaper operators, promoter of social networks. The digital version of *El Telégrafo* has eight digital journalists in Guayaquil, i.e. where the headquarters of the general management of all digital content is located. While in Quito, the capital of Ecuador, four journalists are responsible for the coverage along with a photojournalist with specific functions that are also in charge of the videos: editing, the written segment of each video, etc.

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[5] Retrieved from: http://www.alexa.com/siteinfo/www.eluniverso.com, on November 15, 2015.

[6] Information retrieved from: http://www.wan-ifra.org/reports/2015/10/01/world-press-trends-report-2015, el 14 de noviembre de 2015.

[7]   Retrieved   from   the   Report   of   Accountability   El   Telégrafo http://www.telegrafo.com.ec/rendicion-cuentas/internas/interior.html?menu=1.3, on November 11, 2015.

El Telégrafo participates with a minimum percentage in the sale of copies, an is subsidized. Even though, it registered losses of more than $ 400,000 in 2013[8].

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However, this media has a multimedia section, which, although limited to videos, is in considerable number, and are highlighted to amplify information about a theme. Specific sections are observed for photos, infographs, maps, and others.

In as far as the business model, we did not observe personal services for digital users such as live spaces in the writing, supplements, and services that facilitate interaction with the user, more than social networks, which are not located in the media's website. Based on the above, one can say that this diary financially depends on the printed version of *El Telégrafo*. For this reason, specific contents are not being created for the digital user.

Comparing the characteristics of *El Telégrafo* with those of *El Universo*, it is seen that the former is more behind than the latter since there is no integration of newsrooms as such. An example of this is that each one has its own editor. On the other hand, it continues prioritizing the printed version, the contents of which are then reproduced on digital platforms such as websites and social networks.

5.1 International models of convergence

The panorama of digital convergence has motivated the creation of specialized cyber-media with a great emphasis on the participation of users, the integration of news items, innovation in the productive routine, and the incorporation of multimedia resources, among other factors.

Within this context, the General Media Group in Tampa, United States comprises an interesting model of a fusion of digital media writing, which was implemented in 2000. Another model that is highlighted in the United States is The *Washington Post*, which, by means of a project of integration, gathered its printed and digital media in one space.

Other dailies such as *The Times*, *Financial Times*, *The New York Times* and *USA Today* have also integrated their copywriting by taking advantage of the resources that both the written and digital platforms offer.

On the other hand, media such as *http://jn.sapo.pt/paginainicial*; *http://www.nytimes.com* and *www.elpais.com*, renewed their products between 2007 and 2008 – providing a great boost to the participation of the users- a strategy that has significantly grown since 2009.

In the Latin American context, we can highlight the examples of *El Tiempo* from Colombia, *El Comercio* de Perú, *La Nación* from Argentina and *El Mercurio* de Chile as initiators of the process of convergence- achieving notable success.

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[8] Información recuperada de: http://www.supercias.gov.ec/consultas/inicio.html?height=578#, el 15 de noviembre de 2015.

5.2 The new consumer

The increase of digital media in Ecuador is due to greater access to IVTs, plus the low costs of connection, and citizens that need to be informed and communicated to in not only national territory, but also in other geographical spheres [2].

"In the case of the Internet, there is a certain paradox with respect to the recipients of the information. On the one hand, there is the possibility of feedback by the users, which enables the author and the media provider to know better their receptors, to know instantly what they think and feel, and what their queries, preferences, and opinions are. On the other hand, the telematics networks convert the users in a universal auditorium. The message may be distributed, received, and frequently answered at any time and from any place"[5].

Taking as a basis this citation, we can see that today the participation of the user in digital mass media is permanent. This does not occur in traditional media, which could make it restricted per se-such as by sending letters to readers, for example.

For Howard Rheingold, who is cited in Pisani and Piotet [15], the main tools of participation in media are: *blogs*, wikis, RSS, *tagging*, social *bookmarking*, sites to share photos, videos or music, *mashups*, *podcasts*, *moblogs,* and others. These tools were consolidated in 2005 with the *Web* 2.0 concept, and enable the user not only to receive information, but also to exchange ideas.

There are various types of interactivity. Alain Lelu and Jean-Claude Marcovici, as cited in Rost [17], highlight two types of interactivity. However, these are centered on communicative interactivity, which coincides in part with these authors. Bretz, for example, speaks about an interactivity between individuals (communicative interactivity), but makes an additional observation in distinguishing two grades of interactivity: one completely interactive and another one mildly interactive.

5.3 Professional Challenges

The demands of media communication are now different to those that we used to have, says José Rivera Costales[9], a multimedia journalist from Ecuador. He added that it is not only necessary to know how to redact a journalistic piece, to design a webpage, or write a news article for the radio and to present it, or to do a report, or prepare a news item for television, but it is also about managing hyper-textuality, multi-mediality, interactiveness, and, above all, those which are promoted by the participation of the users, which have made the media open their eyes to this new communication market.

Additionally, a contemporary journalist should be familiarized with cloud-based computing since they are not just tied to a computer; that mobility is basic at that moment. "It is not that important to know whether in the future these had fused completely –giving rise to a new electro-domestic product, but rather think that convergence is operating in a diverse manner: we used various apparatus to satisfy our desire for information, communication, education, and pastime according to the circumstances and needs" [12].

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[9] Personal interview with José Rivera Costales

In this sense, it is important to highlight that we are facing a situation in which power is in the user's hands, as well as how they consume information and how the time of profession itself is, compared with those that the media require as training for their journalists, and to incorporate within their companies people who are capable of meeting the needs of the users, and converting them in actions and services in the media, Meyer [8] explains it as follows: "In the same way that the development of modern agriculture led to a demand in variety in processed food, the era of information created a demand for processed information. We need someone who places it in a context, who gives it a theoretical framework, and suggests ways of using it".

Within the context of users, it is important to mention the young public (digital natives), whom, based on their particular characteristics, prefer the consumption of digital media. This implies arduous processes of innovation in media companies, which range from the incorporation of multi-tasking journalists to the creation of sections and contents capable of capturing the audience. However, one should not forget the big audience mayor, which has maintained their fidelity to printed media for several years, and which have the greatest capacity of consumption. This implies the segmentation of audiences with individual contents for each one.

6. Conclusions

La convergence of editorials is a means, not an end. The challenge is, on the one hand, in the training of journalists, and on the other, in the capacity of media companies to assume the challenges that implies meeting audiences with more and more diverse needs.

It could be said that there does not exist an ideal model of convergence, which may be assumed in a general way by all the communication media, given that within its design, the following should be taken into account: the social, economic, political and technological context in which the media are developed, which underscore the trends and needs – both the media and the audiences

The cases that have been analyzed, namely *El Telégrafo* and *El Universo*, are a sign of the   integration of newsrooms implies the development of efficient mechanisms in the management of contents, but apart from this, they help to recognize that it is necessary to expand the gamut of services and products aimed at audiences with different needs, because beyond the new structuralization or organization of physical spaces, convergence implies a change of mentality of those who deal with media companies and wish to be part of this great challenge

Both *El Universo* and *El Telégrafo* as a strength of its printed version is that which leads its business models.

The business models of digital media should not only be concerned about creating vast quantities of products and services, but also the quality of these, and that can be adjusted to the needs of the public.

Finally, it is up to Ecuadorian media to describe and innovate the tools for the creation of contents, and take maximum advantage of the latest generation technology. Within this context, it is necessary for mobile technology to be developed and include as an additional element of the work of newspaper newsrooms- namely

that which we should add professional convergence, which helps to innovate the journalistic exercise.

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Part VI
Pervasive Information Systems

Pervasive Patient Timeline for Intensive Care Units

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Abstract. This research work explores a new way of presenting and representing information about patients in critical care, which is the use of a timeline to display information. This is accomplished with the development of an interactive Pervasive Patient Timeline able to give to the intensivists an access in real-time to an environment containing patients clinical information from the moment in which the patients are admitted in the Intensive Care Unit (ICU) until their discharge This solution allows the intensivists to analyse data regarding vital signs, medication, exams, data mining predictions, among others. Due to the pervasive features, intensivists can have access to the timeline anywhere and anytime, allowing them to make decisions when they need to be made. This platform is patient-centred and is prepared to support the decision process allowing the intensivists to provide better care to patients due the inclusion of clinical forecasts.

Keywords. Pervasive Patient Timeline, Intensive Medicine, Intensive Care Unit, INTCare, Patient-centred, Timeline

1 Introduction

Over the years, technological devices and information systems have been introduced into medicine with the purpose of increasing the quality and efficiency of the health care facilities in the patient best interest [1, 2].

In the Intensive Medicine field several medical equipment was introduced into the Intensive Care Units (ICU) resulting in an increase of the amount of data available [3] (e.g. ventilators, vital signs monitors) in real-time. The high number of data available can be a problem because they also can be overwhelming to deal with, hindering their ability to combine all the information, analyse it and make a decision [4].

Another important aspect is also the fact that almost all of the device presents the information in its own unique way, be it graphs, tables, text or any other format, resulting in a need of learning about how to interpret each one of the devices.

These reasons gave origin to this research work. In this work a new and interactive platform was developed. It holds in one place data from different data sources (interoperability), homogenizes its representation and sorts it chronologically in order

to simplify data readability and facilitate the understanding of possible cause-effect relations. Therefore the work focus is to help intensivists in the decision making process. The research project was conducted and implemented in the ICU of the Hospital de Santo António, Centro Hospitalar do Porto.

The Pervasive Patient Timeline is a web platform and it presents several characteristics, such as, real-time data, flexibility, adaptability, interactivity, scalability and one of most important, the pervasive access to its features and the context awareness. With the implementation of these characteristics it focuses on addressing the difficulty associated with dealing with too many information presented in different ways by different devices. The Pervasive Patient Timeline looks to sort chronologically and standardize the presentation of clinical information in one platform by gathering the data from various medical devices and presenting it in its interface. In this way intensivists can have a faster and easier access to all the information that they need to make decisions.

Apart from this introduction, the article consists of other five sections. The second section is the Background focused on contextualizing of the work. It is divided in four sub-sections, such as Intensive Care, the INTCare, the Timeline and Pervasive Healthcare. In section three is presented the research methodology used for the development of this research. The next section talks about the Pervasive Patient Timeline, its development and features. The fifth section discusses the work developed and the results obtained, while the last one, Conclusion, makes final remarks on what was achieved and the importance of the research done.

2   Background

2.1   Intensive Care

In field of Medicine there is a branch called Intensive Medicine (IM) which it is responsible for treating patients in serious health conditions and recover them to a health state and quality of life prior to the conditions affecting them [5]. An Intensive Care Unit (ICU) is a critical environment where patients are usually in coma and they are always being monitored [6]. The life support is done using many technical devices in order to ensure that the patients can get back to the previous health state [7]. These devices, like bedside monitors collect and present patients' data in real-time allowing intensivists to have a better understanding of the patients' condition.

2.2   INTCare

The INTCare system is a Pervasive Decision Support System (PDSS) developed as part of a project with the same name. It is responsible for modernizing the information system of the Intensive Care Unit of the Hospital de Santo António, Centro Hospitalar do Porto (CHP). The system acts autonomously and in real-time, and it is composed by four subsystems that interact between each other through intelligent agents: Data Acquisition, Knowledge Management, Inference and Interface [6, 8].

The purpose of the INTCare system is to help intensivists in the decision making process, by providing capabilities such as monitoring patients' conditions, predict clinical events, like organ failure [9], length of stay [10], readmission [11], among others, and issue alert messages when the patients being monitored have vital signs outside of the normal range [6]. In this way it is ensured that the intensivists have an easier job but also the patients have a better and safer care. The new knowledge that the system provides helps the decision making process

The Pervasive Patient Timeline was developed under the phase II of the INTCare project, therefore it is going to be integrated with the existing INTCare system, taking advantage of its features.

2.3   The Timeline

The timeline is one of many common ways of representing graphically information. Its most characteristic feature, which distinguishes it from others, is the fact that it displays its content sorted chronologically.

The representation of information in a timeline format allows to observe when certain events happened, the duration of the event and the time between the events, overlaps between events, among others. The granularity of the timeline is also an important part of its design, because it will define the level of detail we want for it.

Historically, timelines have always been used to catalogue events of various types, such as, wars, diseases, revolutions, discoveries, epidemics, among others [12]. In the field of medicine they are commonly used in records concerning diseases outbreaks, studies, but also on the daily practice. In Intensive Medicine they are also presented in the monitoring of blood pressure, heart rate, among others [13].

Nowadays with the advances in technology it is possible to visualize and interact with timelines digitally, allowing to change content without having to redo the timeline, with no space limitations, adding categories to the content displayed, among others [14]. Finally the representation of information using timelines allows the observer to see the data sorted chronologically, understand better the relationships between data, especially cause and effect situations.

2.4   Pervasive HealthCare

Pervasive computing is an emerging approach focused on developing intelligent environments where the devices are interconnect and inserted in an environment that offers a continuous, reliable, non-intrusive connectivity with added value. The result of this systems tends to be the improvement of human experience and quality of life without an explicit perception of the underlying interaction between technology [15].

Over the years, technology has evolved towards more pervasive and ubiquitous infrastructures as a result of the increased ease of access to the Internet. As an example of this is the increasing number of mobile devices that are capable of collecting, sharing, storing information [16], but also wireless networks and communications systems [17].

The application of these type of systems and devices on the medicine field makes it possible to create a pervasive healthcare environment where everyone has access to healthcare anywhere and anytime, as a result of the removal of time and location restrictions [17].

Therefore pervasive data can also be seen as data that can be accessed anytime and anywhere. In critical environments, such as Intensive Care Units, where the decisions need to be made at the right time, the complete information needed to make an assessment is not always available there. Being not possible to overcome all medical errors, the pervasive data approaches can facilitate the data distribution. Healthcare quality can be enhanced through the reduction of information redundancy and allowing it to be stored in mobile devices or in situated devices available in the locations where decisions will be made [18]. An example of pervasive data is the system which sent alerts from the monitoring patient system. These alerts are sent when patients are out of the normal range of the attributes monitored.

In general pervasive healthcare helps healthcare professionals by creating an environment allowing them to access information anywhere and anytime.

3   Research Methodology

The development of this research was done under the Design Science Research (DSR) methodology, in order to ensure an appropriate orientation for the research life cycle. The DSR consists in a set of analysis techniques and perspectives use in research in Information Systems. According to Peffers [19], the DSR is composed by six activities: Identify Problem and Motivate, Define Objectives of a Solution, Design and Development, Demonstration, Evaluation and Communication.

In the context of the research, the iteration process had a beginning centred on the problem, having started in the moment of problem definition and its importance. The first activity, Identify Problem and Motivation, is focused in understanding how the implementation of a pervasive timeline could improve the decision making process. In the second activity, Define Objectives of a Solution, the objective of the research was established in which it is the development of a pervasive timeline capable of providing new knowledge and facilitate the decision making process in clinical environments, without space and time restrictions. The third activity, Design and Development, consisted in executing tasks with the purpose of designing the characteristics of the artefact, followed right after by the development of the artefact itself. In the fourth activity, Demonstration, clinical data of patients were incorporated into the pervasive timeline, as a way to simulate and present the disposition of the information in the timeline. The fifth activity, Evaluation, a set of metrics responsible for the evaluation of the Pervasive Patient Timeline performance in the clinical environment was defined. Lastly, in the six activity, Communication, some scientific papers were written and published in journals and conferences, in order to express the importance of this work.

4   Pervasive Patient Timeline

The Pervasive Patient Timeline can be seen as a Clinical Decision Support System (CDSS) having as main objective to support the decision making process of intensivists in clinical environments. It can be done by centralizing data from various data sources making it interoperable and presenting it in a more standardized, concise and easy way to understand. The platform works in real time, without location restrictions and it allows to observe the clinical history of patients from the moment they were admitted into the Intensive Care Unit until their discharge. Therefore it is possible to access to past and present information, but also future predictions through the incorporation of Data Mining models' results into the timeline. The data presented in the timeline is acquired by the INTCare system in real-time and treated through the application of an Extract Transforming and Load (ETL) process to ensure the quality of the information acquired.

4.1   Data Source

The clinical data used for the development of the Pervasive Patient Timeline was provided by the Intensive Care Unit (ICU) of the Hospital de Santo António, Centro Hospitalar do Porto (CHP). The data is retrieved from six different data sources:

- Vital Signs Monitor (VS) – this source is where patients' vital signs, such as, temperature, heart rate, blood pressure and many others are measured and presented;
- Laboratory (LAB) – the laboratory is responsible for holding the results of patients' exams, like potassium, sodium, leucocytes, urea, among others;
- Drugs System (DS) – this system is responsible for recording the therapeutic plans prescribed to the patients;
- Ventilation Monitor (VM) – in the ventilation monitors are collected data relative inspired oxygen, pulmonary compliance, positive end-expiratory pressure, among others;
- Electronic Nursing Record (ENR) – in this data source are presented all the clinical data validated about patients and human registered;
- Electronic Health Record (EHR) – here are kept the data concerning patients' admission and discharge, chronic diseases and such information that describe the medical history of the patients.

4.2   Requirements and Features

The development of this Pervasive Patient Timeline underwent a process of trying existent timeline software and then change and adapt them to the needs of the clinical environment, in order to fulfil the research objective. The choice process was based on an analysis conducted on each of the experimented timelines. The timelines were evaluated based on their features, interface, documentation, development time and extra functionalities. The timeline which was scored highest was selected as the one to use as a base of development. For the development the XAMPP platform was used

along with the programming languages, PHP and JavaScript. Oracle SQL was used to treat the data before adding it to the timeline. By the end of the development process the following features were implemented:

Data:
- Possibility of loading into the timeline data retrieved from databases of different data sources.

Granularity:
- Maximum: 15 to 15 min;
- Minimum: Decade to Decade.

Usability:
- Choose a patient from a list to visualize his data in the timeline;
- Choose the type of data to visualize: all data or only critical data;
- Slide horizontally the timeline, in to visualize past and future events;
- While visualizing the timeline, zoom in and zoom out the granularity;
- Filter the categories of data visible in the timeline;
- Adjust the events time according to the time zone;
- Find events by searching for words in title or description;
- Click to go to the next or previous event;
- Define a date and advance to the defined moment.

Event Features:
- Title, absolute values of the first hour and maximum, minimum and average hour values;
- Event description, which can contain text, images, links;
- Events with start and end date;
- Capacity to add events to different categories;
- Indicator called importance level that defines the granularity at which the events can be seen (can be important when there are too many events cluttering the timeline).

Since the Pervasive Patient Timeline is a platform, it has some system requirements that are needed for it to function properly:
- Internet access;
- Interoperability with different systems;
- Context awareness;
- Privacy of access to data presented;
- Continuous access to data;
- Database infrastructure.

As main characteristics of the Pervasive Patient Timeline it is the fact of it works in real-time by presented the data collected in the moment; it is flexible and adaptive, allowing the possibility to add new different events to the timeline (e.g. other data sources, data mining models); it is scalable since it allows the increase of data present in its system; its pervasive aspect makes it possible to access the data from the timeline in any location and anytime and lastly, its interactivity provides a more engaging way of data visualization.

4.3 Timeline Interface

In Figure 1, is an overview of the Pervasive Patient Timeline. In this figure is data concerning a patient admitted into an ICU. Specifically, there is information retrieved from the hospital's VS, VM, LAB, DS, EHR and ENR data sources. In this figure is possible to consult critical events (as red), patient admission information and choosing the data sources. As example of event description of an event is possible consult maximum, minimum and average values of the hour, along with the respective unit.

Fig. 1. Example of the Pervasive Patient Timeline

Data mining (DM) predictions which provide the estimated probability for the event that the data mining model covers, were also added to the timeline (Figure 2). With this feature intensivists can start planning ahead before a predicted event occurs. This feature can help reducing costs and manage resources. In this case Data Mining models were developed to predict the vasopressors need [20]. The figure is presenting the probability of a patient need vasopressors in the next hour. Other DM models can be added to the timeline as is predict critical events [21, 22], length of stay [23], outcome, organ failure, sepsis [24] among others,
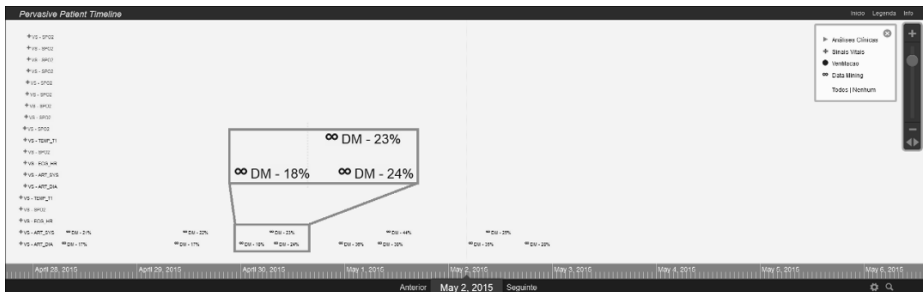

Fig. 2. Data Mining Models in the Pervasive Patient Timeline

5 Discussion

The use of the Pervasive Patient Timeline intends to provide new knowledge in clinical environments, by allowing intensivists to visualize information aggregated from various data sources in only one place and in an innovative way, i.e., the timeline. Here intensivists can access the information in real-time and without place restrictions, allowing them to consult the data when the need arises. The presentation of data sorted chronologically is another of its main features that eases the understanding of cause-effect relations between data and the finding of patterns, which it is fundamental in a critical environment such is Intensive Care Units.

Its interface provides an easy and intuitive control over the information in the timeline. The Pervasive Patient Timeline holds information related to vital sign monitors, laboratory exams, drugs, ventilation monitors, electronic nurse record and electronic health record. It allows to see past historic data, current data and future predictions by using data mining models to make such predictions. The data presented is part of the INTCare system, so the autonomous agents perform ETL tasks in order to provide data with quality. This task is important because intensivists need retrieve information with quality in which it will result in a more accurate and safer health care given to the patient.

The pervasive aspect of the timeline and the incorporation of data mining models are very important to improve the decision making process. In the first case it makes possible remote access to the timeline content at any moment, and the second because it makes future predictions over the patients' condition, allowing the intensivists to act in advance. Together, the artefact developed allows a more pro-active approach in the patients' best interest.

In the big scope, the Pervasive Patient Timeline allows the intensivists to acquire new lines of thought that lead them to consider relationships between the data that otherwise they would not consider.

6 Conclusion

The development of the Pervasive Patient Timeline showed that a new and innovative way of presenting information can, not only facilitate the job of intensivists, but also increase the quality of care given to patients, through the reduction of medical errors associated to the difficulty in crossing too much information. It covers a new approach in visualizing information which can be adopted in other similar situations. This flexibility allows for an easy addition of new data sources or data mining models in order to increase the amount of data presented on it, and therefore improve the quality of decisions made.

Its pervasiveness allows it to be accessed anytime and anywhere, through various and different devices. This option allows a simpler, accessible and functional access to the data and knowledge provided by the INTCare system.

This work proved the viability of adopting timelines as a way of visualizing clinical data of patients. It highlights the importance of a good and pleasant representation and presentation of the data, which can affect positively the decision of

the intensivists, but also the importance of having only one platform that aggregates, homogenizes and displays distinct data, allowing for a faster, easier and intuitive access. Intensivists are also motivated to use the solution developed and its features, particularly the presentation of all patient's data sorted chronologically. Other positive aspect is the possibility of aggregating data from different data sources in the same location and the ability to access its information anywhere and anytime when they need to make decisions.

This new approach is important for Intensive Medicine, an environment with many technological devices that are constantly collecting and processing big amounts of data in real-time. All the collected data (with a date associated) can be incorporated into the Pervasive Patient Timeline in order to help the intensivists to make better and faster decisions in the patient's best interest. In the future some new models and data sources will be incorporated in the pervasive patient timeline. At same time the artefact developed will be also evaluated by the users (intensivists).

Acknowledgements

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iRecomendYou: A design proposal for the development of a pervasive recommendation system based on student's profile for Ecuador's students' candidature to a scholarship

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Abstract. All recognized successful Ecuador's students have the opportunity to apply for a scholarship abroad within a set of relevant world's universities listed on-line on SENESCYT's website. Students are invited to choose from a list with more than 1500 universities. From those, they only have no more information than each university general URL address. Considering student's limitation to compare and analyze all available courses it is frequent to exist students that complaint about their selection due their capacity to understand all available possibilities. Along this work we develop a proposal design for a pervasive recommendation system based on students' profile for scholarship's application based on their profile and universities programs' main characteristics.

Keywords: Pervasive; Recommendation systems; Profiling.

1 Introduction

Actually almost all countries and almost all developed societies had adopted technologies to support their activity. Nowadays is often to have innumerous examples whereas all the process (application, processing and results) is based on technologies. Countless an individual has little or no personal experience to make choices among the various alternatives presented to it. This happens by questions of time (normally on-line procedures don´t have too much time to be executed) or by the large alternatives presented – normally impossible to evaluate and consider all of them.

Pervasive systems consists of a large set of networked devices, seemingly invisibly embedded in the environment [12] Pervasive systems research was introduce in '80s at Xerox PARC. From de beginning a diversity of application domains have been proposed for pervasive systems, e.g., education [13], [15], public spaces [16] or health care [17][18].

In this work the proposed design solution it will focuses on the availability and manageability issues of pervasive systems. Here the goal is to find dependability

mechanisms and structures inside websites contents databases that (1) maximize the information required for support user decision, while (2) minimizing user's involvement cost of operation (basically time and effort). Informally, we it be used the term pervasive to refer to these two requirements [22]. Regarding pervasive computing concept, it admits that computing resources might be perceptible or imperceptible distributed related to the user environment (context-awareness). Context-aware applications promise richer and easier interaction, but the current state of research in this field is still far removed from that vision [14]. That is, users´ don't need to understand where system takes place or where to which devices is connected.

Considering options to handle with decision making support, it is possible to identify some scenarios, such as: trusting and using recommendations being passed by others, which can get directly (word of mouth) [2] or given by recommendation texts, reviews of movies and books reviewers, printed newspapers, social networks, among others.

The recommendation systems help to increase the capacity and effectiveness. This nominating process is already well known and established in the social relationship between humans [3].

In a typical recommendation system, there are sources of information (valid and accredited) recognized as recommendations input data, to the system that aggregates and directs (system processing) for individuals potentially viewed interested in this type of advise (target or user). One of the great challenges for this type of systems is to achieve the right mix between the expectations of users and the products, services or people to be recommended to them, that is, define and discover these interests' relationships.

This work focuses the development of design proposal for a recommendation system to solve a specific problem presented by Ecuador's national superior education secretary (SENESCYT): which program should a student select from a list with more than 1500 universities and 3000 possibilities (estimated student options by each scientific area).

From the beginning some conceptual definitions about recommendation and pervasive systems and will be presented (section two and three). Thereafter it will be discussed different sources of data (section four) and the strategy for the recommendation method (section five). Then the architecture is presented (section six) followed by results and conclusion at the closing section.

2   Recommendation systems

The proponents of the first recommendation system called Tapestry [3],[4] coined the term "*filtering collaborative*", aiming to designate a specific type of system in which the filter information was performed with human aid, e.g. the collaboration between stakeholder groups. Thereafter, same authors considered that could have another type of recommendation based on the content, that is, one element just might be considered as recommender if it was familiar, updated and contextualized with the subject: *context-based filtering*. Therefore they assumed that *collaborative filtering*

and *content-based filtering* systems are types of recommendation systems applying different approaches, but have the sole purpose of the recommendation.

Others authors [5] highlighted and proposed that there is a third type of filter referred to as demographic information filtering. *Demographic filtering* uses the description of an individual (profile determination) to learn the relationship between a particular item and the type of person that would come to be interested. This approach uses descriptions of people how to get learned the relationship between an item and the type of person who would like this. The user profile is created for classifying users in stereotypes that represent the characteristics of a class of users. Personal data is requested to the user, usually in registration forms, and used as characterization of users and their interests.

Later another's authors [6],[7] introduced two other techniques. In the first, entitled *filtering based on knowledge*, the recommendation of the items is done based on user preferences of inferences and their needs through structured functionally knowledge; the second technique, entitled *utility-based filtering*, the recommendation is made considering the utility of items for a given user.

Currently e-commerce websites are the main players recommendation systems use and exploration. They use different techniques to find the most suitable products to their customers and thus increase profitability. Introduced in July 1996 MyYahoo was the first website to use recommender systems in large proportions, using the customization strategy [8]. Currently, a large number of websites employ recommendation systems to bring the different user types of suggestions, as cross related offerings (something like, "customers who bought X also bought Y item"), or selling items on each customer´s favorite categories, among others.

This work focuses the development of a recommendation system to solve a specific problem: which program should a student select from a list with more than 1500 universities

2.1 User profile

The *identity* it is one of the most important related to recommendation objectives where's individuals' objectives, subjectivities and features, emerges. Recommendation systems use individuals' identity in order to provide clues on future behavior and needs of users such as in a given environment where customization becomes effective. In computer science, algorithms used to formalize individuals' identity on a given computing environment are based on *User Profile* determination.

On the web, there are many types of user profiles with different degrees of complexity. They are developed in the context of e-commerce, e-learning and e-community, among many others. Nevertheless there are some researchers [9][10] that had developed shell's for users models pointing, as example, categories of information about users in order to better customize the web applications [9] or to model specific users, such as, model of students' profile for learning activities [10].

The user profile might be used to predict user´s needs and behaviors in a computing environment.

To determine a user profile it is necessary to use strategies. On the web, two of the most common forms of user identification are:

- ▪ On server: systems' usually provides users with a registration area where's beyond username/password, with personal data such as name, date of birth, sex, address and others. These data is stored in a database on the server. Whenever the user accesses the system, he may make his identification / authentication updating their previously registered login. This mechanism allows the website identify more accurately the user that it connects;
- ▪ On the client device: normally use cookies, a mechanism by which a website can identify that particular computer is connecting once again it. This method assumes that the connected machine it is always used by the same person. So to identify the machine, the website is in reality identifying its user. This is a simpler mechanism than the identification through the server, but less reliable, especially if the identified computer is used by more than one person.

Thereafter user identification process, it is possible to collect data about him, implicitly or explicitly, thus allowing the generation and maintenance of their profile. In the explicit collection mode (also known as customization), the user spontaneously indicates what is important to him, improving his profile determination and explicit

3   Web Crawler

Given the current volume of data on the Web, an automatic, methodical process of content indexing becomes extremely necessary. It is in this scenario that the web crawler is present searching, filtering and often persisting content. One of the most powerful known web crawlers is the googlebot, Google's web crawler, he is responsible for scrub the web, looking for new pages to index and analyze whether the existing pages were updated. A Web crawler, which is also known as spider or web robot web, is a software agent used to automate research, data gathering and extraction. Usually trafficked in HTTP along with the TCP/IP model, the most developed robots are meant for the traditional web where *html* documents connected by *hyperlinks, tags* and *keywords* are used to track and meet specific needs as download images and files, mining of e-mail addresses, collection of specific contents for price quote for a particular product or service and can also be developed to aggregate data from various internet sources, among many others conveniences.

These agents are not limited to a specific language actually, since it is possible to extract and apply regular expressions obtained over the contents, any language can be used for the implementation of web crawlers.

The basic structure of running a crawler is not very complex, though the same cannot be said for its implementation. See a model of the basic structure of a crawler in Figure 1.
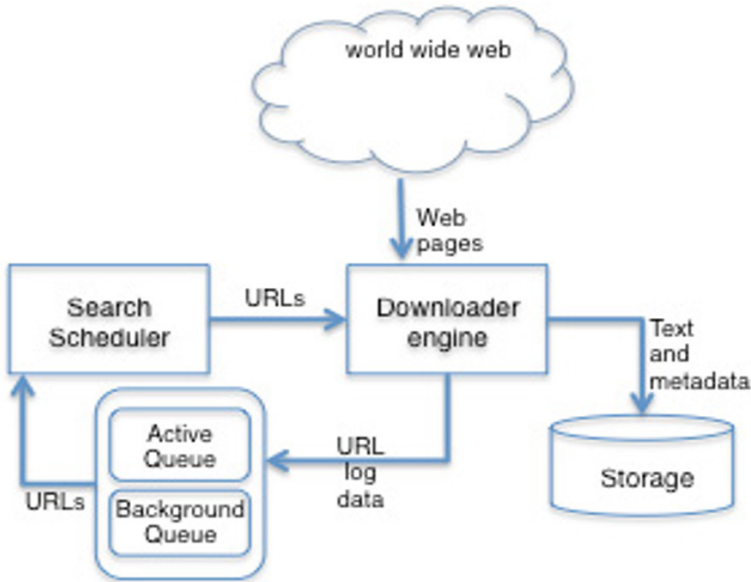
Fig. 1. web crawler's basic model structure. Adapted from [23]

General web crawler's activity steps goes around a content request, which is set in a scheduler. From the scheduler, a list of URLs is passed to the downloader engine, which acts as a multi-threaded download sniffer. This component is responsible to search over through in order to find out the requested webpages referenced on scheduler. All successful web pages found are saved on a specific storage (text and metadata for post processing). Unsuccessful analyzed URLs are posted in a queue (active queue) in order to be included in new late scheduler. The crawler queue storage also includes a background queue, in order to support background updates, to be programmed in order to update some specific URLs related data. The scheduler alignment and downloader engine (extraction process) are inherent in any process of crawling, regardless its objective or technology used.

As noted previously, the crawling is not tied to a web contents, indeed it is possible to act on various types of sources. Thus it can be used over different protocols such as HTTP SMTP, FTP, and others. Once selected the protocol, the agent take a request to the data source, which ultimately return the desired content, which will be working for the extraction of information. The protocol used in this article will be explained more technically below.

3.1 Web crawler at work

The crawler starts with a list of URLs seeds to visit. This is constructed and introduced at user/system request. During crawling work, the application visits these URLs, it identifies all the possible hyperlinks in each page that corresponds to the overall search objectives. Not all visited URLs revels positive results. Here it was considered three different types of possible outcomes: not correspondent contents;

positive contents; unavailable page. Whenever a URL is inaccessible, the application put that address in a queue list. On other side, there is the possibility to select some URLs by their importance to be included on background queue. Each URLs in this queue list is visited periodically (programmer defined) in order to have updated information.

When there is large volume of URLs to explore implies that the crawler can only download a limited number of the web pages within a given time, so it requires to prioritize its downloads. To that end all returned retrieved data (text, metadata, images, among any other type) from analyzed web pages are stored in table, to be delivered and used by the user and also to act as cache for next visit (avoiding all retrieval process over previously visited pages). Generally web crawler's behavior is the outcome of a combination of policies:

- *selection policy*, to determine and define the URLs to analyze and download;
- *re-visit policy,* to consider the set of URLs that might be considered relevant and therefore to be monitored;
- *politeness policy*, despite this doesn´t have direct influence on application results, it should be considered in order to avoid targeted web sites' traffic overload;
- *parallelization policy*, regarding web crawler running multiple process.

As described in the next section, considering the objectives for the current design proposal these policies were considered in terms of search scheduler, download engine and queue list definition.
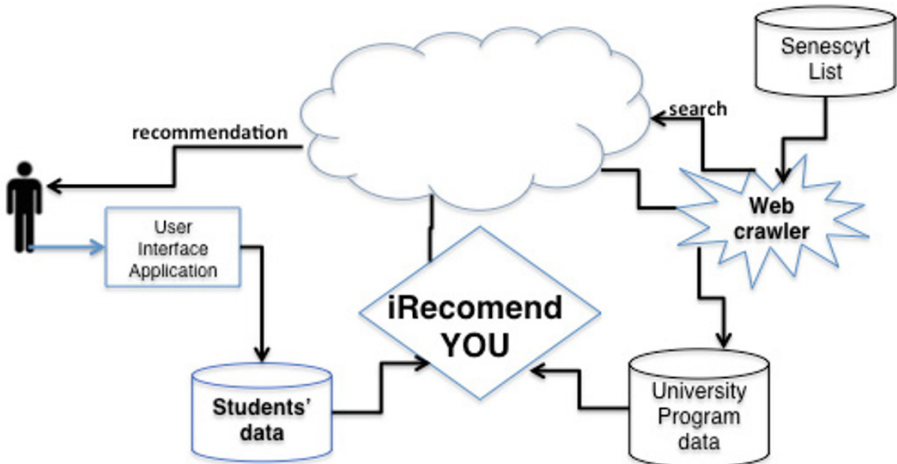
4   Design Proposal

Fig. 2. Proposed iRecommendYOU framework design's structure.

The design proposal, as depicted in figure 2 involves three main components: from user side (student's objective fulfillment); web exploration (data gathering from web) and recommendation system (iRecommendYOU). System's workflow begins with

user's profile determination that will determine the set of URLs to be analyzed. Next, using the web crawler application, the system will collect data from related web pages, that will be stored on a data structure. At the end, using a recommendation algorithm, the system will provide the user with the results that better fits with his profile.

4.1 User profiling and objectives fulfillment

User profiles are generally represented as sets of weighted keywords, semantic networks, or weighted concepts, or association rules. Keyword profiles are the simplest to build, but because they fundamentally have to capture and represent all (or most) words. This technique requires a large amount of user feedback in order to learn the terminology by which a topic might be discussed [23].

This proposed user profile system incorporates a registration section where's user's needs introduce some personal preferences (questionnaire) and personal data (curriculum vitae). Moreover students would be are required to fulfill a questionnaire, that will. As illustrated on figure 3, user's profile is determined through two sets of data: the first considering academic preferences and curriculum; the second, related to a questionnaire previously fulfilled by the student. This questionnaire it is presented by SENESCYT in order to have a standard source of data and covers a variety of subjects' information such as students' preferences, professional options or research investigation interests. The profile is constructed using the most keyword descriptors on user's data. The profiler module uses a knowledge base in order to search, evaluate and define user's profile
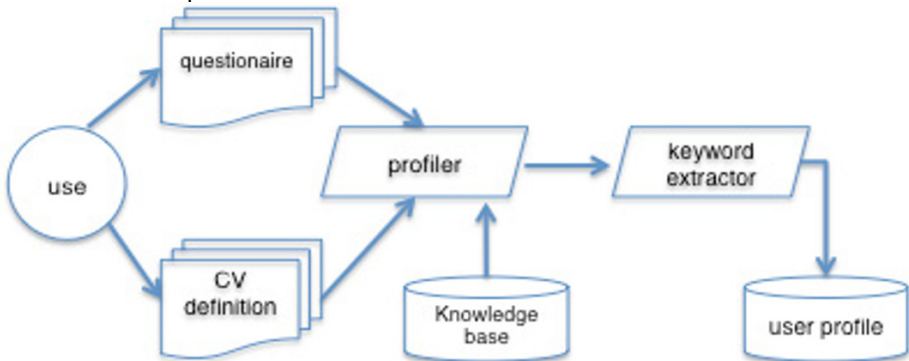

Fig. 3. Users' profile system.

Keyword-based profiles are initially created by extracting keywords from Web pages collected from some information source, e.g., the user's browsing history or Bookmarks[23]. To calculate user's profile it is used the keyword's weighting technic to identify the most important keywords from user's curriculum and questionnaire data. Often the number of words extracted from a single document is capped so that only the top N most highly weighted terms from any page contribute to user's profile [23]. The keyword extractor module will determine final user profile using all keywords extracted and registered on user's profile storage.

4.2   Data gathering

This accomplishment is performed by the web crawler application in order to explore and retrieve data from SENESCYT's universities URLs list (a set of pre selected universities across the world to which students may apply for a scholarship grant).
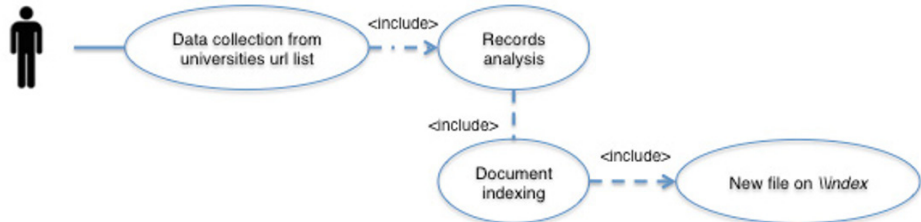

Fig. 4. Data gathering.

As depicted above on figure 4, the web crawler starts with a single URL, collected from universities url's list, downloads that page, retrieves the links from that page to others, and repeats the process with each of those pages – records analysis. Before long, web crawler discovers links to most of the pages on the Web, although it takes some time to actually visit each of those pages – document indexing.

The implementation of this algorithmic might be developed based on Apache LuceneTM, which is a high-performance, full-featured text search engine library. It is a technology suitable for nearly any application that requires full-text search, especially cross-platform. [24]

4.3   Decision support supported by recommendation systems

The recommendation is performed based on match work between the user profile and the programs that have a set of descriptors and keywords similar or on the same scientific area.

This recommendation system allows on this way a customization, over the short list of programs that meet the user's needs or expectation's [1]. From the computational point of view, one system capable of treating each user individually requires a set of specific functions, as example, through constant selection of related program to user interests, a personalized system can reduce the time they take to find relevant information. The user will have a list of possible programs that match his profile. That list has in each record, the program name, the university, the origin country, the set of keywords used to select the program and a matching estimator between user profile and program descriptor. Over the list the user may perform some actions such as select, download related program and create wish list for future analysis.

The system additionally, may identify relationships between items (e.g., "those who view the program X also analyzed the program Y").

5　Discussion and Conclusions

Considering the lack of information from both sides of the problem (candidates and financed programs) it was necessary to propose a valid solution that allows both, users' profile (student) determination from questionnaire and personal data, and data gathering (programs) work from a single url information. The research work was developed towards a solution that covers data collection (candidates and programs) for automatic filtering and analysis in order to support the recommendation action. The recommendation work would be supported by a set of rules that would be matching users' profile main characteristics with main programs' descriptive (scientific area, research lines and objectives) keywords.

Therefore this paper, based on developed work, presents a possible solution for system development in order to solve a problem presented in a national secretary for superior education and investigation.

All proposed development system and solution are based on related works and also on related bibliography.

For future word it is planed the development of this solution and make it available for the large community of Ecuadorian students that every year looks for scholarship opportunity.

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Pervasive Decision Support to predict football corners and goals by means of data mining

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Abstract. Football is considered nowadays one of the most popular sports. In the betting world, it has acquired an outstanding position, which moves millions of euros during the period of a single football match. The lack of profitability of football betting users has been stressed as a problem. This lack gave origin to this research proposal, which it is going to analyse the possibility of existing a way to support the users to increase their profits on their bets. Data mining models were induced with the purpose of supporting the gamblers to increase their profits in the medium/long term. Being conscience that the models can fail, the results achieved by four of the seven targets in the models are encouraging and suggest that the system can help to increase the profits. All defined targets have two possible classes to predict, for example, if there are more or less than 7.5 corners in a single game. The data mining models of the targets, more or less than 7.5 corners, 8.5 corners, 1.5 goals and 3.5 goals achieved the pre-defined thresholds. The models were implemented in a prototype, which it is a pervasive decision support system. This system was developed with the purpose to be an interface for any user, both for an expert user as to a user who has no knowledge in football games.

Keywords. Data Mining, Bets, Pervasive Decision Support, Football, Corners, Goals

1   Introduction

Betting on sporting events these days is a fashionable activity. The sport that arouses more interest and it has more fans in the world is football. There are several bookmakers such as is Betfair, Bet365, and Bwin that allow you to perform a wide range of betting, and if you can bet on the outcome, you can bet on the number of goals, number of corners, etc. The number of bookmakers have grown greatly in recent years, leading to the conclusion that this is a profitable business for them at the expense of its users. This project appears with the aim of increasing the betters' profits.

This project is focused on the induction of data mining models. After evaluation these models a Pervasive Decision Support System prototype was implemented. This project distinguishes itself from other platforms due the use of several Data Mining techniques. This article focuses on the release of the first results obtained in the forecast number of goals and corners in the 2013/2014 English Premier League season.

The methodology used to develop this project was the Design Science Research. This methodology is applied when the goal is to develop technology-based solutions to important and relevant business problems [1].

The best models achieved an accuracy between 78% and 82% to predict 7.5 and 8.5 corners and 1.5 and 3.5 goals.

The article is divided into six sections. The first section contains a brief introduction of the project. In the second section is presented a bibliography review. In the third section is presented the methodology used to develop the project. In the fourth section is displayed the development of the completely practical work. In the fifth section is conducted a discussion of the obtained results in the realized tests to the prototype and in the last section is presented the conclusions and suggestions for future work.

2 Background

2.1 Knowledge Discovery, Data Mining, Decision Support and Pervasive Data

Knowledge Discover in Database (KDD) is a modelling and automatic exploratory analysis of large data repositories. It is an organized process that aims to identify useful patterns, which can be understandable, in large and complex dataset [2]. It is an interactive and iterative process where interaction of a responsible for making decisions is required at various stages [3]. The basic framework is divided in five main steps: Selection, Pre-processing, Transformation, Data Mining and Evaluation [4].

Data Mining is the process of discovering patterns and interesting knowledge in large amounts of data [5]. It is considered a key process to any organization [6]. DM contains technical activities that can be subdivided into two major focuses of research, according to the analysis to be achieved, it can be interpretive or predictive analysis [4].

Decision Support Systems (DSS) can be described as an interactive computer system that supports managers to make decisions related to attributes, goals and objectives, to solve semi-structured and unstructured problems [7]. The purpose is giving support to problems solving them by following the development stages of the decision-making process [8]. Simon [9] defines the decision-making process as having only three phases, Intelligence, Design and Choice. Years later, Simon [10] and many other authors defined a fourth phase, Implementation and a fifth phase Monitoring.

Pervasive computing focus on taking the technology from centre stage to the "background" [11], abstracting the user from its complexities. In order to bring the technology to the background a characteristic named "invisibility" is necessary. This concept means that technology is used unconsciously, removing the need for adaptation or understanding of how to utilize it.

Pervasive Data is the possibility of putting the knowledge achieved by means of Artificial Intelligence techniques (e.g. Data Mining) available anywhere and anytime, running in background being the process totally hidden to the user.

2.2   Football Gambling Support Systems and related work

The activity "bet" is an industry that is expanding. There are more and more bookmakers. The activity focus occurs online, each online betting company has their own odds and betting exchanges. Bets on football matches are the most common. Being the result the bet that moves more money. The bookmakers tend to innovate and other markets have emerged, such as the number of corners and number of goals. This is an interesting area to develop research works. However, it is very difficult to control the game variables. A little change in a game can modify the bet result. Due to this fact, the number of gamblers with big winners is lower. The idea of earning money by making bets is a very interesting subject, but at same time it is very dangerous (the gambler can lose a lot of money).

For that reason, there are several suggesting system on this area. There are some web platforms with the same goals. However, they are not using DM techniques. There are also mobile platforms using mathematical calculations which is the case of applications, "KickOff", "Smart BET Prediction "and "FootWin".

Some scientific studies were conducted in this area. Owramipur et al [12] intend to make the prediction of the results of the Barcelona games in the 2008/2009 season. Joseph et al [13] Effected identical to the previous work, but the team under study was Tottenham. Rotshtein et al [14] effected a study that aims to predict the results of the Finnish League. Tsakonas & Dounias [15] through its study were intended predict the results of the Ukrainian league and what would be the winner of the championship. Nunes & Sousa [16] created a model that predicts the results for the Portuguese league. Ulmer & Fernandez [17] aimed to make the prediction of the English Premier League results. Hucaljuk & Rakipovic [18] did a study in order to predict the results of games in the Champions League. And finally Suzuki et al [19] did a job that has the objective of predicting the outcome of the 2006 world championship.

3   Pervasive Intelligent Decision Support System

3.1   Phase 1

The main purpose of this phase was to identify the problem or opportunity that could be exploited. In this case has emerged one opportunity, to support the gamblers in football games on the decision about which it is the bet more "safe" to carry out in a certain game. This opportunity has been identified after check the increase of the number of bookmakers in the last decade. This reality shows that it is a profitable market for the bookmakers, and therefore detrimental to its users, being in some cases the user profit equal to null. To explore the context a research was carried out in order to understand the business and the environment by gathering information about the business.

First, there was an effort in finding an open-access database containing a high number of statistical variables associated to football matches. After a depth research a database were found (http://www.football-data.co.uk/). This database contains a relevant number of football games variables. Some other variables can be used (e.g.

rest time, players ratings) however there is not a database containing this information with the same detail and frequency.

3.2 Phase 2

After a review of the existing information related the statistical data related to football games the dataset was created using the data found on the website "football-data-co.uk", the dataset only contains continuous records between 2000 and 2014 football games involving 41 distinct teams, the variables related to the half-time were not considered. The variables contained in that dataset are Match Date (dd/mm/yy); Home Team; Away Team, Full Time and Half Time Result (H=Home Win, D=Draw, A=Away Win); Crowd Attendance; Name of Match Referee and Betting odds data from several bookmakers. For each team (home and away) the dataset contains: Full Time Goals; Half Time Goals; Team Shots; Shots on Target; Hit Woodwork; Team Corners; Fouls Committed; Offsides; Yellow Cards; Red Cards. This dataset contains information from 5320 games.

   After the data are collected, a treatment and data processing phase was executed. For this, it was used an Extract Transforming and Loading (ETL) process which it is presented in the Fig. 1.
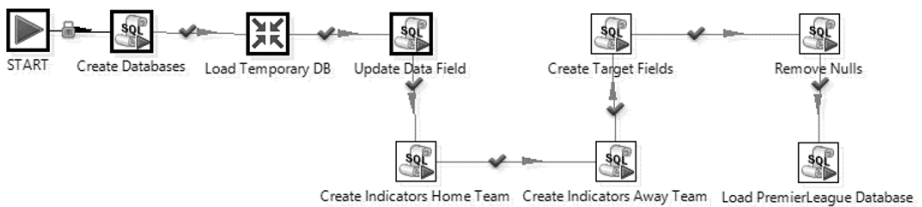

Fig. 1. ETL Process

The "PremierLeague" database was fully treated and it only contains the data that will be needed to the DM models (variables present in the final table). This variables are, "season", "day, "month", "year", "home team (HT)", "away team(AT)", and it is also composed by several variables one for each team (Home and Away): "AVG Goals", "AVG Goals Conceded", "AVG Shots", "AVG Shots Conceded", "AVG Shots Target", AVG Shots Target Conceded", "AVG Corners" and "AVG Corners Conceded".

   Also in this phase, the Data Mining (DM) models were induced. The models used the data previously processed, which are on the table "PremierLeague", through four distinct DM techniques: Naive Bayes (NB), the Support Vector Machines (SVM), the Decision Trees (DT) and Lazy Learning (LL). To apply these techniques in the induction of the models the Weka tool was used. This tool allows running several algorithms like NaiveBayes, LIBSVM, J48 and Kstar, each one of these algorithms were applied for the above techniques respectively. For the development of the models two different sampling methods were used: Holdout Simple (HS) that uses 66% of the data for training and 34% for testing and the sampling method 10-Folds Cross-Validation (10FCV).

The variables loaded in the table "Premier League" were grouped into different groups to define different scenarios. For this, it was necessary to focus on the characteristics and existing processes in each football game. Each of these groups is composed for two sets, one related to the variables associated to the home team and other by the indicators of the away team. The following groups and the respective variables are Attack (AVG Goals, AVG Shots, AVG Shots Target, and AVG Corners) and Defence (AVG Goals Conceded, AVG Shots Conceded, AVG Shots Target Conceded, and AVG Corners Conceded)

Then it was necessary to define the scenarios through which the DM models would be induced. Eleven scenarios were defined: SA (All Variables), SC (Attack HT and Attack AT), SD (Defence HT and Defence AT), SE (Attack HT and Defence AT), SF (Defence HT and Attack AT), SL (SD+ SE), SO (AVG Corners HT, AVG Corners AT, AVG Corners Conceded HT and AVG Corners Conceded AT), SP (AVG Corners HT and AVG Corners AT), SQ (SC+SD), SR (AVG Goals HT, AVG Goals AT, AVG Goals Conceded HT and AVG Goals Conceded AT) and SS (AVG Goals HT and AVG Goals AT). Therefore, the DM Models (DMM) are composed by:

- Eleven scenarios (SA, SC,…,SS);
- Two sampling methods: 10FCV and HS;
- Four DM techniques: NB, DT, SVM and LL;
- Seven Targets: More or less than "7,5C", "8,5C", "9,5C", "10,5C" corners and more or less than, "1,5G", "2,5G" and "3,5G" goals.

Initially 416 models were induced. 192 related to the target variables related with the number of goals, the "G1,5", "G2,5" and "G3,5" variables and the remaining 224 models were related with the number of corners, "C7,5", "C8,5", "C9,5" and "C10,5". Then for target variables "C7,5", "C8,5", "C9,5", "G1,5 and "G3,5" (which had unbalanced values of the number of instances of each class) 24 more models were induced for each, using the oversampling technique. For each target attribute a total of 121 new models were induced. In total, 537 DM models were induced.

To oversampling an existing function in WEKA was executed, namely SMOTE. This function doubles the number of class instances that contains fewer occurrences and it can be used repeatedly until the classes contain a number of similar occurrences.

A DMM can be represented by the following tuple:

$$DMM = <\Delta, \alpha, DMT, DMSM, DMTG, SCENVAR> \tag{1}$$

Where Δ is the DM rules, α is the DM model configuration, DMSM is the sampling method, DMT is the DM technique, DMTG is the target and SCENVAR are the variables that can be used by each scenario (SA-SS)

For example, if the model chosen is composed by the scenario SO, using as sampling method CV, as DM technique DT and the target which is intended to predict was "3,5G" this tuple can be represented as:

$$DMM=<\Delta, \alpha, DT, CV, "3,5G", HomeTeam, AwayTeam, \tag{2}$$
$$AVGCornersCHT, AVGCornersConcededHT, AVGCornersAT,$$
$$AVGCornersConcededAT>$$

3.3   Phase 3

The third phase of the project is the combination of three distinct phases of the methodologies used for the development of this project. The phase "Evaluation" of the CRISP-DM and the phase "Choice" of the decision-making process. The evaluation of the DM models induced was made in this phase in order to choose which it is the best model to be used. To evaluate all the induced models, the metrics contained in the confusion matrix were used

Using the confusion matrix several metrics can be calculated such as sensitivity, specificity, accuracy and area under curve (AUC). So, to evaluate all the DM models induced four metrics were used.

For each target a set of thresholds were defined to ensure the quality of the models and at the same time facilitate the choice of the best model for each target. If the models do not meet the parameters, it is possible to conclude that the models do not have the quality required to support gamblers in that particular bet. Based on the performed literature review and as it was not possible to contact an expert in football games betting in order to understand what would be the thresholds that models should achieve, the quality parameters were defined with a minimum value of 65% in metrics accuracy, specificity, AUC and sensitivity. Accuracy was considered the most relevant metric to perform the evaluation of the induced models.

In the Table 1 are present the best models obtained for each previously defined target. In the table are only the targets that meet all thresholds

Table 1. Best DM Models (percentage)

Target	DMSM	Scenario	DMT	Specificity	Sensitivity	Accuracy	AUC
7,5C	HS	SO	LL	89,16	71,34	80,99	0,90
8,5C	10FCV	SO	LL	87,89	68,40	78,32	0,89
1,5G	10FCV	SQ	LL	90,08	71,87	81,65	0,91
3,5G	10FCV	SQ	LL	90,08	71,87	81,65	0,91

These four models were obtained after application of the oversampling technique to the dataset. All models can be represented by an expression, for example, to the target "7,5C" the expression is:

$$DMM=<\Delta,\alpha,LL,10FCV,'C7,5',HomeTeam,AwayTeam,AVGCornersHT,AVG \qquad \textbf{(3)}$$
$$CornersCOncededHT,AVGCornersAT, AVGCornersConcededAT>$$

3.4   Phase 4

The fourth phase is composed by the combination of two phases, the "Development" phase of CRISP-DM and "Implementation" phase of the decision-making process. In this phase, the development of the prototype was initialized. This prototype allows the user to make intelligent predictions of various events in real time at football games anywhere and anytime [20, 21], being the system designed following some of pervasive features as is scalability, context awareness and ubiquity.

It was decided to create a web platform, because this allows easy access from any location in different devices. In the Fig. 2 is presented the architecture by which the prototype can be represented.
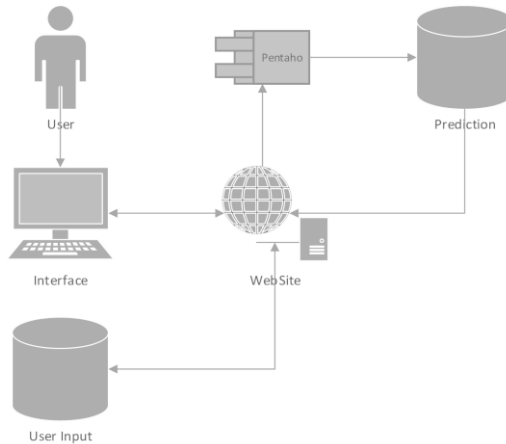

Fig. 2. Prototype architecture

To use the prototype, the user starts by entering information necessary for the system know of which the game is intended to make a prediction. This information is stored in a database that is shown in Fig. 2 by the "User Input". The platform will then use this information to make a request through a *.bat* file that automatically starts the process designed in Pentaho tool.

After starting the job in Pentaho, the information previously entered by the user is used by the model DM previously created, "Weka Scoring", which is an existing process of Pentaho, to generate a prediction that it is stored in the database "Prediction".

The generated prediction is then sent to the web platform to be used by the better. In Fig. 3 is the prototype main menu.
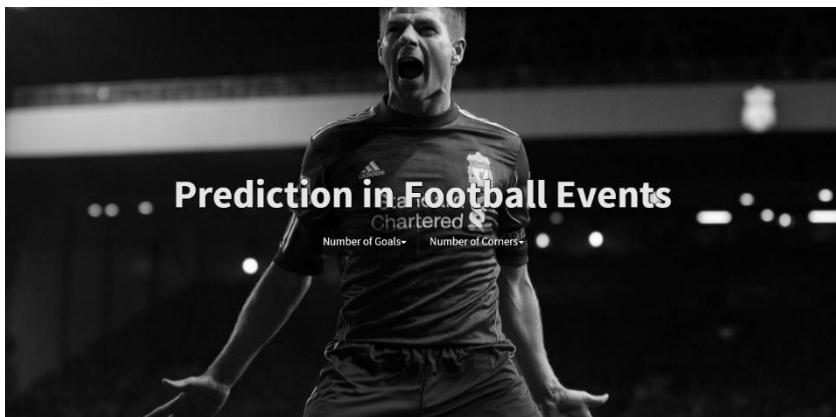

Fig. 3. Prototype

In this prototype, the user starts by selecting one of two groups of predictions, a group that includes the predictions related to the number of corners and another with the number of goals. Clicking, for example, in the "Number of Goals" button will emerge two new buttons, the "More or Less than 1.5 Goals" and "More or Less than 3.5 Goals". If you click on one of them emerges the form that the user needs to complete to pass the information to the DM model. After the user fill form it is submitted, automatically and the prediction is presented for the user. The predictions are presented as the possible result and the probability of it occurs. For example, the output can be: *There is 95% probabilities of the number of goals be "More or Less than 1.5 Goals".*

5   Discussion

To induce the models, for all targets two sampling methods were used, the 10-Folds Cross-Validation (10FCV) and Simple Holdout (HS). Four Data Mining (DM) techniques were also explored: Naive Bayes (NB), Support Vector Machine (SVM), Decision Trees (DT) and Lazy Learning (LL).

The targets that have unbalanced classes, for example, the target "More or less than 1.5 goals" (G1,5) have 74% examples of more than 1.5 goals, which means that there is an imbalance in the model. In these situations, the oversampling technique was used to balance the dataset records.

For each target defined related to the number of corners, 56 DM models were initially induced and in the case of targets associated with the number of goals 64 DM models were induced, also for each target.

The values obtained in metrics do not have a significant variation associated to the sampling method and the DM technique used in the induction of DM models.

The first results obtained in the metrics in each target were weak and did not meet the defined quality parameters. It was then applied the oversampling technique into the dataset to balance the classes of each target. The metric values obtained in the models have substantially improved after the application of this technique having four targets that hit the defined quality parameters, "C8.5", the "C9.5", the "1.5G" and "3.5G". The DM technique that stands out was the LL, with this technique the models obtained best values in the evaluated metrics as can be observed in table 1.

6   Conclusion and Future Work

The objective of this project was to obtain predictive models that will support gamblers to increase their profits. In particular when they are betting on the number of goals or number of corners in a specific football match in order to reduce the risks that have on each placed bet.

Several targets were defined within these two groups. After the DM models were induced, they were evaluated according to the defined thresholds, the models that have value to be entered in the prototype are "C8,5", "C9,5", "G1,5" and "G3,5". These models were obtained after the application of the oversampling technique to the dataset; this technique has substantially improved the values obtained in the evaluated metrics.

Future work will pass for adding new variables to these models, to try different scenarios in order to obtain models with even greater precision to be added later to the prototype. In parallel, the prototype will be converted into a system able to disseminate all the probabilities anywhere and anytime in mobile or situated devices. This prototype also will incorporate the other predictions made in this field related to the final result [22–24].

Acknowledgments

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Towards a Pervasive Data Mining Engine - Architecture overview

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Abstract. Current data mining engines are difficult to use, requiring optimizations by data mining experts in order to provide optimal results. To solve this problem a new concept was devised, by maintaining the functionality of current data mining tools and adding pervasive characteristics such as invisibility and ubiquity which focus on their users, providing better ease of use and usefulness, by providing autonomous and intelligent data mining processes. This article introduces an architecture to implement a data mining engine, composed by four major components: database; Middleware (control); Middleware (processing); and interface. These components are interlinked but provide independent scaling, allowing for a system that adapts to the user's needs. A prototype has been developed in order to test the architecture. The results are very promising and showed their functionality and the need for further improvements.

Keywords. Data Mining, Pervasive computing, Data mining Engine

1 Introduction

Nowadays, there are many data mining engines. However these engines are difficult to use and optimizing the results takes a large effort. For this reason a new data mining concept was devised. This concept joins the general characteristics of data mining engines with the characteristics of pervasive computing. By bringing the technology into the "background" it is possible to improve the perceived usefulness and ease of use of data mining tools. The Data Mining Engine (DME) architecture proposed is divided into four major components: Database, Middleware (Control and Processing) and Interface. In fact, it provides, at least, the same services as any other data mining engine with extra features. It also provides fully automatic configuration and autonomous data mining services in any place, and in any device available to all users.

Providing Data Mining functionalities and their results (probabilities, dashboards and alerts) automatically and in real-time to anyone, anywhere and anytime is the main goal of this project. This new solution offers an Intelligent Mining and Knowledge discovery to anyone who wants to make previsions without the need to learn how it works. To assess the concept viability and architecture functionality, a case study was performed using the developed prototype. The achieved results are motivating. A

complete and autonomous data mining process was executed using real data collected from Intensive Care Unit (ICU) of Centro Hospitalar do Porto (CHP), Porto.

This article contains five sections beyond this section. The second section provides the state of the art on pervasive computing, data mining and data mining engines. The third section provides an overview of why and how the system was conceived and intrinsic features. The major architectural components are described in the section four. In the section five, a case study is conducted making use of a prototype of the system. The article ends with the conclusion and future work.

2 Background

2.1 Pervasive Computing

Pervasive computing (PC) focus on taking the technology from center stage to the "background" [1], abstracting the user from its complexities. In order to bring the technology to the background a characteristic named "invisibility" is necessary. This concept means that technology is used unconsciously, removing the need for adaptation or understanding of how to use it. This implies the capability to identify and adapt the solution to the environment and its users [2]. To make these decisions there are two different approaches possible, creation of specific models for each environment, or dynamic changing models that detect the environment [3] and then adapt to it. Another key characteristic is ubiquity. This means that technology must be everywhere without the necessity of bringing any specific device anywhere we go [1] so that the user is not aware of its presence. We must understand that this problem is more than a technology problem. Yes its technologically complex, it requires a solution which is a distributed and mobile system, among other concerns, but it has a human component mainly in the way its users perceive it. It may also automatically notify the user about pre-defined requests using the best available device or method: situated devices, email, phone application, etc., depending on the user location.

Satyanarayanan [4] considers pervasive computing as an evolution of distributed systems and mobile computing. Most of the challenges are addressed and a direct solution can be implemented into PC. Challenges in distributed systems [5] such as heterogeneity, openness, security, scalability, failure handling, concurrency and transparency must be addressed and resolved. In mobile computing wireless networks, mobility and portability are the challenges to consider and address [6]. As determined earlier pervasive computing bring new challenges [7]: Localized scalability, physical spaces Heterogeneity, Integration, Invisibility, Context awareness and management.

As advantages it allows the technology to be used by all the people, removing the need for adaptation and resistance to change. In more specific situations, pervasive computing allows a greater comfort in life thanks to smart spaces [8], higher productivity with access to information and computation anywhere [1], and automatic devices configuration [9]. Concluding pervasive computing promises a new age of computation, focused on the people with technology in second place, promoting direct, simple and intelligent access to information and services anywhere [10].

2.2   Data Mining

Data Mining (DM) is defined as the application of algorithms to the discovery of patterns in data [11, 12], in order to potentially find useful information. There are two different objectives or categories in Data Mining, prediction and description [13]. Predictive modelling produces a model of a system based on initial data, and its objective is to predict a specific attribute, based on others. If the attribute to be predicted is numeric or continuous, then regression [14] is used, if it is discreet, classification is used [15].

Descriptive modelling creates patterns that describe data and its objective is to allow the interpretation of those patters. There are four main approaches: Clustering, Summarization, Dependency [16] and times series. Algorithms are implementations of generic models (classification, regression, others). In DM there are different algorithms (decision trees, neural networks, others), some are specific to a model type, and other encompass several model types [17]. This project only attempts to solve classification and regression problems. In order to determine the quality of a model it must be evaluated. To perform this, the simplest way is to divide the data into training and evaluation sets. Normally 1/3 of the data is used for evaluation and the remaining for training [12]. Dividing the data in this faction may not be optimal. To solve this problem, there is a process called stratification, which guarantees that each class is properly represented in both data sets, but this is not enough to guaranty adequate representation. For this a common statistical technique is normally used, called cross-validation. Several different partitions of the same data are created, called folds. These two methods [12] are the ones available in the prototype although the architecture allows for other methods to be implemented. There are several metrics [12] to evaluate a prediction model depending on the problem objective / model type. Scoring functions quantify the fit quality of the model created, its usefulness is to compare the fit between the models [14]. Without scoring functions it is impossible to determine the best model or even optimize the parameters of the model or to find the probability associated to a target.

2.3   Process

Specifically for this architecture a four stage data mining process is used, composed of Extract Transformation Load (ETL), Modelling, Model Induction and Evaluation. Each stage is composed by several tasks. ETL is composed of data collection, exploration analysis, data transformation and data selection. Modelling is composed of model selection and model configuration. Model Induction has no sub tasks. Evaluation is composed of model evaluation, process result evaluation and scoring. At any time the process can be returned to the any previous task in the process. The process ends when the model evaluation coincides with the process evaluation target.

2.4   Data mining engine and similar engines

Data mining engine is a mechanism that offers a set of data mining services to its clients. It can be seen as if it was a black box, everything done inside is invisible to its users,

only displaying its services as an input and output. The services can be at a process level or very specific tasks, it depends on the data mining engine capabilities.

There are many data mining engines, ranging from specific tools only providing data mining services, to business intelligence packages with data mining functionalities [18].

Engines like R, Weka, Knime, Rapid miner are well known in the data mining world, but they all suffer from the same problem, ease of use. Data mining engines are considered more difficult to use than other information technology [19], being the two most important factors in tools adoption the ease of use and perceived usefulness. This new engine tackles these two factors. Its perceived ease of use is increased by providing a fully automated process, removing the need of a specialized data mining expert and bringing the potential of data mining to everyone. The perceived usefulness of the data mining engine is increased by autonomous optimization and notification system.

3   The concept

From the limitations facing current data mining engines a new concept emerged. By joining the characteristics of pervasive computing and data mining a new engine was developed. By devising the system as a distributed systems it can serve multiple users in multiple places/devices. Pervasive computing also goes much further than a concern for user interface, it requires the system to perform tasks without user intervention, by recording the entire process a knowledge base is created for the system and to apply Data Mining algorithms to make better decisions (e.g. first model to use). It will use past processes to make its decisions. This allows the system to mold to its users, even user choices will be reflected in future system choices. To better understand how this was accomplished this new engine is capable of:

- Scaling according to the needs – The system can run on single or multiple server, and can scale each component independently according to the number of processes and users.
- Multiple users – The system is online and designed to service simultaneous users.
- Services anywhere and in any device – As it is a web application it can be accessed from any place from any device.
- Uses other engines for data mining tasks – The system is capable of using other engines to run its data mining tasks, it basically is an abstraction on top of other data mining tasks. The system does not implement new algorithms, it uses code and libraries already deployed to support any data mining service.
- Services to other engines for data mining tasks – Because of its ease of use, online availability and minimal configuration it can be easily used by other programs for easy access to data mining services.

Service to:

- Novices – Because of its automatic process, novice users can start using data mining services without needing to understand the technical necessities. The only minimal knowledge required is a business knowledge in order to understand the significance of the results.

- Experts – Because of the pervasive characteristics, the system must respond to the expectations of its users, providing an environment to expert users, able to perform any task than other DME provides, adding some extra features.

Services that are:

- Automatic/Optimized – The system provides several levels of abstraction and automation. This provides many possible ways to operate the system, combining expert knowledge and system knowledge to suite every user expectation. The system also provides optimization at several steps, such as data selection and model configuration for example.
- Concurrency – Because of its design, it is capable of running multiple models in concurrency, limited only by the physical resources available.

4 Architecture

4.1 Requirements and Features

This project has several requirements derived from the three areas regarding pervasive computing and data mining itself. The requirements are:

- Scalable – In order to meet this requirement a distributed system solution with some component replication was selected. This was done in order to provide not only scalability but also better performance according to the task at hand.
- Available in every device and operating system – For this requirement a web solution was designed, requiring only an html browser application in the device.
- Physical – The physical requirements of the system are as broad as the possible environments. It can run on a single machine, for small data mining projects, to multiple servers providing resources for large companies.

The main features are:

- Pervasive/Ubiquitous – The system is always available anywhere in any device.
- Distributed system – The system operates in several machines, performing its tasks in specific environments, being the access remote to the server.
- Persistence – The entire system is stored in the database, including its decisions.
- Automatic configuration – The system requires none or minimal configurations.
- Expert/Novice – The system provides an interface for varying types of users.
- Optimization – The system has built an optimization process, removing the need for manual optimization of the entire process.
- As a service – The system is designed to support multiple users and working as a service, not as a desktop application.
- Adaptability – Allow easy implementation of new models and data mining engines, allowing the customization even to specific areas of data mining.
- Scalability by component – The system provides scalability by component. Allowing a better suit of the hardware resources and performance concerns.
- Multiuser - The system is designed to work with simultaneous users.
- Privacy – Because it is a multiuser environment the system allows for the encryption of that, for privacy and security reasons.

4.2 Benefits

The principal benefit is the possibility to use DM efficiently without years of training. All tools require making choices that impact significantly the results and without experience it is impossible to know which is best. Also running all manually or making your own tool to automatize the process is time consuming or impossible to some users. It can also be very useful as a learning tool seeing as the system runs automatically the user is able to view every choice it makes. On a more technical note, it supports new tools/algorithms that may arise, as it uses other tools to provide its modelling services, without having to make major changes to the system.

4.3 Description

As mentioned before, this architecture (until now) only solves classification and regression problems. It internally uses some descriptive modeling, joined with prediction to attempt to run the better probabilistic model first. Because of this the architecture is far more complex than the simple process explained earlier. This architecture is composed of four major components: Database – Responsible for the persistence of the system; Middleware (Control) – Composed of the three other components, it manages all the decisions, the servers and the process; Middleware (Processing) – Component where almost all of the processing is performed, it runs the models and the ETL; Interface – Handles all client operations to the system. These four components are in constant communication and require each other to properly function and each component is responsible for its own fault tolerance. Each major components is comprised of several sub-components. Each components is described in the sub-sections below.

a) Database
A major component of the system, it provides persistence for the entire system. But it is more than a way to save data. The system runs completely on top of the database (DB). Many events are triggered when a change is detected, some processes are notified at the Middleware level, but no task is started without the confirmation of the database. The system simply does not work without the database. The communication is constant and intensive (requiring high physical resources), this is a conscious and intentional decision. Today the systems are very responsive and reliable, by delegating responsibilities to the database, synchronization efforts at the Middleware level are alleviated by preventing common problems of synchronization at the middleware level. Because of the requirements, the DB is responsible for its own scaling, an independent system. Allowing the administrator to implement a DB that handles the load required is depending on the user's needs. Requiring only that the connecter is changed according to the DB. Implementation is very important on this subject, currently any SQL DB is easy to implement as long as a java connecter exists to that DB system.

b) Middleware (Processing)
Comprised of one or multiple servers. All the ETL, modelling, evaluation and scoring tasks are performed in this layer. As a performance and diversity concern, it allows any other data mining tool functioning on this system. Engines such as R, Weka can be used

to perform any of the tasks, even if a new engine appears, as long as a command line is available it can be used as a component in this system. This functionality allows incredible adaptability, requiring minimal implementation. This can be achieved by creating a connector for each tool that is able to perform datamining task. By defining the entry and end point of each task, as long as these stay the same, the engine is able to perform these tasks. This can be achieved by programing scripts for each task in the control and send it to processing by the connector. Due to the fact of each task being independent to any other task, specific tools can be inserted to perform only specific tasks. For instance the ETL can be performed on R and the modeling on Weka or vice-versa, because each task is recorded on the database, any other tool can continue the process where it was stopped. The only requirement for this system not failing, is for the entry and exit points to be the same. For example, if two models are to be performed, one in R and another in Weka, both models will load same data, and it will record the same information (necessary for the next task), this ensures that implementations are compatible with the current process. The differences are in the task itself, not in the process. All the tasks are available, allowing them to be called from the control/interface, or from other software/devices. The scalability issues are solved by replicating processing servers. Several servers of the same type can be started. The system will scale linearly, as each server processes only one model at a time, if there are ten models to be performed and ten physical servers available they will start one in each server. This example was for modeling process but the same tasks is applied to all other tasks. Several ETL servers can be started depending on the needs of the system. This is not possible in a standard desktop data mining engine (DMEs available in the market at the moment).

c) Middleware (Control)

The core of the system, capable of individual scaling with repetition in each of the sub components except server control, that requires scaling throw partition responsibility.

- Server Control – Responsible for the processing servers, it controls the starting of all the ETL, modelling, scoring and evaluation tasks. It determines the available servers and assigns the priority tasks for each server. Every single task started in Middleware (Processing) has to go through server control.
- Modelling Control – Responsible for generating all the scripts for running and configuration of each individual algorithm implemented in the system. It is a separate system to allow a better division of the code, so that future implementations of new models are easier to perform and comprehend without compromising the integrity of the entire system.
- Process Control – Responsible for the entire DM process it provides individual calls to each DM task, allowing for each individual task to be performed at any time. It also controls the flow of the process, which tasks are performed and in what order. The process is terminated when the target evaluation result is reached, this target can be the default of the system or defined by the user.
- Decision Support System (DSS) – It is where the major decisions are made: transformation, data selection and modelling. To make these decisions, several DM processes are induced. Using the data accumulated from previous processes, a model is created in order to score new data presented to the system. When a decision is requested the DSS always uses the best model

available at that time. The system automatically maintains the model or change when a deviation is detected.

d) Interface

Composed by one or more webservers (depending on number of users). It is able to scaling independently of the other major components. It provides access to data mining services, configuration to the user and administrator, notification medium for the user, and reviewing the results. The notification can also be made by email or message. The interface also provides a different layout (interface) for each type of user.

- Simple – Provides nothing more than dataset loading, define the prediction target, and show the current results. It is designed to be as simple as possible providing only information strictly necessary.
- Advanced – On top of the simple functionalities it provides information on the decisions made and the current stage of the process. It allows the user to define any task manually or a mix of manual and automatic task. For example it allows the automatic selection of attributes and model. It also allows the change of evaluation stopping target.

5   Case Study

A first version of the solution was tested using real data collected by INTCare project [20, 21] in the ICU of CHP. The current development still does not have a graphical interface but already implements a partial process, from start to finish. The automatic transformations and the intelligent system inside DSS are not implemented. Excluding these features the system is up and running on a server with two R processing threads, a MySQL database and a java Middleware. The system loads the data, selects the model and performs the induction, evaluation and scoring, stopping when the target evaluation is reached. The dataset used has 214709 records, 32 columns with information about patient vital signs. The target is a numeric field with two possibilities (1 – critical, 0 – stable). The goal was to predict if the patient is in critical or stable condition [22].

The process starts with the input of the dataset. This is done manually by the user, as well as selection the column for the target. The system automatically loads the dataset and generates descriptive statistics about the dataset (column data type, number of classes, max, min, and others). After loading is complete, the model is selected. A set of predefined configurations was selected by the system, according to the priority levels defined to each configuration, this information is stored in the database. After the configuration is terminated, the system detects which servers are available and assigns the models for induction. The instructions for processing are sent from the control to the processing, and the model is created, evaluated and all the results are saved directly to the database. When this is finished the control is notified, and the process checks if the evaluation target is reached using the scoring process, otherwise a new model is assigned to be inducted. The system records all the available metrics. In this test the metric used was relative absolute error, defined at the start as 25%. The target evaluation was reached on the 4^{th} model and the system stopped. As mentioned above, it still does not have a graphical interface as such the user notification is not yet

implemented. All the request, even the request for loading initial data is recorded in the database, and the server control is then notified. The processing server access directly to the databases to minimize transactions, when it finishes the request, it notifies the server control and/or process control depending on the task it is performing. After model selection is determined and the configurations are defined in the database, the server control allocates the script to the processing server. When evaluation target is not reached, the connector notifies process control with an unsuccessful status. The process control then determines if new models or parameters are needed.

6 Conclusion and Future Work

In this paper was presented a new data mining engine with pervasive characteristics. Although the system is still in development, the concept is well defined and a working prototype was deployed. Its capabilities for simple and fast data mining services is undeniable. The tested prototype is capable of looking for optimal results, and the architecture works as expected providing the base for future and improved developments. On a more specific note, it is apparent that the information generated by the system provides useful information for all types of users, be either for new users learning how data mining works, at home or in school environments, or by expert users, providing new, unexplored paths to achieve the same or better goals.

At the moment many possible data mining approaches are explored with minimal knowledge of which will produce the best results, improving the system in this subject is the real challenge. We cannot also ignore that the system is designed to learn from itself, requiring more time to produce better results.

The main difference between the DME proposed and the existing one is in the concept novelty and in the architecture. This approach is totally new for the scientific community. From the development made it can be concluded that the characteristics of pervasive computing and data mining can indeed be joined to create a new concept as explained in this article. The architecture presented has already proven it can minimize the technical expertise needed to use a data mining engine. A case study demonstrated that interesting results can be attained by the system. Nevertheless it does seem that the architecture devised is capable of performing and reaching the goals defined in the project, requiring improvements in the decision support system.

Briefly and as main gain with this solution the user only need to load a dataset, choose a target and then click in start. Then the system is responsible by treating the data, induce and evaluate the models. Finally the scoring tasks is performed and all the probabilities are presented to the user.

Future research should be focused in the decision support system and in a statistic module. Two major features will be included in the system. First, a clustering approach as a description and prediction modelling. The clusters allow not only for one more type of data mining but also to explore large datasets. Second another descriptive data mining techniques to provide metadata to the cluster modelling. This way, better and dynamic models can be created. So in the future the models does not need to have predefined classes, the cluster can be used to decide which classes should be considered based in their relation with the target.

Acknowledgment

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Pervasive Adaptive Data Acquisition Gateway for Critical Healthcare

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Abstract. The data acquisition process in real-time is fundamental to provide appropriate services and improve health professionals decision. In this paper a pervasive adaptive data acquisition architecture of medical devices (e.g. vital signs, ventilators and sensors) is presented. The architecture was deployed in a real context in an Intensive Care Unit. It is providing clinical data in real-time to the INTCare system. The gateway is composed by several agents able to collect a set of patients' variables (vital signs, ventilation) across the network. The paper shows as example the ventilation acquisition process. The clients are installed in a machine near the patient bed. Then they are connected to the ventilators and the data monitored is sent to a multithreading server which using Health Level Seven protocols records the data in the database. The agents associated to gateway are able to collect, analyse, interpret and store the data in the repository. This gateway is composed by a fault tolerant system that ensures a data store in the database even if the agents are disconnected. The gateway is pervasive, universal, and interoperable and it is able to adapt to any service using streaming data.

Keywords: Gateway, Pervasive Data, Vital Signs, Ventilation Data, Medical Devices, Real-time, Data Streaming, Data processing, Sensors, Adaptability.

1 Introduction

In critical healthcare environments the patients are typically connected to medical devices by sensors. There are a set of sensors able to monitoring the patient condition to the monitors (e.g., vital signs and ventilation). However in many cases these data only are shown in the monitors and they are not stored in database. They are considered temporary values. Having conscience of the problems associated to a delay recording and data loss and how the services can benefit with the introduction of this data in the database (clinical data available to be consulted in real-time), a universal gateway was designed and implemented. This gateway is able to collect patient data in real-time, independent of the medical device used. A report from the Institute of Medicine [1] presents a set of new concerns arising from the increase of information technologies in healthcare and the needs of it support the patients. One of the concerns is related to data quality. This problems can be overcame by implementing systems able to automate

some clinical workflow as is the introduction of autonomous system to acquire the data monitored. In summary, integration of information systems in the healthcare environment has provided the opportunity for improvements in work, being the tasks performed faster, more consistently and with less cost [2].

The main goal of this work is developing a pervasive universal and adaptive system able to collect the monitoring data in real-time. The system should be prepared to collect data from a set of medical devices / sensors connected to the patient (eg. ventilator and vital signs monitor) and using an ethernet network approach to provide data streaming. The proposed system complements the existing architecture in Intensive Care Unit (ICU) of Centro Hospitalar do Porto. Actually the ventilators are only used to consult the values in a single moment. The monitored data are not stored in the database. In this context there is the need to create a system capable of collecting these data. In order to overcome this problem, it was developed a pervasive universal gateway that was integrated in the data acquisition subsystem. It is able to collect all patient data (being ventilated) in real-time, making them available for consult and analysis. This gateway presents as main features: adaptability, universality, autonomy, pervasiveness and fault tolerance, data streaming from sensors, data acquisition and data processing in real-time.

This paper is organized in five section. In the second section, it is covered a background of the work. The gateway data acquisition requirements and their characteristics are presented in the third section. The third section also presents the interaction between Client-Ventilator and Client-Server, it is presented the algorithm used to create the Health Level Seven (HL7) messages, the failure mechanism and the system to control the Client versions. In section four is made a discussion of the work and finally the concluding remarks are made in the fifth section.

2 Background

2.1 INTCare

INTCare is a research project which gave origin to a Pervasive Intelligent Decision Support System (IDSS) with the same name to Intensive Care Units. It is able to support physicians and nurses decision process in real-time [3]. INTCare take advantages of data streaming, intelligent agents and an autonomous Extract, Transformation and Loading (ETL) process. INTCare is able to support the decision making process by providing new knowledge in real-time [4]. INTCare is composed by semi-autonomous agents responsible for several tasks in real-time, as example: Data acquisition from sensors and medical devices; data streaming; data processing and transformation and induction of data mining models. These tasks do not require human intervention. The Data acquisition subsystem is based in the sensory processing tasks using intelligent agents. When a patient is admitted to an ICU, the clinical staff connects several sensors to the body. These sensors are prepared to collect patient clinical data as is vital signs and ventilation values. In the case of ventilation system, the sensors are connected to the ventilator which is prepared to receive all the signs sent by the sensors. The data received are shown in the ventilator monitor. INTCare interferes in this phase by

developing a gateway able to process and collect these data to a database. The process starts when the data arrives to the ventilator. The data are received through a gateway and they are packed into HL7 messages. Then the data are stored on the database by another agent. Automatic data acquisition and consequently data streaming eliminates transcription errors, improves the records quality and allows the assembly of large electronic archives of data [5]. The system characteristics were defined taking into account the environment, the information needs and Data Mining requirements. These characteristics are fundamental for the development of a universal and adaptive gateway [6] providing data acquisition in real-time.

2.2 Interoperability and Pervasive Health

The biggest challenge of this work is to ensure the interoperability of consistent communication of information between all the hospital system and platforms. It should allowing a data streaming process provided by heterogeneous systems [7]. To facilitate the process is necessary defining a communication protocol / language.

The Health Level 7 (HL7) is a language composed by a set of patterns where the interoperability perspective is evident. HL7 help to improving the communication processes that handle with information [8]. Given this context the Agency for Integration, Archive and Diffusion of Medical Information (AIDA) were used [9] as a gateway support. One of the Interoperability change is Pervasive HealthCare. Pervasive in Healthcare (PH) can be defined as a "system for providing healthcare to anyone, anytime and anywhere by removing restraints of time and place, while enhancing the quality of health care" [10]. This approach is based on the information that are stored and available online [11]. In the field, the implementation of PH solution has technical and administrative obstacles, such as resistance to significant changes in the area of technology and information systems [12]. As a solution it is recommended to put the necessary information available electronically, complemented by predictive models that can help clinicians make better decisions in real time [13].

3 Gateway

The first requirements and the interaction between the client and server was already presented [14]. This section makes a short introduction of the system requirements and the interaction existing between client and server. Then the new features are presented.

3.1 System Requirements

In this section functional and technical requirements for developing the gateway are presented. As functional requirements: Client communication with ventilator must be done through the RS-232 port; The server must be able to receive messages from different clients (data acquired through client communication with the monitors ventilation); Store the data into a database; Create HL7 messages for communication between the systems; Efficiently treatment of exceptions; Log and alert system (mail sending when an error occurred); Secondary mechanisms for controlling data missing.

As technical requirements: Low disk space and restricted memory usage. The processes of data acquisition and data storing are supported by intelligent agents. These agents are programed to make their tasks autonomously and in real-time. The gateway was developed in python taking advantage from the several libraries existing in this field.

3.2 Interaction between Client and Server

The Clients are installed in computer associated to the ventilator. Each Client is waiting by the ventilator message. These messages are produced after a signal be measured by the patient sensors. Then the Client receives the message and performs some changes (formatting) in order to send it to the Server in a universal format (HL7) through ethernet network. In order to provide a deeper understanding of the Gateway, a use case diagram, according to the modelling language UML (Unified Modelling Language), is presented in Figure 1.
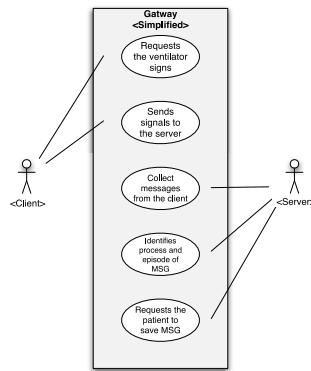

Fig. 1. Use Case Gateway

As mentioned in the first version already published [14], In Figure 1 is possible observe the interactions between the system and the user. "However and since there are not human interactions presented in this functional unit, the interlocutors (client and server) presented are an integral part of the system. The client and server are two integral parts, each of which performs a set of tasks necessary to provide all the functionalities of the gateway. To demonstrate the interactions between objects and scenarios performed by the methods or operations through two operations, a sequence diagrams were depicted.

Figure 2 elucidates how the data is acquired through Client and from the ventilator. The Client (Ventilator (X) - where X is an individual ventilator) performs a set of messages exchanged between two objects: Port RS-232 and Ventilator. Initially the Client has to identify if there is any Serial port installed that supports Client execution. If yes, it sends a message (MSG) identified by the ventilator port. Then, the Ventilator sends a message with the respective values of the fields requested by the Client. Finally, the Client receives the message sent by the Ventilator and chooses the set of fields that will be introduced, creates a message according VL syntax and sent it to the Server."
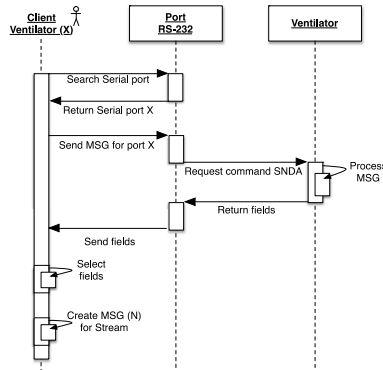
Fig. 2. Client Sequence Diagram

Figure 3 presents the sequence diagram of the operations made during the data streaming process from the Client to the server through Agent HL7. This diagram is a sequence of the diagram presented in figure 2. The Server System receives the message and then it identifies the Client IP and the patient Bed associated to this message. Then a request is sent to the database to identify which is the patient that is being monitored in those bed. Then, the collected data are correctly identified (there is a match between the data collected and the combination of patient identification (PID) and patient bed in the Electronic Health Records). At the end, the Server System updates the message (adding the PID) and sends the data collected from the patient for Agent HL7.
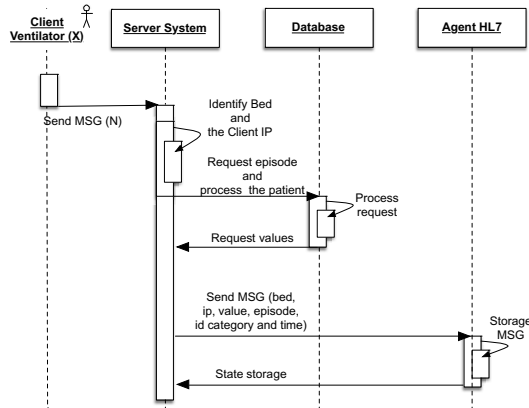
Fig. 3. Server Sequence Diagram

Sequence diagrams of Figures 2 and 3 represent the operations performed by the Gateway developed. The Client and the Server System are responsible to ensure an integral communication between heterogeneous systems parts.

3.3 Server parallel processing

The Server is always listening for Client messages. When a message is received by the server, it is instantiated one high-level threading class. This message implicitly gives

origin to a new task. Each task is responsible for the creation of all HL7 messages and sent it to the multi-task server. In case of the server is receiving a new message but if it has not yet finished running (is processing the last message received) it creates a new task. Always this situation is verified the Server creates a new task with parallel processing. The developed Server is a distributed processing system.

3.4 Create and sending Health Level Seven messages

When the Server creates a new task, the database is queried to know who owns the received message. Then it proceeds to the process of creation and sending of HL7 messages. The next algorithm presents all the process.

Algorithm 1 - Create and send HL7 message to the Agent HL7
Require: date_number, date_value, process, name, bed and fields
1: **Function** create HL7 message (date number, process, name, bed, value_fields, num_fields, service)
2: **For** all fields **Do**
3: MSH=Create segment MSH with (name, date number, generateID)
4: PID=Create segment PID with (process, name)
5: PV1=Create segment PV1 with (bed)
6: OBR=Create segment OBR with (num_fields, name, date_number, service, bed)
7: OBX=Create segment OBX with (field)
8: MSGHL7= Concatenate (MSH, PID, PV1, OBR, OBX)
9: **Call** function SEND_MSGHL7(MSGHL7)
10: **Function** SEND_MSGHL7(MSG="empty")
11: **If** MSG **!=** "empty" **Then**
12: **Send** MSG for Agent HL7
13: **Wait** for Ack
14: **Else**
15: **Print** "MSG is empty"
16: **If** Ack == -1 **Then**
17: **Call** booking engine
18: **Else**
19: **Print** "Successfully received message"

The first function of the represented algorithm generates an HL7 message. The number of messages generated it is directly dependent of the number of fields collected. For example if the ventilator collects 10 fields then the respective task will send 10 HL7 messages for Agent HL7. Then, the second function is created and it is identified whether the Agent HL7 is receiving messages. Table 1 describes the segments used in the HL7 message created:

```
MSH|^~\&|NAME_IDNET|MSG_ID1||ORU^R01|MSG_ID2|P|2.3.1
PID|1||PATIENT_ID||NAME^PATIENT
PV1|1|U|BED_NUMBER
OBR|1|||NAME_IDNET|||MSG_DATE|SERVER_DATE
OBX|1|SM|VARIABLE_ID||VARIABLE_VALUE||||||R|||MSG_DATE
|ID_SERVICE^BED_NUMBER||^AUTOMATIC
```

Table 1. HL7 Segments and Description

Segment	Description
MSH	Message Header
PID	Patient Identification
PV1	Patient Visit
OBR	Observation Request
OBX	Observation/Result

All the messages sent to HL7 agent must have the presented structure. The five represented segments must be sent in the same message. If some segment is missing the HL7 agent did not process the message properly. Another important aspect for the message to be processed by the Server it is the message ID. The ID of each message cannot be repeated, in this case an automatic ID is created based in message date (timestamp number), the service ID and a continuous and non-repeatable number.

3.5 Reserve Engines

The reserve engines is a failure tolerant system able to ensure a continuous data storing, even if there is some problems in the HL7 process. The server receives messages from Clients and it has as priority handling the messages and sending them to the Agent HL7. However if for some reason the Agent HL7 is down, a set of mechanisms are automatically activated. With goal to avoid losing messages, two extra mechanisms able to store the messages not stored by the agent were developed. The first extra mechanism (second mechanism) is triggered in the case of Agent HL7 fails. This mechanism sends the message directly to the database. In fact it gets and processes all the received message and creates several messages in SQL. Then the Server insert each of the messages into the database. The SQL message data are the same presented in HL7 messages, only the shape of segments differs. In extreme cases when the database is down it is need to activate the third mechanism (second extra). The third mechanism is only called when the first and second storing mechanisms are unable to store the data sent by the Clients. The third mechanism does not send data to any server or agent. It stores the data locally on files. The files are generated in two formats (.sql and .hl7). The messages generated (in HL7 and SQL) in the previous mechanism are not lost, they are stored locally on files for future processing. Each file has the messages generated by each mechanism, i.e., it has all the information provided by a Client in the message. Later it is possible to take the files generated and insert the information by the HL7 Server or put it directly into the Database. Once they are generated two files with the same information only it is possible to select a format to store the data in the database. One flowchart was designed to represent the process above described.

Figure 4 is focused in demonstrating the mechanism developed, their conditions and server actions. Briefly when the first message is received, the number of fields (variables) are counted. Then it is verified if the message received can be converted in a HL7 message. If yes, the message is created and it is sent to the server agent. Then and after the agent storing the message in the database it sends an acknowledged (ACK) message. This process is repeated for all the message fields. In case of ACK failure, the agent will convert the first message in Sql code and he will store it directly in the

database. In case of database connection fails, the data will be stored in a file. This is a three steps process and only if one steps fails the following task is activated.
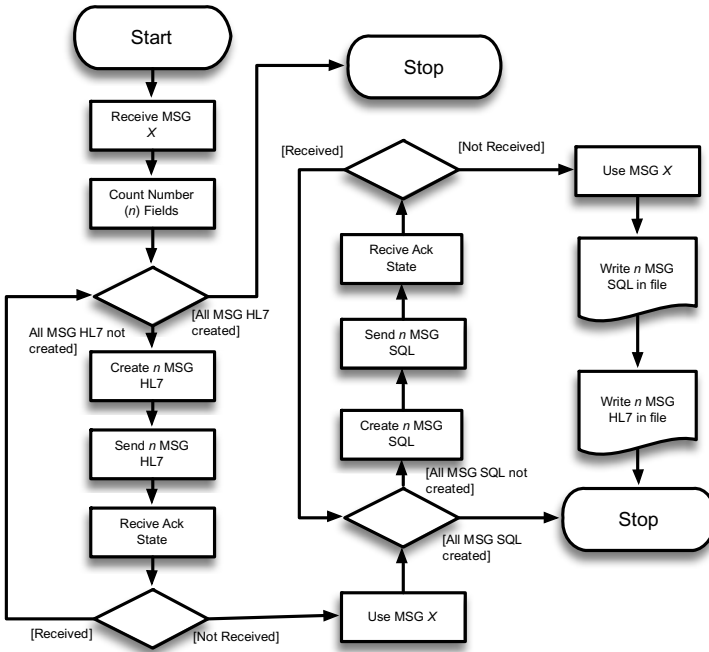

Fig. 4. Flowchart of Server mechanisms

3.6 Starting and Alerting Systems

The Server which are receiving the messages from ventilators and Agent HL7 has a restart mechanism. This mechanism was developed in a file Batch to automate the tasks. Each Agent is associated to a Server and it is composed by a set of commands. This Agent can start the Servers always they are not running. The agent checks periodically (5 min) if the Servers are running or not. Additionally, it was implemented a warning system to inform the state of Servers and Agent HL7. This system sends an email periodically to inform the state of the gateway. So it is possible to know whether the Servers and the Agent HL7 failed / are down. In case of the down time be long, it is sent an email informing that the servers and the Agent HL7 are still off.

3.7 Control gateway versions

The development of an interoperable gateway will provide greater ease of use in the future. It can be applied to other ventilation system monitors since it was developed a module capable of controlling clients' versions. This module was developed for three reasons: The ventilation systems may change; It is need to change the fields that are collected and there were changes in system settings: values, IP and Port. A Client is always waiting to receive a message with an order to update the software. If the client do not receive any message to make an update, it continues to make their work. When

the Client receives a message, it identifies if it is an update message and if the message was written in a local file. Then the Clients software version are updated. At the end, all the Ventilator Clients will be with the most recent version and up-to-date.

4 Discussion

The development of a gateway system to collect data from ventilators and the sensors connected to the patients provides a new way of consulting and view clinical values. The spectrum of values collection provides a better understanding of changes in the patients values. Thus, the system has demonstrated to be useful, due to be interoperable with many data acquisition devices and it can be easily adaptable to other environments, providing a data streaming in real-time. The fact of being used a universal language (HL7) makes this gateway a universal solution, because it can connect to others clinical system and the data can be used for several other goals. The gateway developed ensures that there are not data loss, due to the development of two extra acquisition mechanisms. The alert system can be used to restart the HL7 Agent and Server and sending emails containning their status. All the development and implementation process was followed by health professionals. Their contribution was valuable to develop a most sensitive system. The data collected are then presented to the medical staff using interfaces already developed, as is INTCare Monitoring System.

5 Conclusion

This paper presented the development of a pervasive and adaptive data acquisition system. The gateway was developed and incorporated in a real hospital system: INTCare. The data streaming is made in real-time and the data acquisition system allows for greater data collection capabilities, giving useful information in order to, for example, predict clinical condition. In order to develop a viable system, a high number of functional and technical requirements that demonstrates to be essential for the proper functioning of the system were taken into account. The system configuration was also important to make all systems interoperable enabling the communication between different systems.

The gateway has already collect around 2 million of ventilation data (in the last three months) from the sensors / ventilator. This situation would not be possible with manual registration. These data are providing to healthcare professionals a greater insight into the state of patients regarding to the respiratory system. It has also provided the development of Data Mining models to make predictions related to barotrauma and patient extubating [15, 16]. The fact of being pervasive, all the technicians can access to their settings anywhere and anytime and the information provided by the ventilator are always available. Additionally it sends emails when something is not working well. All of this development are an important pointing to the researchers in order to have an interoperable, universal and pervasive system able to ensure a full data acquisition in critical healthcare environments. For the future it is expected improving the gateway by adding security flaws and deploying the gateway in other hospital services.

Acknowledgements

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Part VII
Healthcare Information Systems: Interoperability, Security and Efficiency

Predicting Triage Waiting Time in Maternity Emergency Care by means of Data Mining

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Abstract. Healthcare organizations often benefit from information technologies as well as embedded decision support systems, which improve the quality of services and help preventing complications and adverse events. In Centro Materno Infantil do Norte (CMIN), the maternal and perinatal care unit of Centro Hospitalar of Oporto (CHP), an intelligent pre-triage system is implemented, aiming to prioritize patients in need of gynaecology and obstetrics care in two classes: urgent and consultation. The system is designed to evade emergency problems such as incorrect triage outcomes and extensive triage waiting times. The current study intends to improve the triage system, and therefore, optimize the patient workflow through the emergency room, by predicting the triage waiting time comprised between the patient triage and their medical admission. For this purpose, data mining (DM) techniques are induced in selected information provided by the information technologies implemented in CMIN. The DM models achieved accuracy values of approximately 94% with a five range target distribution, which not only allow obtaining confident prediction models, but also identify the variables that stand as direct inducers to the triage waiting times.

Keywords. Data Mining, Real data, Obstetrics Care, Maternity Care, Gynaecology and Obstetrics Care, Emergency Room, Triage Systems, Triage Waiting Time, Interoperability, Intelligence Decision Support System.

1 Introduction

Healthcare professionals are increasingly turning to clinical decision support systems (CDSS) as well as health information technologies that provide hospitals with patient-specific assessments and recommendations to aid clinical decision making [1] [2]. In the emergency department (ED), triage CDSSs are used in order to optimize the patient workflow, improving the quality of care and reduce the risks associated to prolonged waiting lists [3] [4]. The most common triage systems are the classification system with five levels of severity, such as the Emergency Severity Index (ESI) and the Manchester Triage System (MTS), efficient in general emergency units [5].

In the maternity emergency care, these triage systems became inadequate for their lack of flexibility addressing the specific patients that attend the gynaecology and obstetrics (GO) care services, such as pregnant women at different gestation stages and conditions [5] [6]. Accordingly, the emergency care of GO in CMIN resorts to a pre-triage system, developed in CHP, specified to categorize women in emergency (URG) and consultation (ARGO) classes. The system integrates the intelligent CDSS implemented in CMIN and allows increase patient's safety [5].

The current study aims to predict the patients' waiting time – the time between the patient's triage and their clinical admission, through the induction of data mining (DM) models. The research is based on real data provided by the information systems used in CMIN to collect and store the patients' clinical records. After inducing DM techniques in several data scenarios, the case study achieved useful knowledge to support the maternity emergency room, since the best DM models reached accuracy values of approximately 94%, concerning a five range target dataset. The prediction of triage waiting times helps the emergency service identify the clinical and environmental features leading to longer waiting times. It assists the professionals prioritizing patients and operations, as well as avoiding medical errors, overcrowding and patient elopement.

This article includes five sections in addition to the introduction. The second section presents the context and related work, and the study description follows in section three. Section four tracks the data mining process following the Cross Industry Standard Process for Data Mining (CRISP-DM) phases. Formerly, section five contains a discussion about the obtained results, while the last section includes the conclusions and future directions to the accomplished work.

2   Background and Related Work

2.1   Context

In maternity care, a variety of gynaecology and obstetrics (GO) conditions are presented, since labour assessment issues to antepartum fetus threatening symptoms [6]. An adequate triage system has to be flexible and dedicated to GO guidelines, in order to provide patients with the proper care.

This study focus on the prediction of the patient's waiting time between the triage and the medical admission, which can be essential to the improvement of the GO emergency room patient flow and satisfaction.

2.2   Pre-triage System for Gynaecology and Obstetrics Care in CMIN

In CMIN, the maternity emergency room has to provide patients with proper GO services such as evaluation of labour, fetal examination and obstetric nurture. In this context, a specific emergency pre-triage system is implemented in CMIN since 2010 and establishes clinical priorities according to the severity of the patients' clinical condition. The triage is based on a set of predefined queries in form if rules of a decision

tree. The pre-triage system is inserted in the intelligent decision support system (IDSS) developed and currently deployed in CHP that supports this process, indicating the triage result (urgent or consultation) [5]. The IDSS is an interactive and adaptable system, which uses artificial intelligence techniques and decision models to answer a question. The presence of the IDSS offers a better understanding of the patient's real state [6]. Currently, the pre-triage system helps increasing patient safety for women in need of immediate care and reducing high-risk care in low-risk patients, maximizing the use of resources [7].

2.3   Interoperability, Archive and Diffusion of Medical Information

This study support data was gathered from distinct information systems (Support Nursing Practice System - SAPE and Electronic Health Record – HER) used at CMIN by the Agency for Integration, Archive and Diffusion of Medical Information (AIDA). The AIDA platform is built on a set of pro-active agents that ensure the standardization of clinical systems, overcoming the medical and administrative complexity of the diverse sources of data from the hospital [8]. By providing this interoperation between the hospital existing systems, this platform allows a suitable information management [9] [10]. The data managed by SAPE, the system supporting nursing practices, regards the records of clinical episodes associated with each patient, as an alternative to the traditional way of saving this information on paper. By the other hand, the EHR system handles storing and retrieving of detailed patient information, as the admission form, assisting monitor, report and improve data on health care quality and safety [11] [12].

2.4   Knowledge Discovery and Data Mining in Healthcare

The knowledge Discovery from Databases (KDD) is a five steps process that aims to identify new valid, meaningful and potentially useful information hidden in large data repositories [13] [14]. First of all, the dataset needs to be chosen, which corresponds to the first step. On the second stage, all the data is cleaned and processed, in order to become consistent. Thereafter, accordingly to the study goal, the data undergoes a transformation so it can be properly explored. The fourth step is the core of all the process, and corresponds to the Data Mining (DM), which is where the knowledge is retrieved from the data, through pattern discovery. Here the DM techniques used will depend on the nature of the problem, which can be segmentation, association, prediction and summarization. Finally, the last phase of the process is to interpret and evaluate the results obtained [15].

Healthcare organizations, which nowadays store most of their data in databases, can benefit a lot from the use of DM techniques. The possible applications go from the identification of effective treatments and best practices (better care to the patients), to anticipating patient's future behaviour and finding solutions concerning institution's management (better services and clinical decisions supported by evidence) [16] [17].

The Intensive Care Unit in CHP employ data mining models to predict patient outcome, readmissions, length of stay and organ failure in real-time, among others [18] [19] [20]. Furthermore, many DM studies have been conducted regarding obstetrics and maternal care, in order to identify services limitations and possible solutions. Among

them, DM classification algorithms were used to predict the type of birth using pregnancy characteristics and to predict events in the voluntary interruption of pregnancy [21] [22]. In these cases, a training set containing a group of attributes was provided, so the classification algorithms could discover relationships between them that would make it possible to predict the outcomes.

3   Methodologies, Materials and Methods

Following the KDD process described in section 2.3, the current study uses SAPE and EHR information to accomplish useful knowledge concerning the maternity emergency triage system. The DM phase applies the Cross Industry Standard Process for Data Mining (CRISP-DM), a sequence of defined six steps that allow to structure and guide the DM process [23]. The six stages are business understanding, data understanding, data preparation, modelling, evaluation and deployment, which support the development of DM models to be used in real environments [24].

A total number of 73330 admissions on CMIN's GO care emergency room are included in the study dataset, comprising a period between 2010-01-06 and 2015-06-25 (1850 days), regarding 31620 women patients. The exploration of the dataset as well as the DM process was performed using the R language and the interface R Studio, for their comprehensiveness and availability. Different classification techniques were considered: Decision Trees (DT), Naïve Bayes (NB), Generalized Linear Models (GLM), Support Vector Machine (SVM) and Neural Networks (NN). The selection of the DM techniques was based on the interpretability of the models, the engine efficiency and their suitability regarding the dataset features.

4   Data Mining Process

The current section describes all the work developed through the DM process, following the KDD process, according to the CRISP-DM phases, having into account the methods and methodologies described previously.

4.1   Business Understanding

The main business goal of the study is to identify the triage features that provide information about the patient waiting time, and therefore, be able to predict it. The prediction of the triage waiting times in the emergency room of the CMIN's GO unit will contribute to the improvement of the triage process.

Thus, the DM aims to develop accurate models able to predict the triage waiting time from the environmental and personal attributes available in the collected data. Decent results can be used by the CMIN's IDSS, enhancing the quality of services among the patient satisfaction.

4.2   Data Understanding

The study dataset meets the data provided by the information systems SAPE and EHR, considering a set of attributes available at triage time. A total of 17 variables were considered, some of those environmental features: the day of the week, the part of the day, the month, the day of the month, the part of the month, the trimester, the hour, the season of the year, the identification number (ID) of the triage professional and their medical specialty, the number of triage professionals working (NTP) and the number of patients waiting in the room (NPW). Additionally, it also considers the age and the gestation weeks (in case of pregnancy) of the patient, as well as their triage result, triage module and motive of visit.

In order to better understand these attributes and their relation with the prediction of triage waiting times, table 1 presents detailed information about some variables and their percentage of occurrence in the dataset. Accordingly, table 2 shows some statistical measures regarding the numerical variables of the study.

Table 1. Classes and occurrences of some variables used in the dataset.

Variable	Class	Percentage	Variable	Class	Percentage
Day of the Week	Sunday	10.23%	Trimester	First Quarter	25.14%
	Monday	18.69%		Second Quarter	27.94%
	Tuesday	14.56%		Third Quarter	24.51%
	Wednesday	15.09%		Last Quarter	22.41%
	Thursday	15.29%	Station	Winter	23.76%
	Friday	14.92%		Spring	28.84%
	Saturday	11.22%		Summer	24.81%
Part of the Day	Morning	44.01%		Autumn	22.59%
	Evening	55.73%	Triage Module	URG	49.02%
	Night	0.26%		ARGO	50.98%
Part of the Month	First Third	29.73%	Triage Result	50	50.98%
	Second Third	36.54%		52	48.99%
	Last Third	33.73%		54	0.03%

Table 2. Statistical measures of the numerical variables of the dataset.

Variable	Min	Max	Avg	Std Dev
NTP	1	63	5.44	3.47
NPW	1	61	1.77	1.92
Age	8	92	32.12	10.53
Gestation Weeks	0	46	11.23	15.40

The target variable *Triage Waiting Time* (TWT) was divided in different range approaches in order to obtained good data mining models. In a first approach, the target was simply distributed in two ranges, separated by the variable mean value. It allowed evaluating the relation between the selected variables and the study's aim, confirming its suitability to predict the triage waiting time, and subsequently, obtaining useful statistical results. On the other hand, following a more clinical approach, the target TWT was organized having into account the categories of emergency of the Manchester

Triage System (MTS). The category of emergency is associated with a maximum waiting time until the patient is attended by the doctor, regarding their condition. Table 3 highlights these approaches' ranges and occurances.

Table 3. Distributions of the target variable through the different assigned approaches.

ID	Approach	Class	Distribution	Percentage
1	Simple Split	0	0 – 17 minutes	96.28%
		1	18 – 516 minutes	3.72%
2	MTS	0	0 – 5 minutes	63.82%
		1	6 – 10 minutes	24.98%
		2	11 – 60 minutes	9.56%
		3	61 – 120 minutes	0.68%
		4	121 – 516 minutes	0.96%

4.3   Data Preparation

The cleaning and processing of a target dataset are important tasks of the data mining process, allowing the transformation of EHR and SAPE information in valuable information. Firstly, the desired attributes are attained from raw records. For instance, the temporal variables were obtained by processing the entrance, triage and admission hours and dates. Similarly, the number of patients and triage professionals available at the emergency room for a particular record required creating procedures to concatenate the dataset entries given the record's specifications. The noise instances, such as duplicates, inconsistences and missing values are removed from the dataset.

As visible in table 3, there is a disproportion concerning the distribution of the target variable TWT in the three last approaches. In order to provide the study with a balance target dataset, the technique of oversampling was implemented. It consists in replicating the lower target ranges, until a composed dataset is obtained.

4.4   Modelling

Once the datasets are ready, the DM models are induced using the DM techniques presented in section 3: DT, NB, GML, SVM and NN, using R miner and the algorithms and configurations featured in table 1. The sampling method Holdout Sampling was applied, having 30% of the dataset composing the testing set, and the remaining 60% used for training. In order to identify which variables influence the triage waiting time the most, the dataset attributes were combined, generating ten different scenarios to test the DM techniques:

S0: {All variables}

S1: {Day of the week, Part of the day, Trimester, Hour, Season, Triage Module, Motive}

S2: {NTP, NPW, Triage Module, Triage Result}

S3: {Age, Gestation Weeks, Day of the week, Part of the day, Trimester, Hour, Season, NTP, NPW, Triage Module, Motive}

S4: {Month, Day, Hour, ID professional, NPW, Motive, Triage Result}

S5: {Age, Day of the week, Part of the day, Day of the month, Part of the month, Season, NTP, Triage Module, Triage Result }

S6: {Month, Day of the month, Part of the month, Trimester, Season, Motive, Triage Module}

S7: {Day of the week, Part of the day, Hour, Module}

S8: {Age, Gestation Weeks, Day of the month, Season, NTP, NPW, Triage Module, Triage Result, Motive}

S9: {Age, Gestation Weeks, Trimester, NTP, NPW, Triage Result}

Each DM model (DMM) can be identified by equation 1.

$$DMM_m = DMT_y \times A_b \times T \times S_i \tag{1}$$

DMT_Y refers to the DM technique, A_b is the target approach, T_s represents the sampling method and S_i identifies the scenario. A total of 100 models were induced (10 scenarios * 5 techniques * 1 sampling method * 2 target approaches).

4.5 Evaluation

The evaluation of the models considered the accuracy statistic metric described in equation 2. The accuracy is estimated through the results provided by the confusion matrix (CMX) of each model.

$$Accuracy = TP/(TP+FT+TN+FN) \tag{2}$$

The CMX contains four types of results: the number of True Positives (TP), False Positives (FP), True Negatives (TN) and False Negatives (FN). The CMX along with the accuracy result were obtained automatically using the package 'caret' in R Studio.

The best results concerning the DM techniques, scenarios and target approaches are exposed in table 4.

Table 4. Best accuracy results in view of the best DM technique and scenario for each target approach

Approach	DMT	Accuracy	DMT	Accuracy	DMT	Accuracy	DMT	Accuracy
1	*Scenario 0*		*Scenario 3*		*Scenario 4*		*Scenario 8*	
	DT	0.9359	DT	0.8982	DT	0.8670	DT	0.8614
	GML	0.8006	GML	0.7954	NB	0.7505	GML	0.7950
	NN	0.7846	NN	0.8041	GML	0.7915	SVM	0.7979
2	*Scenario 0*		*Scenario 3*		*Scenario 8*		*Scenario 9*	
	DT	0.7494	DT	0.7081	DT	0.7277	DT	0.6636

Overall, the best DM models were attained by inducing decision trees (DT). Regarding the attributes, scenario 0 presents best accuracy values, showing that the selected variables influence indeed the triage waiting times in the maternity emergency room.

4.6 Deployment

The best DM models, as well as the new knowledge obtained about the attributes that influence the triage waiting times in the GO unit of maternity emergency room are reported to the maternity care unit of CMIN, being implemented in the IDSS and the Business Intelligence (BI) platform in use in CHP [25]. The BI platform supports the clinical and administrative decision process, concerning the care and the patients.

5   Discussion

As presented in table 4, the study achieved worthy results for all the persuaded target distributions, allowing sensible predictions of the triage waiting times and therefore, the support to the CMIN's triage process. It is up to the healthcare professionals to choose which target approach could be most beneficial to the melioration of the maternity emergency room patient flow. On the one hand, the first approach, which classifies the admissions in two classes according to the mean triage waiting time in the last 5 years, is the most opportune regarding statistical grounds. On the other hand, if the most clinical fitting approach would be classify the triage waiting times concerning the levels of severity; the second approach should be persuaded. Table 5 briefs the best models to predicting the triage waiting times.

Table 5. Top DM models that present the higher values of accuracy in view of the best target approaches

Target Approach	Scenario	DMT	Accuracy
1	0	DT	0.9359
2	0	DT	0.7494

Another useful contribution of the study is the identification of the dataset attributes as enhancers to the patients' triage waiting time. Variables as the number of patients present in the waiting room, the number of triage professionals working at the moment and some temporal variables can be used to identify outstanding situations in the triage process, and therefore, improve the healthcare services.

In a real time environment, physicians can rely on the DM models to send warnings informing about the triage waiting time itself, but also about workflow issues and uncommon or risk conditions. Consequently, the physicians can be observant and alert to special cases and can put the patients on watch accordingly, allowing the healthcare institution saving resources and time.

6   Conclusions and Future Work

By means of real data obtained from CMIN's information systems SAPE and EHR, it is possible to prove the viability of using DM models to predict the triage waiting time, in maternity emergency room, through environmental and individual characteristics of

the GO unit and patients. Clinically suitable results were achieved regarding the accuracy metric, by inducing the DM technique Decision Trees on data from scenario 0, achieving approximately 96% of accuracy, when using a five level target approach. The best DM models to predict the triage waiting times can also be used to implement a time tracker in the emergency room, since studies indicate that the awareness of waiting times increases the individuals' satisfaction and reduces anxiety and unattended leaves [26]. Accordingly, the best models and the results achieved will be included in the IDSS and the BI platforms, allowing the improvement of the GO patient flow and satisfaction, supporting the physicians' decision-making, leading to quality improvements in the maternity care. Applying the present DM strategy on a different setting or environment could represent a significant step to evince the support decision solutions benefits on improving the quality of the emergency services, by aiding both health professionals and patients.

Acknowledgments

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Critical Events in Mechanically Ventilated Patients

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Abstract. Mechanical Ventilation is an artificial way to help a Patient to breathe. This procedure is used to support patients with respiratory diseases however in many cases it can provoke lung damages, Acute Respiratory Diseases or organ failure. With the goal to early detect possible patient breath problems a set of limit values was defined to some variables monitored by the ventilator (Average Ventilation Pressure, Compliance Dynamic, Flow, Peak, Plateau and Support Pressure, Positive end-expiratory pressure, Respiratory Rate) in order to create critical events. A critical event is verified when a patient has a value higher or lower than the normal range defined for a certain period of time. The values were defined after elaborate a literature review and meeting with physicians specialized in the area. This work uses data streaming and intelligent agents to process the values collected in real-time and classify them as critical or not. Real data provided by an Intensive Care Unit were used to design and test the solution. In this study it was possible to understand the importance of introduce critical events for Mechanically Ventilated Patients. In some cases a value is considered critical (can trigger an alarm) however it is a single event (instantaneous) and it has not a clinical significance for the patient. The introduction of critical events which crosses a range of values and a pre-defined duration contributes to improve the decision-making process by decreasing the number of false positives and having a better comprehension of the patient condition.

Keywords. Critical Events, Intensive Care, INTCare, Ventilated Patients, Data Acquisition, Real-Time, Streaming Data, Interoperability.

1   Introduction

The process of ventilating a patient using artificial techniques is complex and it involves a set of concerns. By default a set of variables is defined in the ventilator according to the patient needs. Then the ventilator is prepared to monitoring the patient condition by collecting a set of patient values (e.g. Plateau Pressure, PEEP, Respiratory Rate, others). Typically these data are shown in the ventilator monitor

and they are partial recorded (only the first value of the hour is considered) in an electronic platform or manual sheet.

To a better decision it is fundamental to have a system able to collect and process the data in real-time. In this sense a data acquisition architecture was designed. The architecture developed uses interoperability, streaming data and intelligent agents to store the patient data in the database. After this process a huge volume of data is available to be consulted by the clinicians in order to make the best decision. However and although the high number of data available, the physicians do not have time to read and understand all the data available in the right moment. In order to support and facilitate this analysis the Critical Events (CE) concept [1] was adopted and it was associated to ventilation variables. The concept was initially applied to vital signs variables [2]. This process was defined using the knowledge obtained through a literature review and after meeting with physicians. The process was tested and it was defined taking in attention the Intensive Care Units (ICUs) particularities.

ICU is a unit where the patients with severe diseases are admitted. In most cases they are needing mechanical ventilation. This work is framed in the INTCare project [3, 4] and it was evaluated using real data provided by the Intensive Care Unit of Centro Hospitalar do Porto, Hospital Santo António. The introduction of critical events [5, 6] has as main goal decreasing the number of false positives and finding an alternative way to avoid the noise alerts presented in the ventilators [7]. Generally the alerts are turned off because they are very noisy and they interfere in the environment. With this new solution an event only is considered serious if a patient has a critical value for a pre-defined period of time. This solution contributes to outwit false positives provided by the ventilator. All the values collected are validated before being used by the agent responsible to categorize the value as critical or not.

As already mentioned all the definition process was based in clinical evidences. The definition of the values was made after meetings with the intensivists and after reading clinical works.

The goal of this work was achieved and as result the critical events concept was defined to mechanically ventilated patients. At same time a platform was developed to show the results and alert the clinicians about the patient condition, i.e., when the patient is with a critical event.

This paper is divided in seven sections. After a brief introduction of the work the concepts are addressed and the project is presented in section 2. Section 3 presents the data acquisition architecture designed. Section 4 presents the critical events ranges and how it is calculated. Then in section 5 a dataset was analysed in terms of critical events and their results are presented. Section 6 makes a conclusion of the work and finally in section 7 there is some points of future work.

2   Background

2.1 Mechanical Ventilation

A patient is connected to a ventilator when he cannot breathing from natural ways. Mechanical ventilation is used to support the patient in their respiratory functions.

Mechanical ventilation in Intensive Care Units is considered an essential, life-saving therapy for patients with critical illness and respiratory failures [8].

The ventilators were developed with a second goal: to generate alarms when patients become disconnected or they are having critical ventilator events [7]. "All ventilators are now designed to detect critical events and are equipped with alarms. However, these alarms are only audible peeps that often are difficult to hear outside of the patient's room. Moreover, the large number of false-positive alarms generated by bedside monitoring devices exacerbates this problem because ventilator alarms can blend in with other accustomed sounds of the intensive care unit" [7].

According to a CDC study [8] Ventilator-associated pneumonia (VAP), sepsis, Acute Respiratory Distress Syndrome (ARDS), pulmonary embolism, barotrauma, and pulmonary edema are among the complications that can occur in the patients. The ventilator events are identified by using a combination of objective criteria: deterioration in respiratory status after a period of stability or improvement on the ventilator, evidence of infection or inflammation, and laboratory evidence of respiratory infection [8].

In this work and having in consideration the definitions above mentioned the goal is to give a new importance to the variables continuous monitored by the ventilator. By combining the values and their duration it is possible defining a set of values from a specific variable as a critical event.

2.2 Intensive Care Units

Intensive Care Units (ICUs) provide intensive care (treatment and monitoring) for people in a critically ill situation or unstable condition [2]. In ICUs are patients which needs a continuing medical attention and support to keep their body functioning (e.g. respiratory system). This type of support is essentially done recurring to technology and to the care of intensivists (nurses and physicians) [9].

Respiratory failure is one of the most common causes of ICU admission and 75% of the patients require mechanical ventilation. Despite of their benefits, these procedures might have some serious drawbacks like contributing to the lung's injury. Mechanical ventilation can have negative effects and its mortality rate ranges from 41% to 65% [10]. The number of re-intubations vary from 2% to 25% [11].

An automatic control of the mechanical ventilation can significantly improve the patient care in the ICUs, reduce the mortality and morbidity rates associated with provision of inappropriate ventilator treatments and reduce healthcare costs.

2.3 INTCare

INTCare is a research project designed to Intensive Care Medicine. This project gave origin to two platforms: patient monitoring and decision support. INTCare architecture is based in a multi-agent system [12].

Using INTCare is possible monitoring patients in real-time. It is possible store, process and analyse data automatically collected from bedside monitors (vital signs and ventilators), therapeutics and laboratory or manually recorded in the platform.

Using intelligent agents all the data are processed and a set of indicators and medical scores is presented to the intensivists.

The second platform is an Intelligent Decision Support System (IDSS). This platform uses ensemble data mining to predict clinical events (e.g. organ failure, patient outcome, length of stay, barotrauma among others). The use of critical events [1, 13] improves the sensitivity of the data mining models [1, 14-16]. Now this project is focused in the respiratory system and in predicting the occurrence of barotrauma [17]. With the development of this new approach and the definition of critical events to the ventilation, the influence of these variables will be studied in the models already induced [18-20].

3   Data acquisition architecture

This section presents the architecture (Figure 1) developed to collect the data from the ventilators using data streaming. To support this architecture a set of intelligent agents [21, 22] is used. First a ventilator is connected to a patient. This ventilator is able to monitoring all the patient respiratory variables. To have a correct identification of the patient, a procedure is used to confirm which patient is using the ventilator. This procedure will consult the Electronic Health Record (EHR) and analyse which patient is admitted in the bed near the ventilator that is collecting the data.

Then the gateway is prepared to send a message to the ventilator with the information about which variables were chosen to be collected. Then and after the ventilator receives the message all the results associated to the variables chosen are sent by the ventilator to the gateway. This process is continuous. Then the received results are processed by the Ventilation Acquisition agent in order to create Health Level Seven (HL7) [23] messages. This message is divided in two levels: header and data. After these messages be stored in the temporary tables a pre-processing agent is executed to analyse the values. This agent has the responsibility to verify if a value is valid and if it is critical or not. Then the pre-processing agent will analyse the last values collected and verify if they can be considered a critical event or not. The pre-processing agent uses the data presented in the critical events table (table 1) to make their job. This agent is responsible by understanding the significance of a value in a specific variable (each time a new value arrives). When a value lower or higher than the normal range appears for the first time, this agent starts recording an event. Then all the values collected are analysed. The event will be closed only (with a finish date) when a normal value arrives, until then the agent will continue counting the event duration. After finishing the event, the agent will verify the significance of the event duration. If the event duration is higher than the time defined as normal, the event is considered critical, otherwise it is normal.

Finally the information attained (events data) by the agent is stored in the database.
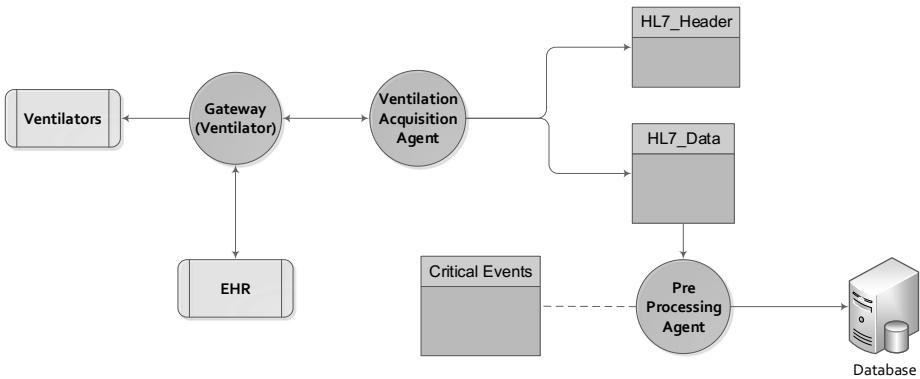
Fig. 1. Data Acquisition Architecture

4 Critical Events in ventilation

As mentioned the critical events (CE) range were defined after a depth literature review about the influence of each variable has in the patient condition and a meeting with experts in this area.

Table 1 presents a set of variables that can be used to define critical events. The Min Normal and Max Normal are the normal values (range). The columns Min and Max value are used to validate the values, i.e., it is the minimum and maximum value that a ventilator can monitoring. The values out of this range are considered noise values and they are not considered in the CE calculation process. The time (in minutes) is used to define an event as critical.

To calculate the CE an agent is used. The pre-processing agent is responsible by verifying if a set of values are lower than Min Normal or Higher than Max Normal with a duration upper than the time defined. Firstly this agent has to validate the values collected and verify if each value collected is in the normal range. Then if both conditions are verified a critical event is defined.

For example in the case of Positive end-expiratory pressure (PEEP) an event is considered critical when a patient has a PEEP higher than 0 and lower than 20 and at same time all the values collected are lower than 5 and upper than 15 for a period higher than 10 minutes.

Table 1. Ventilation critical events definition

Variable	Units	Min Normal	Max Normal	Min Value	Max Value	Time
Average Ventilation Pressure (AVP)	cmH2O	6	25	0	40	10
Compliance Dynamic (CDYN)	mL/cmH2O	21	43	0	250	30
Flow	litters per minute	20	80	20	250	10
Peak Pressure	cmH2O	8	50	0	100	10

Variable	Units	Min Normal	Max Normal	Min Value	Max Value	Time
PEEP	cmH2O	5	15	0	20	10
Plateau Pressure	cmH2O	8	30	0	100	10
Respiratory Rate	breaths per minute	8	25	1	200	10
Support Pressure	cmH2O	6	26	1	100	10

5   Data Analysis

After create the CE it was possible to make an analysis of the data collected using real data provided by ICU of Centro Hospitalar do Porto. This analysis had in consideration the data collected from 2015, 1, January and 2015, 31, June. This data corresponds to 67 ventilated patients.

Table 2 presents the number of values collected and how many values are critical. Then it was studied the values duration and if they can represent a critical event. In the critical events column it is the number of events categorized as 1 (critical). In the column Critical Events Time is the number of events categorized as 1 and they had a duration upper than the time presented in table 1. The percentage represents a values ratio. This ratio is presented in figure 2.

As can be observed in table 2, Compliance Dynamic (CDYN) is the variable which present more values out of the normal range with a percentage of 41.79%.

In the case of Critic Events is interesting verify than in average most of the events are not critical, i.e., they did not have a significant duration. In this case Average Ventilation Pressure (AVP) is the most critical variable with a percentage of critic events higher than 62%.

It is important to note that the normal events (values between the normal ranges) were not considered in this analysis.

Table 2. Ventilation Values and Critical Events in an ICU

Variable	Critical Value	All Values	Critical Value%	Critical Events Time	Critical Events	Critical Events Time %
AVP	618	61733	1.00%	545	871	62.57%
CDYN	24360	58293	41.79%	522	895	58.32%
Flow	848	51311	1.65%	19	35	54.29%
Peak Pressure	2708	61653	4.39%	365	775	47.10%
PEEP	10910	61985	17.60%	32	68	47.06%
Plateau Pressure	5584	61312	9.11%	103	404	25.50%
RR	1576	50768	3.10%	44	80	55.00%
Support Pressure	510	14639	3.48%	29	61	47.54%

Figure 2 presents the number of critical events verified in this ICU during the last 6 months. For example analysing the Plateau Pressure there is a considerable number of

critical values (9.11%) but from these only 25.5% has a duration upper than 10 minutes and it is considered a critical event. In the opposite site it is AVP with 1% of critical values being 62.57% of these values considered as critical events.
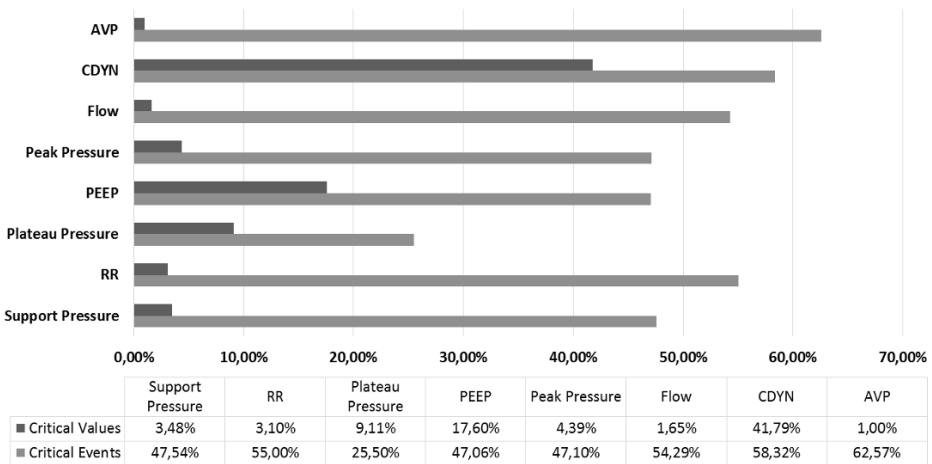

	Support Pressure	RR	Plateau Pressure	PEEP	Peak Pressure	Flow	CDYN	AVP
■ Critical Values	3,48%	3,10%	9,11%	17,60%	4,39%	1,65%	41,79%	1,00%
■ Critical Events	47,54%	55,00%	25,50%	47,06%	47,10%	54,29%	58,32%	62,57%

Fig. 2. Data analysis distribution

6 Conclusion

In this work a new concept was associated to mechanical ventilation. Critical Events were introduced in order to better categorize a patient. CE help the intensivist to have a better comprehension of patient condition without to have to look to the ventilator all the time.

As mentioned in the background, typically the ventilator alarms are shut down due to their noise. With this new concept, a set of patient values can be considered a critical event or not instead of being used a single value.

Intelligent Agents are used to process all the results collected automatically and in real-time. These agents follows a set of rules pre-defined. First the values are validated and categorized as critical or not using table 1 by the agent. Then and having in consideration the event duration a set of values is defined as critical or not. As can be observed in the analysis made there are a set of patients values that are constant collected and can active an alarm but they are considered a noise value.

With this new concept only the values with clinical relevance are considered – in case of a patient is suffering a values variation out of the normal range for a determined period of time. With this work it was also possible observe a set of negative values, i.e., out of the acceptable range (e.g. plateau pressure equal to - 9). Beside this fact validating the values is true important in order to avoid false positives and to have a correct calculation of critical events.

The system developed is intelligent because it is able to analyse the values collected, understanding if it is or not critic basing their decision in the value range

and in the event duration. In parallel it is able to automatically and in real-time processing all the values collected and send alerts when some abnormal value is verified or a patient is in risk due to the event duration. A patient tracking system [24] also was developed using the concept presented in this paper.

Some study are being performed using Critic Events [25]. Data Mining models are being induced and the results are very promising (blood pressure [26] , arrhythmias [27]).

The goal of this paper was not to study the Critical Events impact but analyse the possibility to introduce CE in the ventilation variables. Section 5 was fundamental to present a possible analysis of the data collected using the CE concept. As main contribution of this work it is the definition of critical events to ventilation and their applicability in the Intensive Care Units. With this work the researchers has a new approach that can be considered in future studies.

7   Future Work

In the future it is fundamental study the real influence of critical events in the patient condition by developing data mining models using this variable. For example CE can be used to improve Data Mining models in order to predict Barotrauma or Early extubation. At same time it is necessary to finish the development of the alert platform.

Acknowledgements

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Optimization techniques to detect early ventilation extubation in Intensive Care Units

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Abstract. The decision support models in intensive care units are developed to support medical staff in their decision making process. However, the optimization of these models is particularly difficult to apply due to dynamic, complex and multidisciplinary nature. Thus, there is a constant research and development of new algorithms capable of extracting knowledge from large volumes of data, in order to obtain better predictive results than the current algorithms. To test the optimization techniques a case study with real data provided by INTCare project was explored. This data is concerning to extubation cases. In this dataset, several models like Evolutionary Fuzzy Rule Learning, Lazy Learning, Decision Trees and many others were analysed in order to detect early extubation. The hydrids Decision Trees Genetic Algorithm, Supervised Classifier System and KNNAdaptive obtained the most accurate rate 93.2%, 93.1%, 92.97% respectively, thus showing their feasibility to work in a real environment.

Keywords. Optimization techniques; Decision Support Systems; Machine Learning; Heuristics; Intensive Care Units Extubation.

1   Introduction

This work is part of an evaluative study integrated in INTCare project. INTCare is an Intelligent Decision Support Systems (IDSS). It is implemented in the Intensive Care Unit (ICU) of the Hospital Centre of Porto (CHP). This IDSS is based on intelligent agents and data mining models [1] that seek to automate tasks and to predict clinical events in order to help the diagnosis and treatment of patients by providing new knowledge able to help them to recover to his previous health state. This type of patients is usually admitted to the ICU where it is possible to monitoring and maintaining their physiological functions through life support devices. These units provide a continuous patient monitoring of vital signs as well as a constant analysis of each organ system: neurological, respiratory, hepatic, haematological, cardiovascular and kidney [2]. At the same time, many of those patients are mechanically ventilated. Around 75% of the admitted patients to ICU require assisted ventilation to support breath function, with an

automatic mechanical control that can improve the quality of patient care. A well-done extubation process can reduce the risk in provoking lung injuries and reduce the morbidity and mortality rates associated with provision of inappropriate cases of ventilation. To enhance this process urges the use of optimization techniques to improve the models already developed by Oliveira et al. [3]. An exhaustive literature review for this work was made and several optimization techniques applied to local and global solutions were found. These techniques are used to interpret the collective behaviours and evolution of species or adapting both making them hybridizing to overcome some or other weakness from one to another.

The results take in consideration the performance of the method present in the system, statistical classification tests, the predictive acuity and representation derivation of the solution more user friendly. To assess the efficiency of the optimization techniques in this case study, 63 techniques were explored to insight the viability of improving the INTCare system. Decision Trees Genetic Algorithm (DT_GA), sUpervised Classifier System (UCS) and K-Nearest Neighbours Adaptive algorithm (KNNAdaptive), with results 93.2%, 93.1% and 92.97% respectively, achieved the best accuracy rates. These models are important to determine the best time to extubation, through the characteristics of these patients.

The present paper is divided in five sections, Introduction of the theme, explanation of the Background scenario, Materials and Methods taken in consideration; CRISP-DM sub phases to guide the work, and Conclusion and future work.

2   Background

2.1   Intensive Care Units

People who have serious illnesses are usually admitted to the intensive care units (ICU) so that it is possible to keep their vital physiological functions through various media devices, such as medical devices (ventilators, vital signs machines, etc.) until they have their organs functioning independently again [4].

The bulk heterogeneous information processing becomes critical, which makes the extremely complex environments in intensive care units taking into account the amount of data that it is necessary consider by medical teams [5]. This reality exposes the fragility of the teams and a few existing decision support models in situations where the decision time on the analysis of multiple variables is critical. The optimization techniques have interdisciplinary characteristics able to optimize the solutions and decisions. For example, these techniques are capable of anticipating the decision making process on a patient while maintaining a monitoring of its vital functions, ensuring their safety and helping to realize the best treatment.

2.2   Mechanical ventilation weaning and extubation

A patient intubation case happens when the respiratory system fails in oxygenation, carbon dioxide elimination or both [6]. The goal of artificial ventilation intubation is to

reduce lung injury due to over distention. In current days, mechanical ventilation is very important to treat many different illnesses, but is relatively costly [7].

In ICU, the weaning process is gradual and it is considered successful when a patient can breathe by himself for a period upper than one hour. Actually there is a set of IDSS to ventilators, an expert advisory system or an automatic control of ventilation [3], however, most of them are rule-based, turning them into static models and not adaptive.

The extubation process is based on clinical knowledge and medical assumption [8] creating a tentative-error procedure. This happens because the ventilators are only used to consult the patient values; the unused data is not stored in any database or file, resulting in a waste of data that could be transformed in information and up ways into knowledge to help the decision-making process.

2.3 Optimization

In medicine, optimization has become ubiquitous [9]. The use of computing power for applications in the medical field has opened up many questions and challenging problems inherent in these communities. The mathematical techniques (continuous and discrete) play an increasingly important role in understanding of several critical problems in medicine. Of course, optimization is one fundamental tool due to the limitation of the resources involved and the need for better decision-making in the shortest time possible [9]. An optimization algorithm is an iterative process where after a certain number of iterations may converge to a solution that ideally will be the optimal solution to the problem. During the interactions that occur in the process, the solutions that emerge are state of evolution that are drawn according to mathematical equations or set of rules for convergent solutions of a self-organizing system. As a result, their ability to represent a self-organizing system shows us some emerging features and its ability to evolve.

Briefly, course, discontinuous, Single-solution based, Population-based, Guided search, Unguided search and hybrid methods are described as some of the most important features for this type of optimization methods [10]. If it is possible to provide a balance between diversification and intensification, the metaheuristics techniques will be successful in a given optimization problem. The increase is needed in the search for parts in space with high quality solutions. It is important finding some promising areas on the accumulated research experience. The main differences between the existing meta-heuristics relate to their particular way of achieving this balance [11]. The classification criteria can be used for the meta-heuristics, in terms of the features that follow in the search, memory feature, kind of neighbour holding used or the number of current solutions created through iterations.

2.4 Population based methods

Dealing with a set (population) solutions instead of an initial solution. Most studies based on these methods are related to Evolutionary Computation (EC) inspired by Darwin's theory, where the population of individuals is modified through recombination, genetic operators and swarm intelligence (SI). Here the idea is to create

computational intelligence to explore simple analogies of social interactions rather than purely individual cognitive abilities [12] in how the simulation of evolution structure their subjects, objectives, through processes of selection, recombination and mutation breeding in order to develop better solutions [13]. In general, the following algorithm serves as an example for the methods addressed in this study.

Algorithm 1 – Evolutionary Computation

Algorithm - EC	
1 Initialize the population with random individuals	
2 Evaluate each individual	
3 **R***epeat*	
4	Select country
5	Recombine pairs of parents
6	Mutate descendants
7	Evaluate new individuals
8	Select individuals for the next generation
9 ***Until*** the stop criterion is satisfied	

3   Materials and Methods

A literature review about optimization techniques to support decision models already elaborated was taken in consideration [14]. To explore optimization KEEL (Knowledge Extraction based on Evolutionary Learning) [15] algorithms were used. This tool allow evaluating evolutionary algorithms in Data mining problems, but also in Machine Learning questions. In this work, methods like Evolutionary Fuzzy Rule Learning, Lazy Learning, Evolutionary Crisp Rule Learning, Prototype Generation, Fuzzy Instance Based Learning, Decision Trees, Crisp Rule Learning, Neural Networks and Evolutionary Prototype Selection were analysed and explored.

Even without any explicit Data Mining technique been used, the Cross Industry Standard Process for Data Mining (CRISP-DM) methodology was chosen to guide this study. CRISP-DM is divided in six phases, Business Understanding, Data Understanding, Data preparation, Modelling, Evaluation and Deploy.

4   Knowledge Discover Process

The following sections were divided according to CRISP-DM phases.

4.1   Business Understanding

This work was proposed to find optimization techniques in order to improve the INTCare system on predicting the best time to a successful extubation. It is also expected creating knowledge to help clinical teams to make better decisions in ICU scenario. The data used for these experiments were from other work already carried out, in the Centro Hospitalar do Porto (CHP) [3]. The study aimed to identify a set of

features / variables associated to a successful extubation. Most of the data provided by INTCare system was already characterized and transformed. The dataset created resulted from the application of DM techniques, more specifically the creation of clusters, using the k-means algorithm and k-medoids based the partition principle and sensitivity difference extreme values [3].

4.2 Data Understanding

The dataset used correspond to 50 patients in a total of 24295 records with fifteen fields from the ventilators in the ICU of CHP, collected between 2014-09-19 and 2015-02-03. Each record is composed by the following variables:

- Pressure support setting in cmH2O;
- End inspiratory pressure in cmH2O;
- Dynamic compliance (CDYN) in mL/cmH2O;
- Static compliance (CSTAT) from inspiratory pause manoeuvre in mL/cmH2O;
- Mean airway pressure in cmH2O;
- Maximum circuit pressure in cmH2O;
- Static resistance (RSTAT) from inspiratory pause manoeuvre in cmH2O/L/s;
- O2% setting;
- Peak flow setting in litters per minute;
- Tidal volume setting in litters;
- Respiratory rate setting in breaths per minute;
- Exhaled tidal volume in litters;
- PEEP or PEEP Low setting in cmH2O.

4.3 Data preparation

To prepare the data, after a brief check, a feature selection algorithm present in KEEL was used. This algorithm allowed determining the most preponderant variables in the dataset. Reaching the results, a new dataset with 14139 records to use on the techniques as inputs was created. The following

Table 1 describes what each input variable means their average, standard deviation and variance.

Table 1. Description and distribution of the inputs

Description	$\overline{x}$	σ	s^2
Peak flow setting in litters per minute (F12)	24.00	23.55	554.86
O2% setting (F13)	49.75	7.65	58.56
PEEP or PEEP Low setting in cmH2O (F15)	5.09	1.05	1.11
Pressure support setting in cmH2O (F26)	14.11	3.60	12.98

Description	$\overline{x}$	σ	s^2
Exhaled tidal volume in litters (F35)	0.52	0.16	0.02
Maximum circuit pressure in cmH2O (F38)	20.53	3.86	14.95
Mean airway pressure in cmH2O (F39)	10.50	1.84	3.40
End inspiratory pressure in cmH2O (F40)	19.98	3.85	14.86
Dynamic compliance in mL/cmH2O (F65)	45.75	40.18	1615.23

As output, the Target variable translates three events. When the value is 0, means that it was not possible to extubate the patient, when the value is 1 the patient was extubated but after some time, he needed to be ventilated again and when the value is 2, the patient was extubated with success. As can be observed Fig. 1 shows a limitation in successes cases.
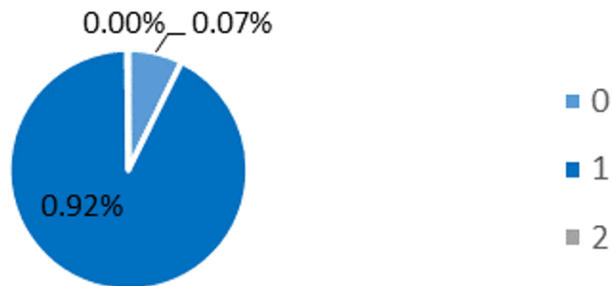
Fig. 1. Output representation from the received data

After that, the dataset was partitioned using cross validation presented by Dietterich in 1998 [16].

4.4 Modelling

In this work only the algorithms proposed after the year 2000 were considered. After elaborate the experiments some algorithms were excluded due to their huge process time consuming and unsuccessful results.

Several experiments were compromised, making them inconclusive, despite being tested. Altogether 63 algorithms tests were conducted, which included 10 models Evolutionary Fuzzy Rule Learning, 16 Evolutionary Crisp Rule Learning, 4 Lazy Learning, 7 Prototype Generation 5 Fuzzy Instance based Learning, 7 Decision Trees, 5 Crisp Rule Learning, 4 Artificial Neural Networks and 5 Evolutionary Prototype Selection with selection criteria as the global average acuity (the set of test data).

To the case study, the configurations presented in Table 2 were used.

Table 2. Parameter settings of the algorithms

Algorithm	Parameters
DT_GA	Confidence: 0.25, instances per leaf: 2, genetic algorithm approach: GA-LARGE-SN, threshold S to consider a small disjunt:10, number of total generations for the GA: 50, number of chromosomes in the population: 200, crossover probability: 0.8, mutation probability: 0.01
UCS	Number of explores: 100.000, population size: 6400, delta: 0.1, nu: 10, Acc: 0.99, pX: 0.8, pM: 0.04, theta_ga: 50, theta_del: 50, theta_sub: 500, doGASubsumption: true, type of selection: RWS, tournament size: 0.4, type of mutation: free, type of crossover: 2PT, r: 0.6, m: 0.1,
KNNAdaptive	K value: 1, distance function: euclidean

4.5 Evaluation

After an exhaustive test made in KEEL the top 3 techniques / results was selected. The hybrid algorithm Decision Trees Genetic Algorithm (DT_GA) [17], the fuzzy rules, learning classifier systems and data mining supervised Classifier System (UCS) [18] and K-Nearest Neighbours Adaptive algorithm (KNNAdaptive) [19]. These algorithms are the best optimization techniques to improve the decision making process to determine the conditions for successful extubation in intensive care units.

To DT_GA, the parameters defined in KEEL obtained a 93.2% accuracy rate, to UCS, the set parameters achieved one accuracy rate of 93.1% and finally to the KNNAdaptive algorithm yielded a 92.97% accuracy rate.

Table 3 show the average results in the Friedman test [20], Multiple test [20] and Contrast Estimation [21]. Table 4 presents confidence matrix for three trust levels: 99%, 95% and 90%.

Table 3. Classification test of the best techniques

	Median error in classification		
	Friedman test	Multiple test	Contrast Estimation
DT_GA	0.06	0.06	0.06
UCS	0.07	0.07	0.07
KNNAdaptive	0.07	0.07	0.07

Table 4. Confidence matrix of the best techniques

	p-value confidence matrix		
	DT_GA	UCS	KNNAdaptive
DT_GA	0.00	0.09	0.25
UCS	0.00	0.00	0.96
KNNAdaptive	0.00	0.00	0.00

DT_GA technique have high interpretability of results by the user. Figure 2 show an example of the sheets (rules) for the case 2 (successful extubation) and table 5 the execution time need to achieve the global average by algorithm.
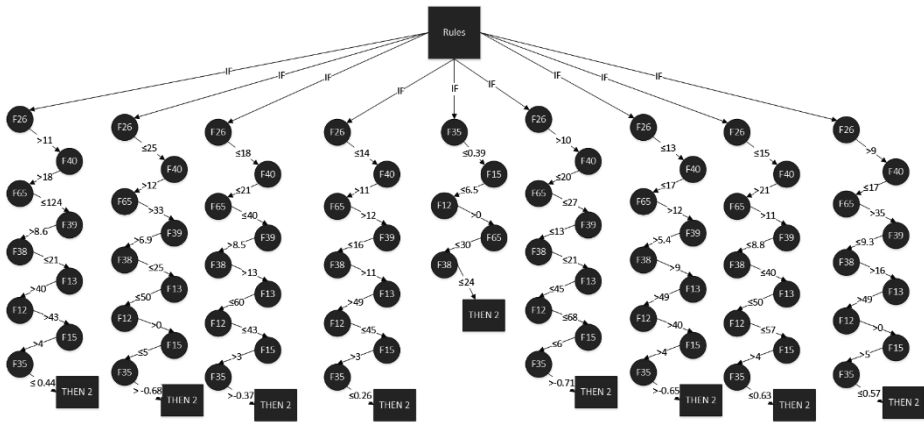
Fig. 2. Decision trees rules created by DT_GA algorithm

Table 5. Global average acuity and execution time of the best techniques

Algorithm	Global average	Execution time
DT_GA	93.2%	4 minutes
UCS	93.1%	4 minutes
KNNAdaptive	92.97%	2 minutes

4.6   Deploy

The best optimization technique to apply in the ICU for this case study was the DT_GA, not only because the predictive accuracy, but also for the interpretability of the results. It shows the value range of the variables to consider in detecting an early extubation and medical teams can take into consideration with the representation of these variables value. These optimization models will be added to INTCare system in order to improve the Data Mining models.

5   Conclusion and future work

Continuing the studies already made in INTCare [3, 22, 23, 24, 25, 26, 27, and 28] in the field of respiratory system and data mining a new approach was explored.

Throughout this work, the study has been extended by a quantitative research based on a benchmarking process, where several existing optimization techniques able to be included in these models were explored. After an extensive and appropriate literature review [14] the most adequate techniques were explored in KEEL. A total of 63 experiments were made.

Evolutionary models: Crisp Rule Learning, Lazy Learning and Decision Trees were selected. The best results were achieved by DT_GA techniques, UCS and KNNAdaptive with the accuracy rate of 93.2%, 93.1% and 92.97% respectively.

In the future, these models will be incorporated in INTCare system in order to improve the results and optimize the support system already implemented to predict

ventilator extubation. The technical aspects of introducing new procedures should be described in detail in order to provide necessary instructions for medical assistance which have to able to interpret the collected data. Moreover, there is a need to analyze the implementation effectiveness of optimization techniques presented in the article and further research on feedback given by medical professionals.

Acknowledgments

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Comorbidity coding trends in hospital administrative databases

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Abstract. Comorbidities are related to an increase in hospital costs, hospital mortality and length-of-stay. The analysis of inpatient comorbidities is therefore important for hospital management, for epidemiological studies, and for health services research and planning. In this paper we study the annual evolution of coded comorbidities in administrative databases. We used data from Portuguese hospitals over a period of eleven years (2000-2010). We identified comorbidities in 7,034,213 inpatient episodes using both the Elixhauser and the Charslon/Deyo comorbidity methods. Our results clearly evidenced a positive association between the number of secondary diagnosis and coded comorbidities. We argue that the increased number of comorbidities over time is mostly related to an increase in the quality of coded data. Data analysts, researchers and decision makers should always be aware of possible data quality bias, such as completeness, when using administrative databases.

Keywords: ICD-9-CM, comorbidity, coding and classification, administrative data, data quality

1   Introduction

A comorbidity is a secondary diagnosis, i.e., a disease condition, other than the principal diagnosis, already present at the time patient is admitted. The presence of comorbidities may have consequences at various levels as, for instance, mortality, quality of life, utilization of health resources and treatment strategies.

Several studies showed that there is a relation between specific patient comorbidities and an increase (or decrease) in hospital costs, hospital mortality and length-of-stay [1–3]. In fact, due to this association with health outcomes, the study and assessment of comorbidities assumes special importance for health services research, for epidemiological and clinical studies, and also for financing and health care planning.

Comorbidities are patient preexisting conditions that should be controlled when using administrative data [1, 4]. In administrative databases, comorbidities can be identified using ICD-9-CM (International Classification of Diseases, Ninth Revision, Clinical Modification) codes associated to secondary diagnoses [5].

In this context, the quality and the volume of the data coded can naturally have influence in the proportion of identified comorbidity conditions. This is especially im-

portant in the study of trends or in any analysis over time. Comorbidities should also be used in risk-adjustment of health outcomes (e.g., mortality) to induce, for instance, a more fair comparison between health institutions.

The study of the number of coded secondary diagnoses is important to understand the evolution in the proportion of identified comorbidities [6]. This number is increasing over years and consequently the number of identified comorbidities is also continuously increasing. This evolution is not necessarily related to an increase in the severity of patients treated.

This paper aims to study the evolution of comorbidities over time using administrative data, and was carried out under the CUTEheart project, Comparative use of technologies for coronary heart disease, an international partnership between the Harvard Medical School and the Faculties of Medicine from the Universities of Lisbon and Porto in Portugal.

1.1 Administrative data

Administrative data (also known as billing or claims data) is routinely collected, commonly available, relatively inexpensive, and involves large amounts of data. Although with some data quality problems [7, 8], administrative data is a valuable source for measuring quality of care. It has a standard format and can be used for many purposes, such as research or public reporting [9]. This datasets typically contains demographic data (e.g., age, gender), "administrative data" (length of stay, type of admission, payer, discharge status, diagnosis related group) and ICD-9-CM codes for clinical data (diagnostics, procedures, external causes) [10].

1.2 Comorbidity classification systems

Comorbidity scores are often used for epidemiological studies and health service research [11]. These scores can be calculated using different data sources, such as ICD-9-CM data, as in the Elixhauser [2] and Charlson indexes [12], and pharmacy claims, as in the RxRisk-V score [13]. These three examples are the most commonly used methods for measuring comorbidities. Next we briefly describe these methods, and give particular emphasis to the two methods that use administrative data (ICD-9-CM).

Charlson et al. [12] defined a weighted index to classify comorbid conditions associated with an increased risk of mortality. In the original definition, the index was calculated using 19 conditions with different assigned weights for each condition (1, 2, 3 or 6), considering the risk of death of each condition. For instance, 'congestive heart failure' had a weight of 1, 'leukemia' had a weight of 2, and 'AIDS' had a weight of 6. There are many variations of this index, including one of the most used, the Deyo et al. adaptation for use with ICD-9-CM administrative databases [1].

The method proposed by Elixhauser et al., [2] also used ICD-9-CM codes in the definition of a list of 30 comorbidity conditions. The performed study showed that the developed measures were associated with an important increase in length of stay, hospital charges, and hospital mortality. After that, several studies pointed out that Elixhauser method has better mortality prediction than the Charlson method [5, 14].

The RxRisk-V is a comorbidity index based on computerized data from hospital pharmacies with good results in the prediction of total health costs [15].

2 Methods

We used data from hospitalizations in acute care public hospitals, with discharges between years 2000 and 2010. This dataset included inpatient episodes (outpatient episodes were excluded) in all Portuguese acute care hospitals, representing nearly 85% of all hospitalizations in Portugal. The access to the data was provided by the Ministry of Health's Central Authority for Health Services.

As in other comorbidity studies, for instance in the study performed by Elixhauser et al. [2], we excluded pediatric (age below 18 years) and obstetrical episodes. Patients discharged to another institution or transferred to/from other hospitals were also excluded. The initial dataset contained 14,873,703 (inpatient and outpatient) episodes and, after applying the exclusion criteria, 7,034,213 episodes were eligible for analysis.

Comorbidities were identified using the two most widely used comorbidity approaches, the Elixhauser [2] and the Charslon/Deyo methods [1]. Specifically, we used the updated version (enhanced ICD-9-CM) proposed by Quan et al. [16]. ICD-9-CM codes for the definition of these two methods can be seen in Appendix A.

Statistical analysis was performed using IBM SPSS Statistics version 21.

3 Results

Table 1 and 2 presents the proportion of identified comorbidities in inpatient episodes with discharges in years 2000 and 2010, for Elixhauser and Charslon/Deyo methods. As we can see, the majority of comorbidities significantly increased from year 2000 to year 2010. Some of them increased more than 100% ('Hypothyroidism' increased 326%). The average comorbidity increase was of 75% for Elixhauser method and of 55% for Charslon/Deyo method. On the other hand, some comorbidities continuously decreased during this period of eleven years. For instance, 'Peptic ulcer disease' decreased 24% and 'AIDS/H1V' decreased 23%.

The average number of Elixhauser comorbidities continuously increased from 0.70 in 2000 to 1.27 in 2010 (81% more). For Charslon/Deyo the increase was of 48%, from 0.66 in 2000 up to 0.98 in 2010. As we can see in Figure 1, this continuous increase is clearly associated to the increase in the number of secondary diagnosis. On average, in 2000, 1.71 secondary diagnosis were coded in each inpatient episode while, in 2010, this proportion was of 3.31 (94% more). In fact, in year 2000, the proportion of episodes with at least one coded secondary diagnosis was 65% and, 10 years later, this proportion was 80%.

Table 1. Comparison of the proportion of identified Elixhauser comorbidities in episodes with discharges in 2000 and 2010

Elixhauser comorbidities	2000	2010	Increase
Congestive heart failure	4.5	7.5	67
Cardiac arrhythmias	6.0	10.8	82
Valvular disease	1.5	2.7	80
Pulmonary circulation disorders	0.7	1.1	67
Peripheral vascular disorders	1.0	1.7	76
Hypertension, uncomplicated	12.8	26.5	107
Hypertension, complicated	1.5	4.5	194
Paralysis	0.7	0.8	7
Other neurological disorders	1.8	3.5	92
Chronic pulmonary disease	4.0	6.6	65
Diabetes. uncomplicated	6.2	13.3	112
Diabetes. complicated	2.4	2.2	-11
Hypothyroidism	0.4	1.9	326
Renal failure	2.6	5.9	124
Liver disease	2.4	3.3	37
Peptic ulcer disease excluding bleeding	0.4	0.4	-13
AIDS/H1V	0.3	0.2	-23
Lymphoma	0.4	0.6	54
Metastatic cancer	3.2	4.0	27
Solid tumor without metastasis	3.5	3.7	7
Rheumatoid arthritis/collagen vascular diseases	0.6	0.9	52
Coagulopathy	0.7	1.4	100
Obesity	1.5	5.2	237
Weight loss	0.8	1.0	22
Fluid and electrolyte disorders	3.6	6.9	90
Blood loss anemia	0.8	0.7	-12
Deficiency anemia	1.1	1.7	51
Alcohol abuse	2.8	3.6	26
Drug abuse	0.7	0.7	-9
Psychoses	0.3	0.5	81
Depression	1.1	3.5	206
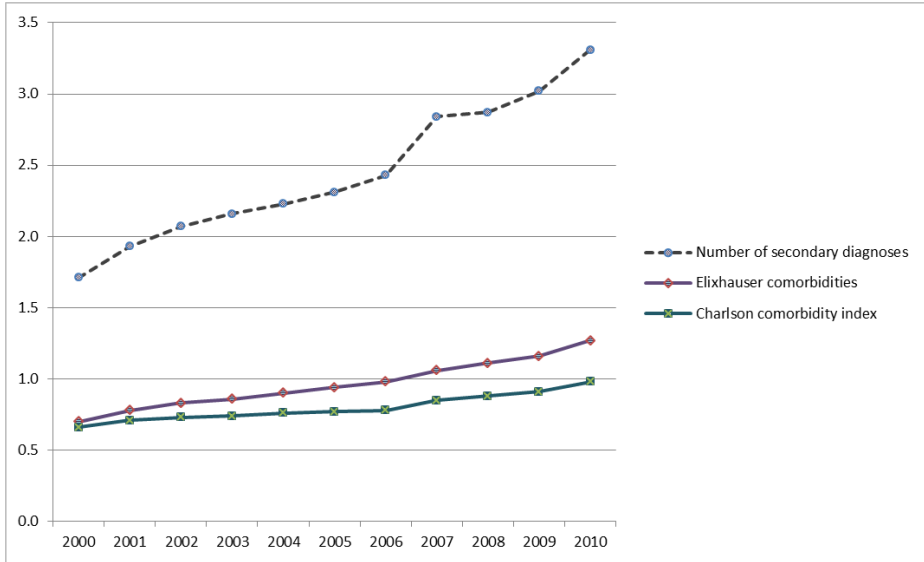
Fig. 1. Average number of secondary diagnoses and of comorbidity indexes (Elixhauser and Charslon/Deyo), per hospital inpatient episode, per discharge year

Table 2. Comparison of the proportion of identified Charlson/Deyo comorbidities in episodes with discharges in 2000 and 2010

Charlson/ Deyo comorbidities	2000	2010	Increase
Myocardial infarction	1.0	2.0	99
Congestive heart failure	4.5	7.5	67
Peripheral vascular disease	1.0	1.7	76
Cerebrovascular disease	4.0	5.8	45
Dementia	1.0	2.3	132
Chronic pulmonary disease	4.0	6.6	65
Rheumatic disease	0.4	0.7	87
Peptic ulcer disease	0.7	0.5	-24
Mild liver disease	1.8	2.7	55
Diabetes without chronic complication	7.7	13.7	77
Diabetes with chronic complication	1.0	1.8	83
Hemiplegia or paraplegia	0.8	1.0	16
Renal disease	2.7	5.9	121
Any malignancy, including lymphoma and leukemia, except malignant neoplasm of skin	4.1	4.6	13
Moderate or severe liver disease	0.9	1.0	10
Metastatic solid tumor	3.2	4.0	27
AIDS/HIV	0.3	0.2	-23

4 Discussion

Our results underlined a continuous increase in the number of collected and coded secondary diagnosis in hospital administrative databases. This increase obviously leads to a general increase in the number of identified comorbidities, as we saw for the two used comorbidities methods. In this context, any analysis or interpretation of administrative data, particularly when using data from secondary diagnosis or from any other not mandatory data (for instance, medical or surgical procedures) should always consider these possible limitations.

The comorbidities are associated with greater use of hospital resources and, in 2010, 60% of analyzed episodes had at least one identified Elixhauser comorbidity, i.e., there is an important role of comorbidities in hospital admissions.

The proportion of episodes with Elixhauser comorbidities increased from 42.3% to 59.4% in the period between 2000 and 2010. As we stated, the number of secondary diagnoses coded is associated with this increase but we think it is not the only factor responsible for this. In fact, we found a great variability in the proportion of comorbidities, we emphasized that the evolution is not equal for all comorbidities, and we even showed that, for some comorbidities, the proportion decreased over time.

5 Conclusion

In this article we studied the evolution of comorbidities using the most common, widely used, methods for administrative data. We showed that the number of secondary diagnosis and, consequently, the number of identified comorbidities, is continuously increasing. We argued that the amount in the increase of comorbidities is mostly related to more, and possibly better, coded data (secondary diagnosis coded with ICD-9-CM), and not necessarily due to a real increase in the number of comorbidities associated to hospital patients. That is, there is not necessarily a so high increase in the severity of treated patients.

Data analysts and decision makers should be aware of possible data quality problems, such as completeness and accuracy. Administrative data is a useful, cost-effective source of information, and is increasingly being used for several purposes, for instance, for performance evaluation, hospital financing, and to evaluate the impact of healthcare policies. However, much work is still needed to develop health information systems and increase the quality of this routinely collected data.

Expert domain knowledge about all the steps related to data collection, processing, and analysis must be considered when using and analyzing healthcare data. All the steps involved in the process of healthcare delivery should be adequately understood in order to correctly analyze data and interpret results.

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Appendix A

Table 3. ICD-9-CM codes for the identification of Elixhauser comorbidities.

Elixhauser comorbidities	Enhanced ICD-9-CM codes
Congestive heart failure	398.91, 402.01, 402.11. 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 425.4–425.9, 428.x
Cardiac arrhythmias	426.0, 426.13, 426.7, 426.9, 426.10, 426.12, 427.0–427.4, 427.6–427.9, 785.0, 996.01, 996.04, V45.0, V53.3
Valvular disease	093.2, 394.x–397.x, 424.x, 746.3–746.6, V42.2, V43.3
Pulmonary circulation disorders	415.0, 415.1, 416.x, 417.0, 417.8, 417.9
Peripheral vascular disorders	093.0, 437.3, 440.x, 441.x, 443.1–443.9, 447.1, 557.1, 557.9, V43.4
Hypertension, uncomplicated	401.x
Hypertension, complicated	402.x–405.x
Paralysis	334.1, 342.x, 343.x, 344.0, 344.6, 344.9
Other neurological disorders	331.9, 332.0, 332.1, 333.4, 333.5, 333.92, 334.x–335.x, 336.2, 340.x, 341.x, 345.x, 348.1, 348.3, 780.3, 784.3
Chronic pulmonary disease	416.8, 416.9, 490.x–505.x, 506.4, 508.1, 508.8
Diabetes, uncomplicated	250.0–250.3
Diabetes, complicated	250.4–250.9
Hypothyroidism	240.9, 243.x, 244.x, 246.1, 246.8
Renal failure	403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 585.x, 586.x, 588.0, V42.0, V45.1, V56.x
Liver disease	070.22, 070.23, 070.32, 070.33, 070.44, 070.54, 070.6, 070.9, 456.0–456.2, 570.x, 571.x, 572.2–572.8, 573.3, 573.4, 573.8, 573.9, V42.7
Peptic ulcer disease excluding bleeding	531.7, 531.9, 532.7, 532.9, 533.7, 533.9, 534.7, 534.9
AIDS/H1V	042.x–044.x
Lymphoma	200.x–202.x, 203.0, 238.6
Metastatic cancer	196.x–199.x
Solid tumor without metastasis	140.x–172.x, 174.x–195.x
Rheumatoid arthritis/collagen vascular diseases	446.x, 701.0, 710.0–710.4, 710.8, 710.9, 711.2, 714.x, 719.3, 720.x, 725.x, 728.5, 728.89, 729.30
Coagulopathy	286.x, 287.1, 287.3–287.5
Obesity	278.0
Weight loss	260.x–263.x, 783.2, 799.4
Fluid and electrolyte disorders	253.6, 276.x
Blood loss anemia	280.0
Deficiency anemia	280.1–280.9, 281.x
Alcohol abuse	265.2, 291.1–291.3, 291.5, 291.9, 303.0, 303.9, 305.0, 357.5, 425.5, 535.3, 571.0–571.3, 980.x, V11.3
Drug abuse	292.x, 304.x, 305.2–305.9. V65.42
Psychoses	293.8, 295.x, 296.04, 296.14, 296.44, 296.54, 297.x, 298.x
Depression	296.2, 296.3, 296.5, 300.4, 309.x, 311

Adapted from: Quan H, et al. Coding algorithms for defining Comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care. 2005 Nov; 43(11):1130-9.

Table 4. ICD-9-CM codes for the identification of Charlson/ Deyo comorbidities**.**

Charlson/ Deyo comorbidities	Enhanced ICD-9-CM codes
Myocardial infarction	410.x, 412.x
Congestive heart failure	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 425.4–425.9, 428.x
Peripheral vascular disease	093.0, 437.3, 440.x, 441.x, 443.1–443.9, 47.1, 557.1, 557.9, V43.4
Cerebrovascular disease	362.34, 430.x–438.x
Dementia	290.x, 294.1, 331.2
Chronic pulmonary disease	416.8, 416.9, 490.x–505.x, 506.4, 508.1, 508.8
Rheumatic disease	446.5, 710.0–710.4, 714.0–714.2, 714.8, 725.x
Peptic ulcer disease	531.x–534.x
Mild liver disease	070.22, 070.23, 070.32, 070.33, 070.44, 070.54, 070.6, 070.9, 570.x, 571.x, 573.3, 573.4, 573.8, 573.9, V42.7
Diabetes without chronic complication	250.0–250.3, 250.8, 250.9
Diabetes with chronic complication	250.4–250.7
Hemiplegia or paraplegia	334.1, 342.x, 343.x, 344.0–344.6, 344.9
Renal disease	403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 582.x, 583.0–583.7, 585.x, 586.x, 588.0, V42.0, V45.1, V56.x
Any malignancy, including lymphoma and leukemia, except malignant neoplasm of skin	140.x–172.x, 174.x–195.8, 200.x–208.x, 238.6
Moderate or severe liver disease	456.0–456.2, 572.2–572.8
Metastatic solid tumor	196.x–199.x
AIDS/HIV	042.x–044.x

Adapted from: Quan H, et al. Coding algorithms for defining Comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care. 2005 Nov; 43(11):1130-9.

Part VIII
Intelligent Systems

Social Simulation of Rescue Teams' Dynamic Planning

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Abstract. This paper focuses on an approach to dynamic planning, for an emergency ambient such as team rescue in indoors fire. First a graph is generated as the simulation runs, creating an effect similar to means-end analysis as each fire trying to reach the firefighter. This graph is updated in real time, improving the solution performance and reacting to new fires. The firefighter creates a plan based on this graph, using shortest weighed paths algorithms, these weights are updated dynamically, they do not only contain the distance but they also contain the importance to reach that node, so a important node to reach costs less for a firefighter to get there. All this together allows real time solutions to be generated, and self improving solutions to be made in the plan. This algorithm is to be integrated on a framework that simulates physics and collisions, and using a navigation mesh and agent perceptions to aid in calculation of a 3D shortest path.

Keywords: Social Simulation, Multi-Agent System, Dynamic Planning, Graph Generation, Team Cooperation

1 Introduction

Fire drills are expensive, the firefighter education is very poor in Portugal and according to a few interviews done and a visit made to the Franco's fire-fighter headquarter in city of Porto. A simulation could help in both cases by simulating certain scenarios where the firefighter would be and allowing him to explore what could happen, but more important, to be tutored on what he should do.

A lot of related work has been done in forest fires such as [1, 2], in indoor fires the situation is different and so must be the strategies used.

Planning algorithms can help the firefighter decide and why take that decision, ending up in learning, these solutions should take into account the reactive dynamics of the ambient and the information we perceive from the surroundings, requiring practice. Another work has been done here, specially related to the agents perceptions in a 3D world with ray cast and path-finding algorithms that would change the weight of the agent task. The agents in the 3D simulation also use a dynamic navigation mesh, so it is easier for them to avoid obstacles and calculate the shortest path between multiple floors, generally taking the stairs. The focus of this paper is on the plan itself, creating a hybrid algorithm based on multiple other generic algorithms. The plan here will be generated on a 2D scenario so it can be integrated later on a 3D by changing the way the short-path is calculated. The current framework does not simulate the fire behaviour realistically yet and it is simulated by a random algorithm, this to test the constant reactiveness of the firefighter team, but later on a more realistic way to simulate fire events can be integrated by using other fire-simulation frameworks or their algorithms if available, which one is best is still being researched, specially for 3D scenarios with stairs. People in the simulation will be walking randomly, this later on could have realistic human behaviour which are being studied to be replicated, this people get injured when they cross fires. In the 3D simulation more realistic scenarios are tested for example the agent taking the role as a person will try to run away from fire. After showing the algorithm and improvements done in the 2D simulation conclusions of the algorithms and their results are presented.

The framework will be a continuation of project SPEED [3, 4, 5, 6], but turned into rescue teams, keeping the idea that serious games can be used to train these teams and extending it with the use of agents to be used for non-playable characters and team members.

The final framework should be able to certificate firefighters, giving them the skills needed for their job, this paper is a continuation of work presented in [7] The final version of the project will have a great social impact through helping firefighter training [8, 9] and certification, with scientific innovation falling within categories such as human behaviour elicitation and modelling to feature bots in multiplayer serious games environments and agents in social simulation of pedestrian evacuation in emergency scenarios such as fire, similar examples are [3, 4, 5, 6].

Planning and scheduling techniques can be used in firefighter and rescue scenarios for a better organisation and strategy planning, later allowing the system to show and explain for example what a firefighter is doing and why. The planning strategies that were used are hybrid, a mix of multiple ideas from generic algorithms and solutions of similar problems such as the multi-travelling salesman, however the problem should have cooperative teams and reactive planning. Other ideas were about the leadership such as [10, 11, 12]. State machines, spanning trees, priority lists, dynamic programming were studied in order to come up with this hybrid solution, trying to take something of each that would allow to create a proper relative solution to the problem. This relative solution means

that it changes with the problem, but more importantly it means that it is or tries to be, very direct to the problem, very related, much like the seed is to the generation of the problem.

2   Method

The method used takes small steps and tries different techniques and tests them to show the way they can improve the algorithm overall.

Technology used was Netlogo, despite previous work was made in Unity3D, this is because Netlogo offers a more agent-based syntax and a different interface which would improve the simulation for reactive planning and testing. NetLogo's scheduling mechanism is completely deterministic. Given the same code and the same initial conditions, the same thing will always happen, if the same version of NetLogo is used.

Problem simulation

The problem is similar to the one presented in the 3D simulation platform[7], there was a scenario with a certain number of fires in certain rooms, with a team of firefighters to solve those, all these were distributed in the generated rooms. On Netlogo all the positions are random, and the firefighters start in the middle. People will walk randomly, eventually bumping into fire, while on Unity3D they try to run away.

Netlogo simulation allows to create a number of people, firefighters or starting fires, the fires will be created as the simulation goes. On the right there will be some monitors displaying important information relatively to the first 3 firefighters, this information contains, their target, their closest objective, overall list of objectives sorted by importance, the weight to the most important tasks, what is the task of the most important tasks that has less weight, and the plan and the objective that each firefighter is doing and calculating every iteration.

The goals for the firefighters are: no person can be burnt (a person too much time near a fire); have the least people in near fire or most people rescued; have least number of fires or most fires extinguished; archive previously mention objectives in shortest amount of time possible.

Prolog was first attempt of creating a short path plan [13], and it could be connected to Netlogo code through netprologo extension, since it is a extension it can access the Netlogo code, which has his variables updated dynamical, however the network extension that already comes with Netlogo works for creating short-paths and other utilities for this problem and simulation. In the future framework the simulation will tested netprologo or YAP which is type of Prolog that allows dynamic data through mutables and show how these can be useful in comparing multiple solutions or plans that different team members generate in a team rescue scenario.

Generic Solutions were taken into consideration due their advantages, such as: Market/Agent Distribute tasks based on trust, this trust could be based

on their performance and equipment for a certain task; Constraint Programming Consistency good for reactive/dynamic problems as this one; Reactive Planning/Dynamic Planning, Condition-action rules, Finite State Machines. All these techniques were used in certain ways in the current version of the framework done in Netlogo in form of a hybrid algorithm.

Allocating Tasks according to [14], were initially planned, they will be a later step of this framework, as tasks need to be ordered for a team. Tasks could have cooperation constraints such as a fire too strong requiring a number of fire-fighters and some water resource.

Travelling salesman problem and multiple travelling salesman problem [15] is a problem similar to the problem presented, as their are tasks that must be visited, these tasks can be done by multiple firefighters or distributed for a faster result, however due to the dynamic nature of the presented problem, it is harder to calculate a circuit for each firefighter for whenever a new fire or a person in trouble appears, however techniques like 2-opt [16] and similar were studied as they could be ran in parallel, similar to what is done the Netlogo framework.

The proposed algorithm is a hybrid similar to [17], based on other algorithms mentioned before. Generating the graph is the first step, as firefighter will use the graph to decide where they will go, this is generated as the simulation goes and adapts to new situations by being reactive. The people in need of help create links to the closest fire or other people in need of help and to a closest fire, this allows people to be in the graph, and when a new one comes, they automatically join. Fires link to the closest fire they have, and if they have more than 3 links, they delete those and link to the closest fire again, when a new fire comes it will be always linked to the graph. This conditions guarantee there won't be too many points disconnected, and that the firefighter can create sort of a journey by going through them and since this is made reactivity, it is good for emergency situations.
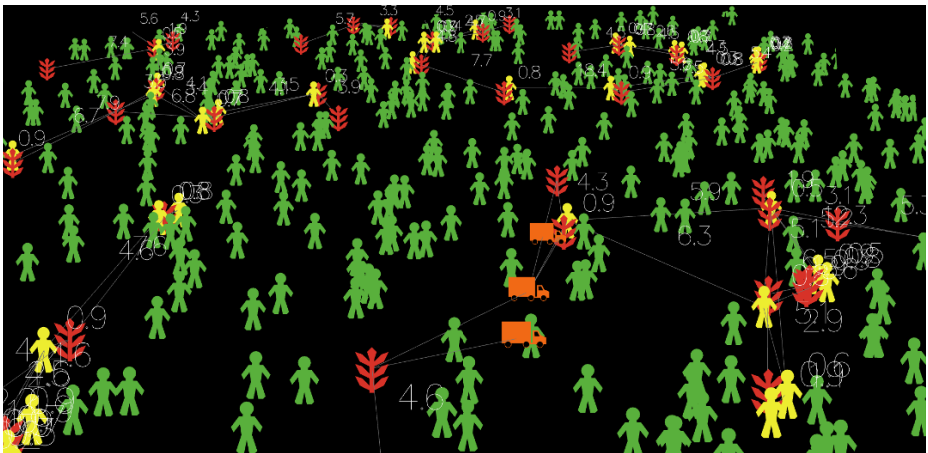
Fig. 1: Color orange(truck) represents the firefighters, red(plant) represents fire, greens are people walking randomly and yellows are people that need help.

Each link contains a variable that is updated constantly, the weight, this is the distance between the two nodes and the importance to reach that node from the first one, the importance is a relation to how long that node has been waiting to be helped or solved by the firefighter in relation to the one that needs most help, this will make the firefighter pick a path with the most important nodes to visit and all the information is updated dynamical. The priority list is a list that stores all the firefighter goals in order of importance. The firefighter gets into the graph by creating links with everything in radius of 5 to simulate his vision and creates a link with the closest fire or person, from those he building the shortest path. The shortest path is made by creating a list of nodes to visit to reach a possible goal, the goal will be one of the top 5 most important tasks for each firefighter, the one that is picked is the one with least weight, being a hybrid of most important and closest. When two firefighters have the same objective, one asks another to change his plan, making him go somewhere else, that is better for him at the moment, he will not change if that plan or path is inevitable.

3   Results

The tests use deterministic seeds so they can easily be replicated and improved. Since genetic algorithms are not used, the problem variables that are defined at start such as random position of objects and the random movement of people are things that make the solution constantly changing, the whole algorithm is about making a relation from the problem to the solution constantly, being updated overtime, this update must be fast and smart enough to save people in a emergency. The first type of tests made were a survival style, if one person in the simulation is burnt the simulation stops. For a person to be burnt it has to have reached a certain number of ticks, ticks are a step in the algorithm for Netlogo. Different tests were conducted to test the robustness of the algorithm and making the problem harder as the algorithm was improved.

In the first tests the simulation stops when a person is burnt, for a person to be burnt a person must have touched fire and changed his state to needing help, which then by each tick on that state increases a variable, when that variable reaches a certain ammount the person is destroyed.

Table 1: These tests had the following set up: Each seed is a different scenario, 300 people, 50 fires and were interrupted when a person was burnt (10000 ticks without being rescued).

Seed 1		People Number 300		Fire Number 50			Person Burnt at 5000 ticks		
Version 2.9 Name:								Ticks:	
closest TARGET FIRES AND PEOPLE								24197 ticks	
link1 fire with other fires link2 people with closest fire TARGET FIRE								27182 ticks	
link1 fire with other fires link2 people with closest people and closest fire TARGET FIRES								13975 ticks	
link1 fire with other fires link2 people with closest people and closest fire TARGET PEOPLE								61468 ticks	
link1 fire with other fires link2 people with closest people and closest fire TARGET FIRES AND PEOPLE								68336 ticks	
link1 fire with closest turtleset link2 people with closest people and closest fire TARGET FIRES AND PEOPLE								150702 ticks	

Table 2: Firefighterlink and Calculateweight variables can be on/off and can changed in runtime, they update a few variables for the user to see.

People Number 300		Fire Number 50			Person Burnt at 5000 ticks		firefighterlink and calculateweight can be on/off		
Fire-Fighter 3.2 link1 fire with closest turtleset link2 people with closest people and closest fire TARGET FIRES AND PEOPLE									
seed 1:	off/off 90019 ticks		on/on 441569 ticks						
seed 2:	off/off 35325 ticks		on/on 532218 ticks						
seed 3:	off/off 167142 ticks		on/on 571527 ticks						
Fire-Fighter 3.2 link1 fire with closest 3 fires link2 people with closest people and closest fire TARGET FIRES AND PEOPLE									
seed 1:	off/off 4303455+ ticks		on/on 1406906 ticks						
seed 2:	off/off 877281 ticks		on/on 455397 ticks						
seed 3:	off/off 663899 ticks		on/on 507190 ticks						

Table 3: As the algorithm improved, the survival time was getting harder to reach, therefor the number of people were increased to 500 from 300 people.

People Number 500		Fire Number 50			Person Burnt at 5000 ticks		Stop at when a person is burnt
Fire-Fighter 3.4 weightpath		seed 1:	5437725 ticks		seed 2:	3731442 ticks	seed 3: 2359764 ticks

Table 4: Version 3.5 tries to understand how many tasks should be saved, this is similar to work done later in 4.0 with dynamic numbers. 3.8 allows to instance multiple firefighters, instead of being static three firefighters.

People Number 500		Fire Number 50			Person Burnt at 5000 ticks					
Fire-Fighter 3.4 weightpath		seed 1:	5018 ticks	seed 2:	72714 tick	seed 3:	seed 3: 5865 ticks	seed 4: 5020 ticks	seed 5: 5011 ticks
Fire-Fighter 3.5		seed 1:	45136 tick	seed 2:	5000 ticks	seed 3:	seed 3: 48300 ticks	seed 4: 116353 tic	seed 5: 5031 ticks
Fire-Fighter 3.5.1		seed 1:	156323 tic	seed 2:	49321 tick	seed 3:	seed 3: 299777 tic	seed 4: 132232 tic	seed 5: 419655 ticks
Fire-Fighter 3.6 all tasks		seed 1:	5000 ticks	seed 2:	5008 ticks	seed 3:	seed 3: 5000 ticks	seed 4: 7707 ticks	seed 5: 5000 ticks
Fire-Fighter 3.6 5 tasks		seed 1:	78902 tick	seed 2:	126029 tic	seed 3:	seed 3: 21994 tick	seed 4: 5020 ticks	seed 5: 154937 ticks

Table 5: 3.9 version makes firefighters tell other firefighter to go do other plans if they have the same objective, this makes them spread.

People Number 500		Fire Number 50			Person Burnt at 5000 ticks		Stop at when a person is burnt
Fire-Fighter 3.9 spread							
seed 1:	8614466+ ticks		seed 2:	8813107+ ticks		seed 3: 8591828+ ticks	

Table 6: This test used 500 people, 50 fires, 3 firefighters, spawn fire every 100 ticks, 200 if the number of firefighters is 10 times lower than the number of fires (to avoid fires completely out-man the firefighters) and stops at 50000 ticks.

Fire Number 50		New Fire every 100 ticks; 200 if the number of firefighters is small				
People Number 300			Person Burnt at 5000 ticks		Stop Simulation at 50000 ticks	
Fire-Fighter 3.8.1 instance firefighter						
seed 1:	burnt: 0	rescued: 17431	extinguished: 540	count fires: 6	count peoples with rescue = true: 82	
seed 2:	burnt: 0	rescued: 16479	extinguished: 532	count fires: 9	count peoples with rescue = true: 201	
seed 3:	burnt: 0	rescued: 16904	extinguished: 540	count fires: 7	count peoples with rescue = true: 91	
Fire-Fighter 3.9.1 spread						
seed 1:	burnt: 0	rescued: 9616	extinguished: 542	count fires: 3	count peoples with rescue = true: 33	
seed 2:	burnt: 0	rescued: 9207	extinguished: 543	count fires: 3	count peoples with rescue = true: 27	
seed 3:	burnt: 0	rescued: 9771	extinguished: 543	count fires: 4	count peoples with rescue = true: 57	
Fire-Fighter 4.0 Importance (div 20) + 5						
seed 1:	burnt: 0	rescued: 10731	extinguished: 544	count fires: 2	count peoples with rescue = true: 15	
seed 2:	burnt: 0	rescued: 10173	extinguished: 546	count fires: 2	count peoples with rescue = true: 13	
seed 3:	burnt: 0	rescued: 10838	extinguished: 543	count fires: 4	count peoples with rescue = true: 46	

3.8.1 and 3.9.1 run the same algorithm as 3.8. and 3.9 respectively, but have their code store data such as the number of fires extinguished and the number of people rescued. On versions prior to 4.0 when the firefighter makes a plan, he just considered the 5 most important tasks, now this was changed to a dynamic value based on how many tasks that exist, to a minimum of 5, and the number increases a bit the bigger the number of tasks.

Table 7: These versions ran on Java Eclipse IDE, to test performance and to easily run multiple times with different parameters.

Fire Number 50	New Fire every 100 ticks; 200 if the number of firefighters is small					
People Number 500		Person Burnt at 5000 ticks		Stop Simulation at 1000 ticks		
FireFighter 4.1 Java.nlogo						
seed 1:	burnt: 0	rescued: 180	extinguished: 20	count fires: 35	count peoples with rescue = true: 431	Time: 114.228546268 Seconds
seed 2:	burnt: 0	rescued: 537	extinguished: 42	count fires: 16	count peoples with rescue = true: 226	Time: 59.948002784 Seconds
seed 3:	burnt: 0	rescued: 194	extinguished: 17	count fires: 38	count peoples with rescue = true: 439	Time: 99.883700603 Seconds
FireFighter 4.2 BDI NO GUI.nlogo						
seed 1:	burnt: 0	rescued: 188	extinguished: 20	count fires: 35	ount peoples with rescue = true: 443	Time: 111.255694207 Seconds
seed 2:	burnt: 0	rescued: 507	extinguished: 41	count fires: 17	count peoples with rescue = true: 262	Time: 66.954862641 Seconds
seed 3:	burnt: 0	rescued: 191	extinguished: 20	count fires: 35	count peoples with rescue = true: 426	Time: 104.784467713 Seconds
FireFighter 4.2 BDI.nlogo						
seed 1:	burnt: 0	rescued: 200	extinguished: 19	count fires: 36	count peoples with rescue = true: 434	Time: 115.345236917 Seconds
seed 2:	burnt: 0	rescued: 473	extinguished: 41	count fires: 17	count peoples with rescue = true: 260	Time: 67.275974899 Seconds
seed 3:	burnt: 0	rescued: 202	extinguished: 19	count fires: 36	count peoples with rescue = true: 436	Time: 104.216919531 Seconds

Firefighter 4.1 JAVA version does not change the algorithm itself, but adds output prints and better inputs for Netlogo. A Java application was created to test scenarios in a more comfortable way. For this version multiple types of interface where tested, the first one, Java opened Netlogo itself, the second opened a jframe with the Netlogo interface, and the third is the headless, with no interface, the only integration is with the output from Netlogo that goes to the Java. From this result other simulations can be run, depending on this result if so is desired, this will have potential later for machine learning.

Firefighter 4.2 BDI changed the interface to better explain the beliefs desire and intentions in this framework, the name is due it was highly based on BDI architectures. It also improved some Java compatibilities with the simulation but the algorithm itself remained, as it could be considered a BDI architecture before. The new Java version allows to queue up multiple simulation scenarios, and a JAR was created. There was also created the same version of Netlogo with no interface, since Java does not make use of Netlogo interface, and in Java it can be tested which one runs faster.

Beliefs Desires and Intentions (BDI) architecture [18, 19] on planning situations allowing agents reasoning to be closer to human reasoning can important for this framework to solve the firefighting problem and improve team or cooperation planning. BDI architecture alike implemented in this simulation allows the user to see the reasoning in real time, and understand why an agent did certain actions, or why the agent is planning in a specific way by understanding the atomic decisions and reactions while doing plan, with some future adjustments it will be possible to deliver this information in a way to teach and give skills to the firefighters and their teams, as their behaviours and their cooperation will be in that plan and taken into consideration on their reasoning. Right now it is possible to see the beliefs, the desires and the intentions of three firefight-

ers, but all firefighters use their own reasoning to archive a goal, creating their own plans and archiving their plans in their own way and communicating with other firefighters to try to spread the work. The architecture should be able to create plans similar to [20] which the authors gave us a sample of their project in which use BDI architecture and planning structure, that project allowed us to get some ideas on how we were doing something similar and how we could improve our current plans creating hybrid solution integrating multiple different parts algorithms in a single one, reactivity accepting all information and depending on time to answer, to prepare a plan. This BDI architecture alike used in this project allows the study of firefighters and their interaction with the simulation and how they perceive the plans. This is to be even integrated with the serious game simulation as mentioned before, where a real firefighter can be part of a team in a simulation with other humans or bots running this algorithm.

4 Conclusion and Discussion

Greedy algorithms were the first to tr since they have a quick reaction, needed for these emergencies, however they let people die too often, as they worry more about what is close to them and not people in real trouble. Algorithms that use too much information, waste too much time deciding what to do, causing them not to answer in time for people in desperate need.

Generic algorithms do not solve the problem, as they often have problem with reactivity or complexity of the scenario, they were mostly built into static scenarios and when the scenario changes the firefighters can't afford to create a new plan from the start, despite this they were taken into account allowing to build a hybrid solution to benefit what from they do best.

Genetic algorithms are too random to always work and then hard to improve, this hybrid solution is related to the solution, so the solution only changes if the problem changes, allowing more reactiveness and quick search on what is new adding to what is old, while genetic algorithms have to everything search again because they do not know if a combination of new and old could be better.

This hybrid solution is in fact trying to get direct solutions for the problem, whenever it changes, the drawback is that it takes time to build up the information, however as information is added procedurally and in parallel, the solutions are made based on what knowledge the system has, upgrading the solution as new information arrives, allowing it a reactive harmony. This works sort of a fantasy hivemind which are similar to swarm algorithms, but sharing all the information and updating that information dynamically and allowing small parts to think as a whole. This way of thinking can also be used for teamwork cooperation to answer non-static problems and emergencies.

5 Future Work

Burnout is the fatigue, stress, emotion disturbance which is more common in emergency situations[21, 22], this will be done in later versions of the framework.

Team Behaviours must be studied to see which one is better, such as: cooperative (working together to save most people); Competitive (countering what other firefighters could get); Egoistic (maximising their "points" gained); Altruistic (going to the people that needs most help). Right now, only Egoistic and Altruistic are implemented, but others will be implemented in the future, similar to what has been done in entertainment games using prolog in [23, 24], taking in consideration how these bots act with humans and the human satisfaction in using them or even being able to find out they are actually bots.

This algorithm is to be integrated on a framework that simulates physics and collisions, and using a navigation mesh and agent perceptions to aid in calculation of a 3D shortest path. This step is already done and it is being currently tested by players to understand their inputs so the agents can also replicate human behaviours.

Possible integration with Unity3D is still being tested, it is possible to run a jar with a Netlogo execution through Unity3D's android libraries, however this means it would only work on android mobiles. However is it expected that Unity3D will allow java or someway to read java in Unity3D will be found soon as Unity3D's android libraries allow to do so at cost of implementation time.

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Monitoring Clusters in the Telecom Industry

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Abstract. In the past years, data has become increasingly fast and volatile, making the ability to track its evolution an highly significant part of the value extraction process. In this work we present a framework to monitor evolution of clusters and present its use on real world data. We develop a framework over a previous one by Oliveira and Gama from 2013. Its biggest contribution is the addition of the concept of *control area*. This area will create a region around the cluster where it is still possible to establish associations with clusters from other time points. It aims to expand the search scope for cluster associations while diminishing the number of false positives. Changes to the transition definitions and detection algorithm are also introduced to accommodate the existence of this area. We demonstrate this framework at work in a real world scenario testing it with a telecom industry dataset and make a detailed analysis of the obtained results.

Keywords: Clusters, Evolution, Monitoring

1 Introduction

The use of clustering techniques is highly popular in the data analysis field. These techniques however are usually applied to static data on a particular time interval. However, in several businesses, data characteristics can change meaningfully along time, leading to possibly harmful business decisions. The telecom industry deals every day with a large amount of data on phone calls, SMSs, etc... This data comprehends information about the clients. The ability to understand how the clients profiles evolve along time can bring insights for marketing giving opportunity to new types of services and promotions. We explore the use of cluster monitoring techniques in a large scale scenario of the telecommunications industry. We aim to track the clusters representing the various types of users and see how they evolve along time, taking into account the four events that may occur to the clusters as the time progresses: survival, death, splitting and merging. This may allow us to obtain information previously hidden, like user trends and other unexplored dynamics, which can provide new key understandings on user activity. We explore a new variant of the comprehension technique

used for clustering monitoring, which makes uses of an area surrounding each cluster dubbed *control area* in the process of event detection.

In section 2 we will make an overview of the current work in the area, specially the one by Oliveira and Gama [1] in which this work is based on. In section 3 we will discuss the clusters characterization and introduce the developed framework. In section 4 we will present our experiments and the results. We then conclude with a summary and the discussion of future work.

2   Related Work

As previously stated, this project has been heavily influenced by Oliveira and Gama's [1] work on cluster monitoring. In this work they propose the MEC framework which provides a characterization and tracking mechanism for the detection of cluster transitions through time. This framework, adopts two main strategies for cluster characterization, one of representation by enumeration and another of representation by comprehension. Each of these will have an associated tracking method. When a cluster is characterized through enumeration it will track transitions through graphs. When a cluster is characterized through comprehension it will track transitions by observing overlapping cluster areas. The use of MEC's enumeration framework is further explored using Economy and Finance data [2]. In this paper we further explore the use of the comprehension method through a variant framework.

MONIC is another framework in this field [3]. Similarly to Oliveira and Gama's [1] work, it also makes use of an enumeration based characterization to track and interpret the evolution of a cluster. MONIC+ [4] is an extension of MONIC which analyses the topology of the clusters in order to capture the cluster-type-specific transitions.

There have also been several approaches who make use of the spatio-temporal space [5][6][7]. These approaches are usually applied to data streams and are dependent on the clustering algorithm used.

3   Developed Framework

Clusters are represented by comprehension as delineated by Oliveira and Gama [1], this method was chosen as it didn't require to store all cluster elements in memory. Three measures are defined: Centrality, density and dispersion. The centrality of the clusters corresponds to the cluster centroids. The density is represented by the radius. Dispersion in this context assumes the objects will be spherical in space. The radius of a centroid is obtained by calculating the average distance between the centroid and all points inside the cluster.

Furthermore another element is added to the cluster, which is the main contribution of this work: the *control area*. This area takes into account the positions of all other clusters in the space. It is defined as a spherical area with the cluster's centroid as its center where the radius is the sum between the cluster's

radius and half of the distance between its radius and the radius of the closest neighbouring cluster.

It's important to note that in reality, it is rare a cluster being perfectly spherical with an even dispersion of elements inside of it. An high concentration in a cluster extremity might cause a situation where the radius of two clusters overlap. In this situation the cluster's *control area* will be the radius and the overlapping areas will be considered contested by both clusters.

To monitor the evolution of a set of clusters through several points in time, two types of transitions are employed: external and internal. These transitions have already been defined in the current literature [1][3]. External transitions relate to how a cluster changes in regard to the space and its neighbours, while internal transitions relate to changes in the cluster's constitution.

Through the use of external transitions it's possible to track how the clusters evolves through time in relation to the space. Five external transitions were defined to that effect:

- Birth: A new cluster appears;
- Death: A cluster disappears;
- Merge: Elements of two or more clusters in the previous time interval form a new cluster;
- Split: Elements of a single cluster in the previous time interval form two or more clusters;
- Survival: A cluster from the previous time interval remains in the current interval with no or minor changes.

To assess the occurrence of such transitions, a framework was created that accommodates the existence of the *control areas* in its detection algorithm.

$C(T)$ represents the cluster set in a T time point and $C(T + \Delta t)$ represents the cluster set in the following time point after a Δt interval. A birth occurs in a cluster of $C(T + \Delta t)$ when the distance between each of the centroids in the clusters of $C(T)$ and a centroid in the cluster $C(T + \Delta t)$ is larger than the *control area* of the C(T) clusters. This will represent that the new cluster's centroid doesn't intersect any of the clusters of the previous time point. Therefore if the control area of a cluster in $C(T)$ doesn't intersect with any of the centroids of the clusters in $C(T + \Delta t)$ it is considered that it dies. If indeed an intersection exists, it can signal one of two events: A survival when a centroid cluster is located inside the *control area* or a split when two or more are present.

Merge detection follows a slightly different process: when the *control area* of a cluster in $C(T + \Delta t)$ contains the centroids of two or more clusters of $C(T)$, it is considered that a merge occurred. When two survivals occur on the same cluster, which might happen when a centroid is located in a contested area, it is likewise considered that a merge occurred.

This use of the *control area* expands the transition search scope, allowing the detection of possible transition associations with clusters farther in the space. Such scope permits the capture of information that might have proven to be difficult in certain situations, for example in fast moving clusters.

A transition should only be signalled when a *control area* intersects with a centroid, instead of when it overlaps with the radius or another *control area* of a cluster in $C(T + \Delta t)$[1]. This decision was implemented with the intent diminishing the number of transitions detected, consequence of the larger search space resulting from the *control areas*. Moreover it helps to diminish the number of hits when the clusters are adjacent to each other and exists little variance in position between each time frame.

The internal transitions represent the internal changes that a cluster may suffer through time. Two main internal values were monitored to keep track of these transitions: the size and density of the cluster. Size of the cluster corresponds directly to the number of elements in a cluster, while the density of a cluster represent the compactness of a cluster. To observe them the statistical data regarding the size of a cluster and its radius for all the time intervals was stored.

4   Case study

4.1   Data set and pre-processing

A data set was provided containing information related to all the calls of a telecom provider in December 2012. To study the evolution of the user behaviour over time, the profiles of the active users of every six hour interval in the first 15 days of December were extracted. Using the available information the following template for features of the user profiles was created: Average duration of a phone call, number of incoming calls, number of outgoing calls, number of calls made in a land network, number of calls made in an mobile network, number of calls made in the same network, number of services calls made, number of calls that do not belong to any of the previous categories, number of voice-mails and number of dropped calls

Through the use of this profiling it estimated that in average each time break has 917356 distinct users. This information is then normalized through the use of Z transformation to create a standard scale between all the call counters and the average duration in order to ensure that all features have equal importance. The X-means algorithm [8] is used to extract the clusters for each time interval. This algorithm allows the computation of the optimal number of clusters for each time interval, unlike other commonly used algorithms (e.g.K-Means). Such flexibility aims to accurately portray how the number of clusters evolves throughout the time, without requiring multiple runs of K-means in search of the optimal k. Each of the clusters is identified by the following: the assigned number during the creation process, the day of the month and the 6 hour interval it belongs to, e.g. $C_0(2,3)$ represents the first cluster of unique users during the December 2nd $[12:00 - 18:00[$ interval. When the cluster number is not specified like in $C(2,3)$, it means the cluster set as a whole in the specified time period is being addressed.

Visualizing the evolution of high dimensional data such as the present one can be challenging. Therefore Multidimensional Scaling was used to reduce the
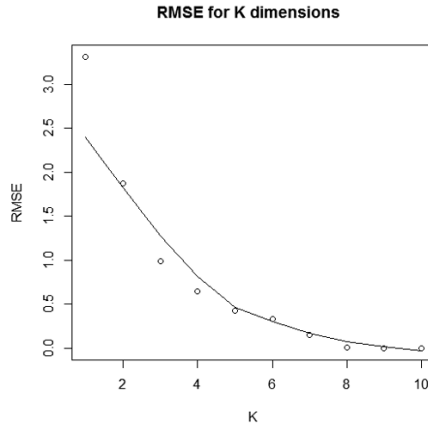
Fig. 1. RMSE for Multidimensional Scaling using different number of features
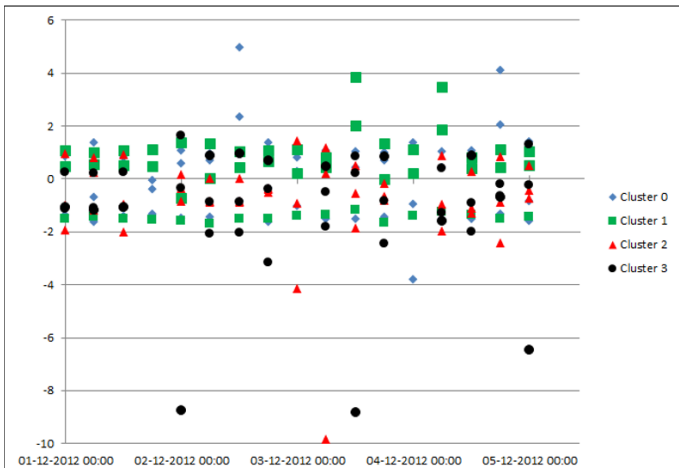
Fig. 2. Evolution from Dec. 1st, 2012 to Dec. 5th, 2012

number of dimensions to a K manageable amount. Taking into account that by reducing dimension, errors are introduced, the root mean- square deviation between the distance matrices of the current dataset and of the possible scaled down sets was analysed to search for the optimal value for K.

By analysing figure 1 it is observable that, according to the elbow curve [9], the ideal value of K is 3. The scaled down clustering results of the first five days of December can be seen in 2 were the y-axis represents the normalized values as described in section 4.1.

In the majority of the cases four clusters were obtained with the X-means. However, four exceptions are present where only two clusters are created: on the
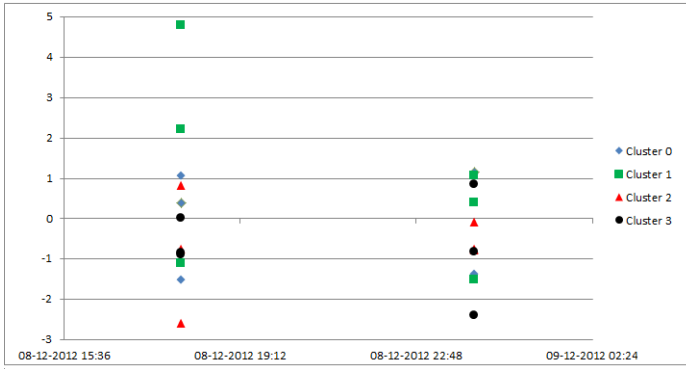
Fig. 3. Dec. 8th at 18:00 to Dec. 9th at 00:00 transitions

December 1st $[18:00-24:00[$ interval, on the December 4th $[00:00-06:00[$ interval, on the December 7th $[00:00-06:00[$ interval and on the December 14th $[00:00-06:00[$ interval. There is also a situation where three clusters are created on the December 3rd $[00:00-06:00[$ interval. After evaluating the internal proprieties of these clusters, it can be observed that these cases seem to correspond to intervals of low user activity.

To verify whether the figures correspond faithfully to the evolution of the original dataset, the most outlying clusters were compared with the corresponding original clusters. To this end two outlier cases in each extreme of the Y axis were analysed, the clusters $C_2(3;2)$, $C_1(8;3)$, $C_1(13;1)$ and $C_3(14;2)$. The RMSE between the distances of the original clusters and the scaled down ones were calculated and errors of 0.0718086 for $C_2(3;2)$, 0.08701041 for $C_1(8;3)$, 0.00174967 for $C_1(13;1)$ and 0.065321 for $C_3(14;2)$ were obtained. These RMSE values are quite negligible, only inducing in errors in situations where several points are adjacent. Which are within an acceptable margin of errors as it was more important to convey the general evolution through time.

4.2 Empirical validation

Some example cases were analysed to validate the framework at work, beginning with the $C(8;4) \rightarrow C(9;1)$ transitions(figure 3).

This case exemplifies a situation where only survivals and deaths are detected. The following survivals are signalled: $C_0(8;4) \rightarrow C_1(9;1)$, $C_2(8;4) \rightarrow C_3(9;1)$, $C_3(8;4) \rightarrow C_2(9;1)$, meanwhile $C_1(8;4)$ dies. These results are validated through the extraction of the distance matrix for evaluating whether the distances do indeed conform with the transitions.

Through the distance matrix in table 1 it can be seen that in fact the survivals correspond to transitions where both clusters are quite close. Meanwhile the only death is relatively distant from all the clusters in the following set. The $C(3;2) \rightarrow C(3;3)$ in figure 4 exemplifies a situation where merges and splits occur simultaneously.

Table 1. Distance matrix for the Dec. 8th at 18:00 to Dec. 9th at 00:00 transitions

	$C_0(9;1)$	$C_1(9;1)$	$C_2(9;1)$	$C_3(9;1)$
$C_0(8;4)$	0.776	**0.008**	2.608	2.893
$C_1(8;4)$	3.789	4.545	6.399	7.313
$C_2(8;4)$	3.819	3.105	2.490	**0.216**
$C_3(8;4))$	3.174	2.798	**0.186**	2.479
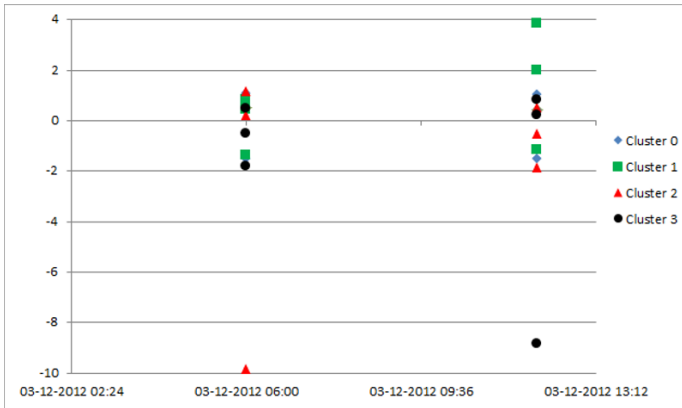
Fig. 4. December 3rd at 06:00 to 12:00 transitions

Table 2. Distance matrix for the December 3rd 06:00 to 12:00 transitions

	$C_0(3;3)$	$C_1(3;3)$	$C_2(3;3)$	$C_3(3;3)$
$C_0(3;2)$	**0.085**	3.469	2.617	10.065
$C_1(3;2)$	**0.261**	3.617	2.441	9.794
$C_2(3;2)$	11.044	12.204	10.801	**1.061**
$C_3(3;2)$	**2.526**	5.896	**0.052**	9.695

This is also a situation where a cluster is the result of the merge of three other clusters ($\{C_0(3;2),\ C_1(3;2), C_3(3;2)\} \rightarrow C_0(3;3)$) with one of these clusters being also part of a split ($C_3(3;2) \rightarrow (C_0(3;3),\ C_2(3;3))$). Furthermore there is a survival from ($C_2(3;2) \rightarrow C_3(3;3)$). In this case the transitions continue to be associated with the shortest distances as shown in table 2. Sometimes situations occur where there are no transitions in a cluster despite the fact that it is closer to a future cluster than other clusters that have transitions with it. This is consequence of the influence of the *control area* in the detection process. By analysing its internal proprieties, it can bee seen in such cases that a large radius allows association with farther away a clusters and vice-versa. Regarding the cluster sizes, we can verify that cluster that split originate smaller clusters (e.g. $C_2(3;3)$) and clusters originated from merges have larger sizes (e.g. $C_0(3;3)$).

Table 3. Distance matrix for the Dec. 1st at 18:00 to Dec. 2nd at 00:00 transitions

	$C_0(2;1)$	$C_1(2;1)$	$C_2(2;1)$	$C_3(2;1)$
$C_0(1;4)$	**2.482**	**3.194**	**0.556**	9.167
$C_1(1;4)$	**0.124**	0.821	1.987	9.976

Finally there are the $C(1;4) \rightarrow C(2;1)$ situation. This case exemplifies a situation where transitions exist between different size cluster sets. Two transitions are present: a three part split of $C_0(1;4)$ into $\{C_0(2;1),C_1(2;1),C_2(2;1)$ $\}$ and a merge of $C_0(1;4)$ and $C_1(1;4)$ into $C_0(2;1)$. Once again the framework is able to detect the appropriate transitions in relation to the distances of table 3. The reason why $C_1(1;4) \rightarrow C_1(2;1)$ and $C_1(1;4) \rightarrow C_2(2;1)$ are not signalled as transitions while $C_0(1;4)$ has transitions with larger distances is an example of the presence of a large *control area*.

4.3   Comparison with the MEC framework

The same data set was also run with the MEC comprehension framework to provide comparative results. The MEC results obtained were considered unsatisfactory in comparison with our framework. For a significant amount of transitions each cluster is split into the majority, if not all, of clusters of the next time period, as seen in table 4. Such results makes it very hard to infer any useful information regarding the cluster evolution.

Table 4. Frameworks comparison

Our Framework	MEC framework
$C_0(8;4) \rightarrow C_1(9;1)$;	$C_0(8;4) \rightarrow \{C_0(9;1),C_1(9;1),C_2(9;1),C_3(9;1)\}$;
$C_2(8;4) \rightarrow C_3(9;1)$;	$C_2(8;4) \rightarrow \{C_0(9;1),C_2(9;1),C_3(9;1)\}$;
$C_3(8;4) \rightarrow C_2(9;1)$;	$C_3(8;4) \rightarrow \{C_0(9;1),C_1(9;1),C_2(9;1),C_3(9;1)\}$;
$C_1(8;4) \rightarrow \{\};\{\} \rightarrow C_0(9;1)$;	$C_1(8;4) \rightarrow \{\}$;

This occurs in the MEC framework due to the fact it signals a transition whenever the radius of clusters in T_i and $T_i + \Delta t$ intersect. In situations where clusters are adjacent and there is little variance in position through time this might occur. Our framework successfully avoids this issue through the use of the control area and transition signalling only when it intersects with a centroid.

4.4   Discussion

During the 15 day time period analysed, only the initial first cluster survives through all the observed time intervals without interruptions, suffering only

changes on its position assignment in each time interval. In certain situations it splits itself into two new clusters and merges again in the next time interval as seen in $(C_0(3;3) \rightarrow \{C_0(3;4),C_1(3;4)\} \rightarrow C_1(4;1))$ and $(C_1(15;2) \rightarrow \{C_0(15;3),C_1(15;3)\} \rightarrow C_1(15, 4))$. Furthermore there is also a split instance where one of the branches will merge into another cluster in the following time interval, leaving the other branch as the continuation ($C_1(13;3) \rightarrow \{ C_0(13;4), C_1(13;4)\}$, $C_0(13;4) \rightarrow C_1(14;1))$. This cluster is characterized by consistently being the largest cluster in each time point and being exceptionally dense. An analyse of the cluster centroids showed that data distribution in this cluster is always balanced. So it can be concluded that this cluster identifies the average user with no exceptional characteristics.

Splits occur often during the evolution: 54% of all transitions contain at least one split. The reason for this common occurrence is most likely the extended search scope that is consequence of the use of the *control areas*. It may also reflect the fact that the clustering covers a highly concentrated dataset without huge variations through time. Worthy of note is the existence of four complete total dismemberments where parts of a single cluster go to all clusters of the next time interval $(C_2(3;3) \rightarrow \{C_0(3 ;4), C_1(3;4), C_2(3;4), C_3(3;4)\}, C_0(4;1) \rightarrow \{C_0(4;2), C_1(4;2), C_2(4;2), C_3(4;2) \}), (C_2(7;1) \rightarrow \{C_0(7;2), C_1(7;2), C_2(7;2), C_3(7;2)\})$ and $(C_3 (9;3) \rightarrow \{C_0(9;4), C_1(9;4), C_2(9;4), C_3(9;4) \})$. These, like most of the splits, tend to be associated with clusters of large internal dispersion and low size where the radius is above average and which are usually represented by the points farthest from the X axis in figure 2. Therefore it can be concluded that the splits tend to occur when the clustering algorithm creates a large cluster for highly skewed elements.

Likewise merges are very common: 61.7% of all transitions contain at least one. The majority of the merges occur when parts of existing clusters resulting of a split are absorbed by others, although there is also a sizeable amount of pure merges where two clusters are fully absorbed into a new one. This tends to happen in 2-size cluster set intervals. Unlike the splits, there is no discernible situation where the merges consistently happen. However the merged clusters do tend to have above average size. Moreover they are only skewed when there are noticeable differences between merged clusters.

In search of seasonality, the evolution between the two weeks was also compared. A parallel analysis was performed focused on the weekly homologous time intervals. An identical cluster is detected when the framework signals a survival between clusters of homologous time intervals.

In all observed instances between both time points it was found there is always at least one pair of identical clusters. Only in three instances all the cluster set is identical $C(3;4) \simeq C(10;4)$, $C(4;2) \simeq C(11;2)$ and $C(5;4) \simeq C(12;4)$. It is sensible to assume that there is always some similar behaviours during homologue periods but only Mondays and Wednesday during the $[18:00 - 24:00[$ period and Tuesdays during the $[06:00 - 12:00[$ period the behaviours are exactly the same. Further study is required to verify whether this is a recurring pattern.

5　Conclusions

In this paper a cluster monitoring framework and its use in a real world scenario are presented. It introduces some key changes to the MEC framework, the major of which is the *control area*. This addition extends the search scope for possible transitions and cluster associations in fast moving data. Furthermore the transition detection process was adapted for these modifications. This framework was tested with real telecom data. The extracted transitions reflected accurately the evolution of the clusters. An analysis of the results is done to detect evolutionary trends and pattern seasonality, as well as on how the cluster characteristics affect transitions.

Future works aims to improve this framework by making the *control area* reflect the density and dispersion of cluster. Through these improvements clusters with large radius and number of elements will have larger *control areas* and therefore an larger influence.

Moreover not all clustering algorithms model spherical clusters like the K-Means, so adapting this framework to those algorithms is part of the future plans. Expanding the analysis scope in search of possible evolutionary patterns is also a current objectives.

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An Approach for Assessing the Distribution of Reporting Delay in Portuguese AIDS Data

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Abstract. HIV/AIDS epidemic is an important public health problem. The burden of the epidemic is estimated from surveillance systems data. The collected information is incomplete, making the estimation a challenging task and the reported trends often biased. The most common incomplete-data problems, in this kind of data, are due to under-diagnosis and reporting delays, mainly in the most recent years. This is a classical problem for imputation methodologies. In this paper we study the distribution of AIDS reporting delays through a mix approach, combining longitudinal K-means with the generalized least squares method. While the former identifies homogeneous delay patterns, the latter estimated longitudinal regression curves. We found that a 2-cluster structure is appropriated to accommodate the heterogeneity in reporting delay on HIV/AIDS data and that the corresponding estimated delay curves are almost stationary over time.

Keywords: HIV/AIDS, reporting delay, KML, GLS, incomplete data, imputation method

1 Introduction

The Human Immunodeficiency Virus (HIV) is an infectious agent that attacks the immune system cells. Without a strong immune system, the body becomes very susceptible to serious opportunistic illness. When the severe symptoms emerge , it is said that the individual has acquired immunodeficiency syndrome (AIDS).

In 2009, the UNAIDS estimated that the prevalence (percentage of infected individuals within the population) of this disease in Portugal was about 0,6%. This correspond to having 42000 people, aged between 15 and 49 years old, living with HIV. So, HIV/AIDS is an important public health problem in Portugal.

The HIV/AIDS epidemic trend is monitored by a specific surveillance system. The collected data is vital to assess the general health care needs, long-term health-policy planning, general disease-prevention education programmes [1]... But data is incomplete and, therefore, the trends are biased.

The main reasons for this missing data are due to the under - diagnosis in all HIV/AIDS stages, under-reporting and to delays in reporting. So, the surveillance data should be adjusted for more accurate trends estimation [2, 3].

This is a problem of incomplete data and imputation, that is, filling in missing data by some plausible values [5, 1, 4]. A solution may rely on a method that generates a probability model relating the complete data set, consisting of both observed values and missing values, and a set of parameters. The goal is to use the observations to generate a predictive distribution for the missing values [6] .

Traditionally, the reporting delay distribution has been estimated from the conditional or unconditional log-likelihood [5]. Also, usually this distribution is assumed as stationary, not depending on the time of diagnosis [7–11, 13].

In this paper we study the distribution of AIDS reporting delays through a mix approach, combining longitudinal K-means with the generalized least squares method. While the former identifies homogeneous delay patterns, the latter estimated longitudinal regression curves.

In section 2 we describe the main characteristics of the Portuguese epidemic and identify the main sources of missing data in the present surveillance system. The problem of incomplete data is addressed in section 3. In section 4 we present main results concerning the identification of the clusters and the longitudinal curves. Finally, we present the conclusions from the study.

2   Portuguese epidemic and surveillance system data

Since 1983, the number of HIV/AIDS cases reported until the present, places Portugal as one of the most infected countries in Europe [14]. The epidemic is concentrated on high-risk and hard-to-reach sub-populations, , thus hindering a timely diagnosis.

All stages of HIV/AIDS (asymptomatic, AIDS related complex, AIDS), changes from one state to the other, and death should be reported to the portuguese Center for the Transmissible Diseases (CVDET - Centro de Vigilância Epidemiológica das Doenças Transmissíveis) within 48 hours after the appropriate event, by the filling in of the notification form (in paper format). This procedure is only mandatory from 2005 onwards [15].

Over the years, the notification procedure has suffered some changes that may be related to the quality of the reports. Here we point out the following:

 1. in 1988, the reporting form was altered and more variables were included;

2. in 1993, tuberculosis was included as an AIDS defining disease;
3. in 1996, highly active anti-retroviral therapy (HAART), with a well-known impact on the patients survival rate, was introduced;
4. in 2005 the notification forms were re-structured;
5. in 2009 the CVDET was re-structured [3].

The under-diagnosis, under-reporting and high percentage of notification form entries with "unknown" or "blank" responses, are well known problems of the portuguese notification system [3] .

3   Incomplete data - The method

As the need for medical care is much higher in late-stage infections, the under - diagnosis is less likely to occur in AIDS cases. We will therefore restrict ourselves only to this stage in the following analysis.

The reporting delay is defined as the time mediating from HIV/AIDS diagnosis and the report of this event at national level [2].

The first case diagnosed (and reported) it will be represented by 0 and x^* represents the end of the observation period. So the time interval $[0, x^*]$ represents the time diagnosis observed. Let this time interval be divided into 3 months-unit length. The same division is set to reporting delay time interval.

The AIDS cases are then cross-classified by the diagnosis and reporting delay quarter. We denote by X_{ij} the annual percentage of AIDS cases that were diagnosed in quarter i and have a reporting delay falling into quarter j. Fixing a reporting delay quarter, one can observe a delay pattern over time.

We now proceed as follows:

1. identification of homogeneous patterns for the observed delays considering that there is no bias. The clustering is performed by a longitudinal version of the K-means algorithm. This step identifies the tendencies across the reporting delays, thus reducing the number of curves of reporting delays to be considered.
2. evaluation of the effects of the reporting delays and date of diagnoses on the evolution of the epidemic (percent-wise). We use linear regression with estimation performed by generalized least squares, thus allowing for hereoscedastic. We will consider only cases diagnosed until 2008 due to the reporting delay.
3. Imputation on X_{ij} according to the obtained results.

4   Results and discussion

The number of AIDS cases diagnosed per year exhibited an increasing trend between 1983 and the year 2000, four years after the introduction of HART. Since then, the numbers of diagnosed cases have been steadily decreasing. When the notification became mandatory a slight growth was observed, as pictured in

Fig. 1. In the lower panel of that figure, we have included information about the historical events that may be introducing bias in the prevalence numbers. Coincidence (or not), the prevalence of AIDS curve changes slightly at these moments.
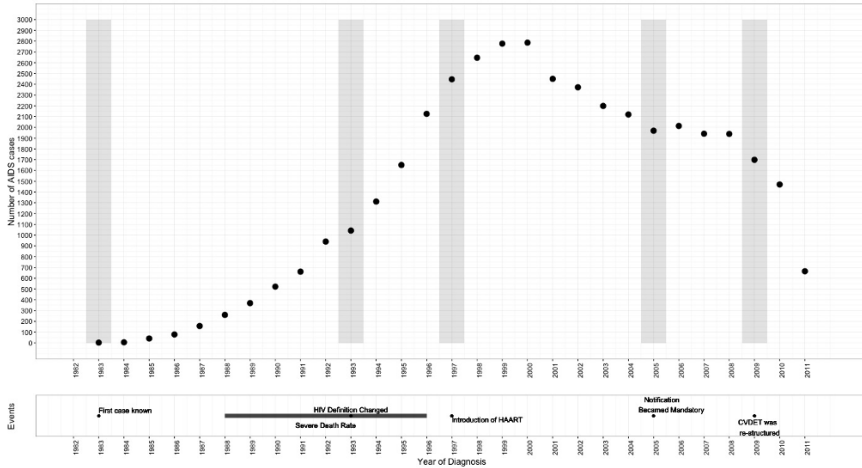
Fig. 1. Number of AIDS cases diagnosed in Portugal per year of diagnostic and historical events in HIV/AIDS history and notification system

Due to the lack of understanding of the HIV infection development throughout its first years, we will consider only cases diagnosed after June 1986.

4.1 Longitudinal K-means

Figure 2 depicts the reporting delays that are registered in the national AIDS surveillance system. The delays were grouped into trimesters and the annual percentage of cases within each diagnosis year is represented.

The most recent year (lighted region) does not seem to be describing the real situation as several cases have not been notified yet.

It can be seen that the majority of cases are reported within 3 months after diagnosis but some are still being reported with more than one year of delay. For the sake of clarity, delays longer than 18 months are omitted from figures 2 and 3.

The longer delays, e.g. more than 6 months, have a almost constant behaviour through time not exceeding the 10% of cases (figure 3).

Graphical inspection may suggest a 2-cluster structure since the delay curve $(0, 3]$ is fully separated from the rest. But due to epidemiological interest it is important to explore other clustering structures.

Since clustering analysis is an exploratory method, 2, 3 and 4-cluster structures, each of them with 40 randomly chosen starting points were studied. The
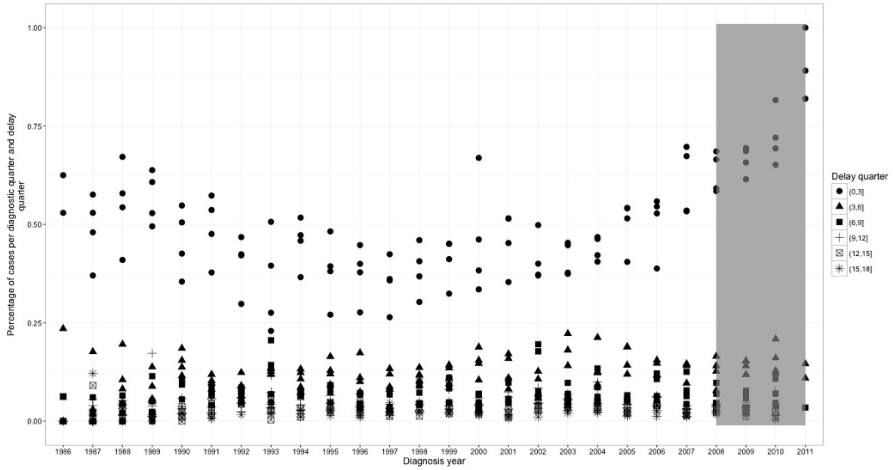
Fig. 2. Percentage of AIDS cases per diagnosis and delay quarters. The lighted region identifies those (recent) years that have to be corrected.
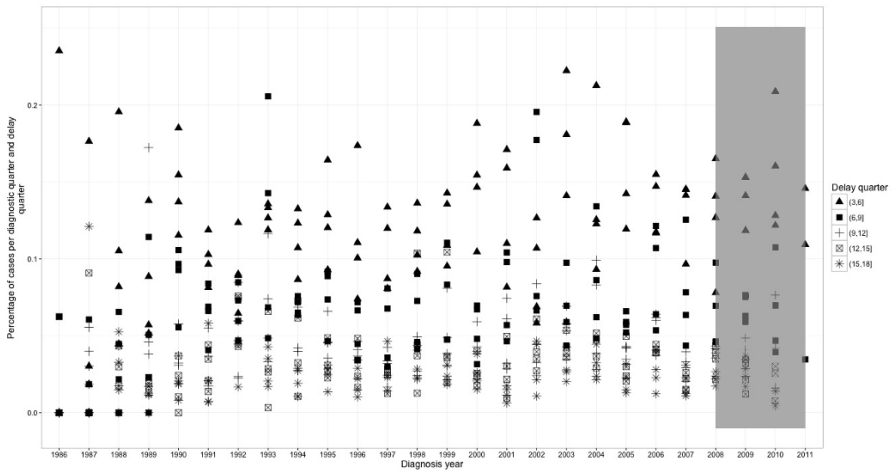
Fig. 3. Percentage of AIDS cases per quarter of diagnosis and delay quarter longer than 3 months

longitudinal K-means algorithm, considering the euclidean distance with the Gower adjustment and implemented via Expectation-Maximization, was applied. The optimal number of clusters was determined with the help of several criteria: Calinsky and Harabatz, Ray and Turi, Davies and Bouldin, and the Bayesian and Akaike Information Criteria (BIC and AIC, respectively). The higher these values, the better is the solution. All should ideally agree and be as large as possible except BIC and AIC that should be low [16].

For the reporting delays and considering partitions from 2 to 4 clusters, the behaviour of the quality criteria is represented in figure 4. The clustering result for 3 classes is described in table 1.
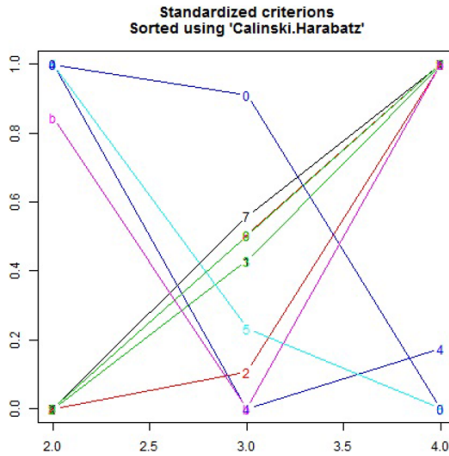
Fig. 4. Quality Criteria for longitudinal clustering. 0 - Calinsky and Harabatz; 1 - Calinsky and Harabatz2; 3 - Calinsky and Harabatz3; 4 -Ray and Turi; 5 -Davies and Bouldin; 6 - Bayesian Information Criterion (BIC); 7 - BIC with correction for finite sample size; 8- Akaike Information Criterion (AIC); 9- AIC with correction for finite sample size

Table 1. Description of analysed clusters

Number of Clusters	Clusters ID
2	C1: (0,3]; C2: >3 months
3	C1: (0,3]; C2: (3,6]; C3: >6 months
4	C1: (0,3]; C2: (3,6]; C3: (6,9]; C4: >9 months

From the analysis of figure 4 and table 1 we consider 2-clustered structure.

4.2 Generalised least squared

Since the number of AIDS cases in the most recent diagnosis are biased due to the effect of reporting delay, it was removed from the adjusted time evolution model, the latest 4 years were removed.

The general equation of the adjusted time evolution model for the reporting delay curves is described in 1.

$$X_i = \beta_0 + \beta_1 i + \beta_2 i * C2$$
$$X_i = 0.0227 + 0.0036i + (-0.0032)i * C2 \tag{1}$$

were X_i is the annual percentage of AIDS cases, i is the year of diagnosis and $C2$ is as described in table 1 (the reference level is the cluster $(0, 3]$) .

The year of diagnosis have an significant effect on the model for incidence of AIDS cross-classified as the interaction term between the clusters and time for a significance level of 0.05.

The model predicted that, with an increase of one year in diagnosis time, the annual percentage of AIDS cases as an increase of 0.0036 ($p < 0.001$) in delay $(0, 3]$, in delay > 3 an increase of 0.0004 ($p < 0.001$). The main effects and the interaction effect are described in table 3.

Table 2. Model for the AIDS percentage cross-classified by year of diagnosis and reporting delay quarter

Variable	Estimated coefficient	Estimated Standard Error	t-value	P-value
Intercept	0.0227	0.0057	4.0135	< 0.001
Year of diagnosis	0.0036	0.0003	10.9577	< 0.001
Year of diagnosis : C2	-0.0032	0.0004	-8.7336	< 0.001

The homocedasticity and normality of the model residuals was studied by graphical analysis and this assumptions did not seem to be compromised.

Individuals delay curves models can be drawn from (1) and this models can be used for estimating the expected percentage of cases for each delay.

Table 3. Individual models for the annual AIDS percentage cross-classified by diagnosis year and reporting delay quarter

Reporting delay	Estimated model
$(0, 3]$	$X_i = 0.4236 + 0.0036i$
> 3	$X_i = 0.4236 + 0.0004i$

5   Conclusions and future work

Considering the Portuguese notification system, it can be seen that majority of cases were reported with delay in $(0, 3]$. This longitudinal pattern is completely separated from the other curves and delays longer than 9 months have very close trajectories. These delays less than 10% of cases each. So, for modelling, and considering the epidemiological and surveillance relevance, we can consider the partitions of $(0, 3]$ and more than 3 months.

From the longitudinal model we can conclude that the delay curves are almost constant over time. Individuals delay curves can be used to estimate the corresponding delay distribution.

For future work we propose introducing in the delay model, co-variates with the historical changes in the Portuguese surveillance system, the region were diagnosis occurred, the probable group of transmission of HIV/AIDS. We also propose applying the method to other data sources for validation propose.

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Part IX
Semantics for Humanities Resources

OntoMP, an Ontology to build The Museum of the Person

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Abstract. This paper is concerned with the creation of a specific ontology for the knowledge repository of the Museum of the Person (Museu da Pessoa). The Museum of the Person assets are composed of several interviews (collected previously for a large cultural project) involving common people, to perpetuate their life stories.

The museum holds an heterogeneous collection of XML documents. In such format, the collection items are many times not recognizable and understandable by the visitors who wish to explore it. Therefore, we intend to use an ontology that allows a conceptual navigation over the available information, enabling the visitors to extract knowledge during the visit to these life stories.

So, this paper aims at presenting the ontology we have developed using CIDOC Conceptual Reference Model (CIDOC-CRM)[1] to enable visitors to lookup individual life stories, read them, and also intercross information among a cluster of life stories to build up the story of a company/institution or to study social behaviors and customs.

Keywords: Ontologies, Virtual Museums, Museum of the Person, CIDOC-CRM

1 Introduction

Virtual Museums are increasingly in vogue, because society is more and more concerned with preserving the cultural heritage and making it accessible to anyone with an interest in studying it.

According to Werner Schweibenz, a Virtual Museum (VM) is "a logically related collection of digital objects composed in a variety of media which, . . . lends itself to transcending traditional methods of communicating and interacting with visitors. . . ; it has no real place or space . . . " [2].

A Virtual Museum, analogously to a traditional museum, also acquires, conserves, and exhibits the heritage of humanity[1] creating a delightful environment

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[1] In such cases, intangible objects, or immaterial things, according to: http://www.unesco.org/culture/ich/index.php?lg=en&pg=00022#art2. Accessed: 17-12-2015

for pleasure or enjoyment, as well as an appropriate place for learning, and research. This type of museum allows people to interrelate information among different stories, to study social phenomena, natural disasters, migrations, season's customs, among others.

The project discussed here is concerned with the creation of a VM that exhibits life stories of common citizens. More exactly, we are rebuilding the Portuguese version of the global Museum of the Person (depicted from here by MP) that connects individuals and groups through sharing their life stories[2]. MP is located in Brazil, Portugal, USA, and Canada.

The museum's holdings are a set of XML documents and our aim is to build a virtual museum using CaVa[3], a Learning Spaces (LS) generator that receives a specification about the LS (using the known vocabulary of the museum curators) as input and generates the final virtual museum web application. This vocabulary has the terms of the literature and the terms of the Cultural Heritage, based on the used ontology. So, a conceptual navigation is available to the visitor of the virtual exhibition rooms [3]. To generate the LS [4] with CaVa, the documents repository must be specified using an ontology [5, 6].

In this paper we will discuss the process of reverse engineering the MP structure in order to obtain a museum standard format view. This process can be split into the two steps described below, as depicted in Figure 1:

1. Reverse engineering of MP (from MP to MP ontology);
2. Mapping the museum standard format view (from MP ontology to CIDOC-CRM [7]).
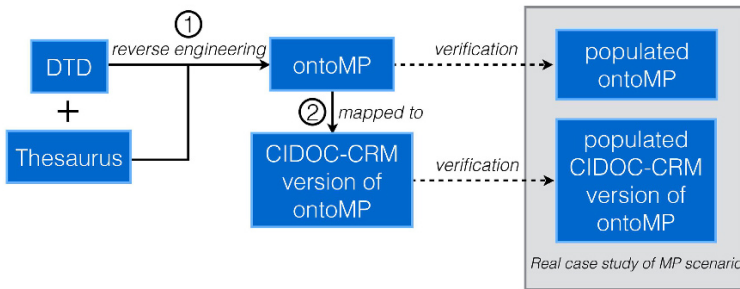
Fig. 1. Reverse Engineering and mapping of MP

Following the diagram of Figure 1, the paper is structured as follows. In Section 2 the Museum of the Person and its documents are described. Based on that description, on the *thesaurus*, and on the DTD's inherited, a first draft of

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[2] http://www.museumoftheperson.org/about/ Accessed: 17-12-2015
[3] CaVa stands for the Portuguese term *Construção de Ambientes Virtuais de Aprendizagem*. In english: Learning Virtual Environments Generator

an ontology for the Museum of the Person is presented in Section 3. Then, in Section 4 that ontology is specified according to CIDOC-CRM standard. Finally, in Section 5, a synthesis of the study is presented and some suggestions for future work are discussed.

2   The Museum of the Person documents

MP was born in Brazil, São Paulo, in 1991, created by a group of historians who decided to build the country's history using testimonials of ordinary people [8–10]. This is still an alive project accessible at `http://www.museudapessoa.net`. MP aims at gathering testimonials from human being, famous or anonymous, to perpetuate his history [11, 9].

From the life stories of individuals, the objective is to write up the stories of families, communities, or institutions [9]. This museum deals with common people, human beings, not with physical objects usually composing the traditional museum assets. Its "*art collection*" is made up of intangible or immaterial things. In this case, the alive objects are used as informers, reporting the events and emotions they experienced [11]. Actually, the narrators, to report their life stories during a predefined structured interview[4], remember events and particular situations they have participated in. These memories will act as a basic element for social research, because the set of life stories allows to reconstruct a social universe [11].

The workflow adopted by Museum of the Person technicians to acquire common people life stories is expressed below:

a. The report of a participant is recorded (audio or video) by an interviewer. Although every interview is a unique thing, interviewers guide to some predefined topics in order to cover the entire life story;
b. Interviews are transcribed;
c. Transcriptions are annotated in XML, marking events, self contained stories, etc.;
d. XML interviews may be used to produce several outputs.

Life stories are evidences in support of facts or statements attested by common people carrying a social and historical character, which must be preserved and processed to become an immeasurable human heritage [11].

The MP's collection consists of XML documents connected to each participant. Typically each interview is split into three parts [8]:

– mini-biography and personal data, such as name, date and place of birth, and job. This information is placed in a separate document, called `BI`;
– two versions of the interview: the text of the original interview, and the edited document;
   The `interview` file refers to the raw interview; it contains all the questions asked and the narrator's answers.

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[4] Recorded in a tape or a film.

The `edited` file (an example can be seen in Listing 1.1) is a plain text, structured by themes that define small portions of a person's life story. In this format, a life history may give rise to thematic stories (eg, dating, childhood, craft, among others).

Both `interview` and `edited` files contain metadata, tagging to define important testimony zones. Examples of this marks are given like institution names, jobs, places, etc.;

- photographs and their subtitles. The subtitle document contains a section for each photo or scanned document as file name and a caption. This caption includes a description of the image and the date, and wherever possible the name of the stakeholder.

Beside the interviews, there is also a *thesaurus* that includes key concepts mentioned in the stories. These concepts are linked by hierarchical relationships, namely: Broader term (BT) / Narrower term (NT) (superclass and subclass, respectively); Has (HAS) / Part-of (POF); Use instead (USE) / Used for (UF); Instance (INST) / Instance of (IOF); and Related term (RT).

As mentioned, the edited interview is in XML format, according to a Document Type Definition (DTD) defined specially for this purpose. It is composed of: identification of the deponent, episode, ancestry, descent, childhood, house, education, tradition, religion, quotidian, migration, place, dating, marriage, office, life's philosophy, event, photograph, among others. Listing 1.1 displays a small excerpt from the MP DTD.

```
1  <?xml version="1.0"?>
2
3  <!ENTITY %histVidaElem "p | identificacao | episodio |
       educacao | ascendencia | descendencia | infancia | evento
       | ... ">
4
5  <!ELEMENT mp ((%histVidaElem;)+)>
```

Listing 1.1. Excerpt of the *Edited Interview* DTD

The root element (`mp`) of our Museum of the Person is a life story composed of life story elements. Each life history contains alternative elements, such as a paragraph (`p`), an identification (`identificacao`), an episode (`episodio`), an ancestry reference (`ascendencia`), an event (`evento`), etc. The event element (`evento`) is defined as follows (Listing 1.2):

```
1  <!ELEMENT evento (%texto;)>
2  <!ATTLIST evento
3    ano CDATA #REQUIRED
4    mes CDATA #IMPLIED
5    dia CDATA #IMPLIED
6    local CDATA #IMPLIED
7    eixo CDATA #IMPLIED
8    titulo CDATA #IMPLIED
9    descricao CDATA #IMPLIED
10   relevancia (Alta | Media | Baixa) "Media"
11  >
```

Listing 1.2. DTD excerpt to describe an Event (`Evento`)

An element (`evento`) is defined as (`%texto`), an XML Entity previously introduced also has a set of alternative elements: a paragraph (`p`), an episode, a theme, among others. As attributes of the element (`evento`) we have: year (`ano`), month (`mes`), day (`dia`), place (`local`), type (`eixo`), title (`titulo`), description (`descricao`), and relevance (`relevancia`), all of type CDATA (simple text).

Section 3 outlines how we have described MP's life stories as an ontology, aiming at creating a more abstract and formal level of description.

3   OntoMP, an ontology for Museum of the Person

From the DTD and *thesaurus* introduced and briefly explained in the previous section, it was possible to build OntoMP, an ontology for MP.

The first step was an exhaustive extraction of the concepts present in the life stories. After a long analysis phase we came up with the following list: people (`pessoa`), ancestry (`ascendência`), offspring(`descendência`), house (`casa`), job (`profissão`), education (`educação`), episode (`episódio`), dating (`namoro`), accident (`acidente`), migration (`migração`), festivity (`festividade`), political event (`evento político`), catastrophic event (`evento catastrófico`), marriage (`casamento`), birth (`nascimento`), dream (`sonho`), childhood (`infância`), uses (`costumes`), quotidian (`quotidiano`), leisure (`lazer`), religion (`religião`), life's philosophy (`filosofia de vida`).

In this phase relations were also identified: performs (`exerce`), depicted (`éRetratada`), visits (`visita`), lives (`vive`), receives (`recebe`), tells (`narra`), has (`tem`), enrolls (`participa`), has-type (`tipo`), occurs (`ocorre`), refers to (`dizRespeito`).

After the extraction phase we built an ontology for the MP using the concepts and relations above. Then we realized that we could still add some more concepts to make a more complete ontology. We add: marital status (`estadoCível`), sex (`sexo`), literacy (`habilitações literárias`), political party (`partido político`), first communion (`primeira comunhão`), death (`morte`), baptism (`batismo`), and photos (`fotos`).

As illustrated in Figure 2, OntoMP has the ability to breakdown the raw story into logically related elements. In this way, the museum visitor can have a conceptual navigation over the collection.

4   CIDOC-CRM

CIDOC-CRM is a formal ontology planned to aid in the integration, mediation, and interchange of heterogeneous cultural heritage information [1].
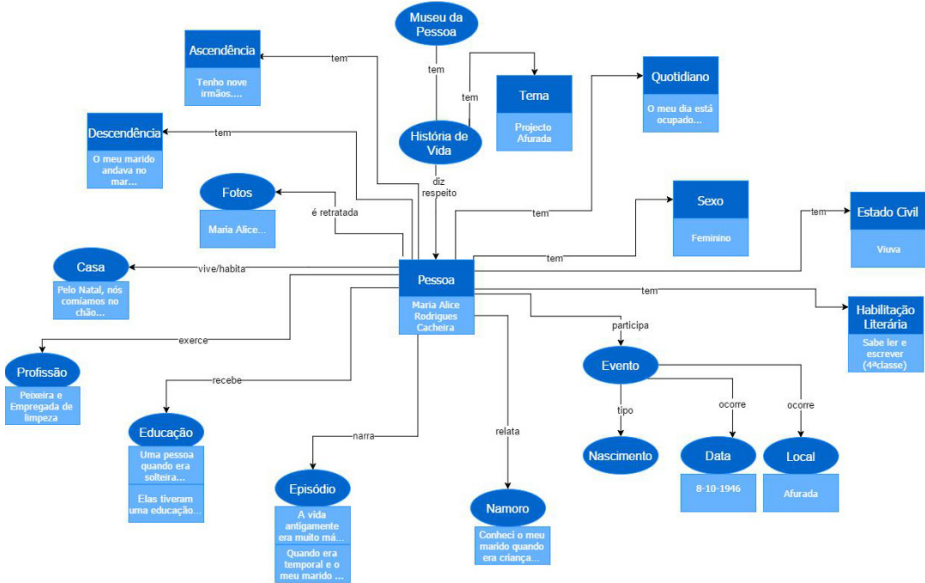
Fig. 2. An instance of OntoMP for Maria Cacheira life story (fragment)

More precisely, it specifies the semantics of museums documentation and document structures in cultural heritage in terms of a formal ontology. Summing up, CIDOC-CRM can be described as the curated knowledge of museums [1].

However, it is so broad and defined at a high abstract level that it can be adapted to any kind of museum. So this work uses CIDOC-CRM as a conceptual reference model to characterize Museum of the Person holdings, aiming to describe all dataset based on a standard ontology.

The core of CIDOC-CRM is based on seven concepts (*Temporal Entities*, *Events*, *Actors*, *Time-Spans*, *Conceptual Objects*, *Physical Things*, and *Places*). CIDOC-CRM is an event-based ontology, so its main concept is related with *Temporal Entities*. As an event-based ontology, it should contain *Time-Spans* and *Places* related with it. Besides, *Actors* and *Conceptual Objects* or/and *Physical Things* also should be related with an event.

CIDOC-CRM ontology can be synthesized[5] as *Actors participate in Temporal Entities/Events*, which *affect or refer to Conceptual Objects/Physical Things within Time-Spans at Places.* All of these concepts can be related to *Appellations* and *Types*. *Appellations* denote a specific instance of some class, serving to identify it. *Types* are used to denote terms of controlled vocabularies that characterize and classify instances of the CIDOC-CRM ontology.

CIDOC-CRM ontology has name conventions that must be followed. The concepts and relations names start with the capital letters "E" (Entity) and "P"

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[5] Notice that CIDOC-CRM ontology is not composed only by these concepts. These are the core of the ontology.

(Property), respectively. Names are followed by identification numbers (e.g. `E21 Person`, `E5 Event`, `P11 participated in`, `P152 has parents`, etc.).

Section 4.1 explains how the Portuguese Museum of the Person collection was described in the standard CIDOC-CRM ontology.

4.1 A CIDOC-CRM version of OntoMP

After the construction of the OntoMP (see previous section), the next stage was to describe it in a standard ontology used for museums, CIDOC-CRM. The ontology was built up having in mind the need to keep it fully compatible with the original, avoiding to add or modify any class. This is demonstrated in Figure 3, which portrays the instantiation of CIDOC-CRM with a concrete life story (just a fragment is shown). For illustrative purposes, this fragment is the same that is depicted in Figure 2.

According to the abstract layer of the CIDOC-CRM ontology in Figure 3: *A life story* `(E31 Document)` *is about* `(P129)` *a person* `(E21 Person)` *and contains photos* `(E38 Image)` *concerning this person.*

Looking at the concrete layer of that ontology, we read that: *Maria Cacheira* `(E21 Person)`, *participated in the* `(E5 Event)` *of her* `(E67 Birth)`. *This event occurred at* `(E52 Time Span)`—*that is identified by* `(P78)` *1946-10-08, an* `(E50 Date)`—*and at a* `(E53 Place)`—*that is identified by* `(P87)` *Afurada, an* `(E44 Place Appellation)`.

In this fragment of *Maria Cacheira*'s life story there are other concepts that were identified in Section 3. All these concepts, in CIDOC-CRM version, are described as `(E55) Type` because they characterize a `(E21) Person` and its instances. To exemplify that approach, consider the following case: *Maria Cacheira* `(E21 Person)` *has type* `(P2)` *Peixeira e Empregada de limpeza* `(E55 Type Job)`.

To sum up, notice that Figure 3 shows a description of a specific life story (partial view) mapping the life story concepts and relations into standard CIDOC-CRM elements. In this way (following this standard representation) it will be possible to query systematically the knowledge repository to explore it.

The full diagrams for OntoMP (abstract ontology and instances) and their CIDOC-CRM version are available at `www.di.uminho.pt/~gepl/OntoMP`.

5 Conclusion

Along this paper we have proposed the development of an ontology to describe the collection of the Portuguese Museum of the Person, in order to enable a conceptual navigation over the museum's assets aiming at extracting knowledge from the different life stories (individually or intercrossed).

The work here reported is a part of a larger project aimed at the automatic generation of exhibition rooms (Learning Spaces) resorting to a framework called CaVa. The present case study was built upon a large repository of life stories collected in the past, in different places under different social research topics, and
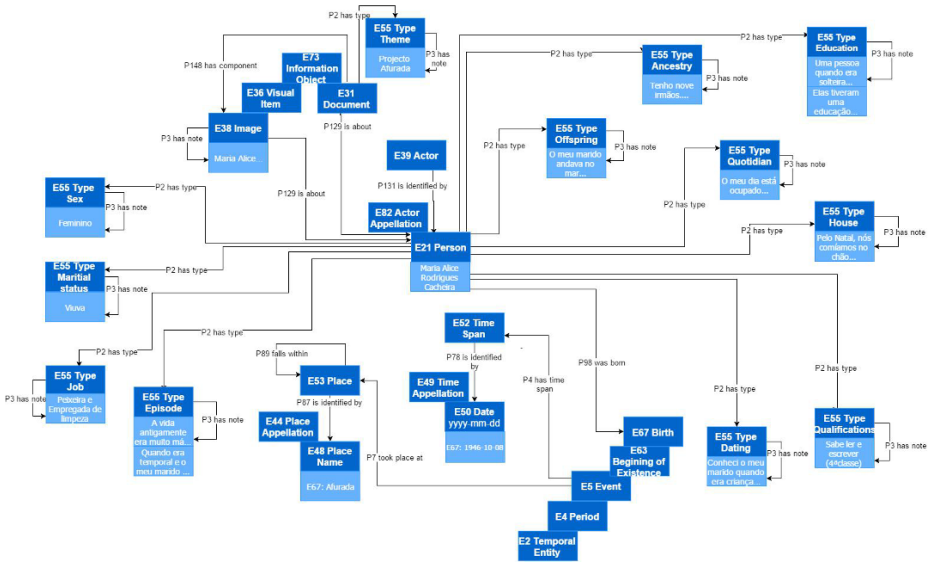
Fig. 3. An instance of CIDOC-CRM version of OntoMP for Maria Cacheira life story (fragment)

archived as structured eXtensible Markup Language documents. So, we did not start the ontology design from scratch; on the other way around, we performed a reverse engineering process on the referred legacy repository.

After building the abstract layer of the ontology that we call OntoMP, we instantiate it with various stories. This exercise was useful to tune OntoMP. Then we converted OntoMP to a CIDOC-CRM compatible form ontology with the objective of adopt a standard format used in the museums area. This way we preserve the interoperability of our repository for further exploration and knowledge extraction.

The next task, to realize the main project, is to build a virtual Learning Spaces (in this case, a Virtual Museum) to tell the world those picturesque and impressive life stories, and to extract knowledge about our society along the last decades connecting and relating the individual testimonials.

As future work, we intend to research how to extend CIDOC-CRM with FOAF[6] (*Friend of a Friend*) network to better describe (i.e., to describe in a more natural way) some of the specific concepts intrinsic to the Museum of the Person. This is because FOAF is an ontology precisely oriented to talk about people; in that sense, FOAF has a descriptive vocabulary specific to individuals, their activities and their relations with other persons.

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[6] Homepage: `http://www.foaf-project.org/`

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Part X
Emerging Trends and Challenges in Business Process Management

Towards Ontology-based Anti-Patterns for the Verification of Business Process Behavior

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Abstract. A business process model defines how an organization perform its activities. Since the incorrect definition of business processes behavior may increase costs and development time, it is required the verification of process behavior. Verification methods based on anti-patterns are a promising approach to deal with this issue, but their informal definition may lead to ambiguities and different interpretations of what problem a given anti-pattern represents, and how it should be applied or implemented to detect behavioral errors in process models. The aim of this paper is to assess the feasibility of business process behavior verification by means of the ontological specification of behavioral anti-patterns. The study is based on the detection of anti-patterns in a BPMN process model by exploiting a set of standard ontological reasoning services.

Keywords: business process management, control flow verification, anti-pattern, ontology

1 Introduction

A business process model focuses on showing a process in the activity level, subprocesses, and the control flow between them [1]. The control flow allows defining the behavior of a business process, and refers to how an organization will perform its activities. BPMN [2] is the standard language for modeling business processes.

Since the incorrect definition of the behavior of business processes may increase costs and development time, it is required the verification of process behavior. In business process models there are different combinations of constructs that could lead to problems in their behaviors, such as deadlocks, lacks of synchronizations, livelocks, or dead activities [3].

For existing verification methods [3,4,5,6,7], supporting complex constructs of a process modeling language (such as those for advanced synchronization, cancellation and exception management, multiple instances, etc.) may decrease verification performance. Performance is usually improved when omitting this type of constructs. Verification methods based on anti-patterns are a promising approach to deal with this trade-off, since they can support different type of constructs and improve response time [4,9].

A behavioral anti-pattern of business processes is a predefined and well-known situation of a deficient specification of the control flow of business processes.

Different anti-patterns have been proposed for business processes [4,8,9,10,11]. Although anti-patterns may improve the performance of verification methods, existing approaches may lead to erroneous conclusions about the behavior of a process, such as indicating an error even though the process behavior is correct [11] (also known as false positive cases). A worst situation could occur if a process has an error and the error is not detected by the verification method (also known as false negative cases). Besides this, anti-patterns are usually informally defined by examples with textual or graphical descriptions [4,8,9,10] or with informal languages [11]. This may lead to ambiguities and different interpretations of what problem a given anti-pattern represents, and how it should be applied or implemented to detect behavioral errors in process models.

To cope with these issues, we propose the use of ontologies to formally represent anti-patterns avoiding ambiguities. Ontologies have been traditionally used to check properties of the data perspective of business processes [12,13], rather than the control flow (or behavioral) perspective. But ontologies can also be used to check properties in the control flow perspective of business processes by means of anti-patterns.

The aim of this paper is to assess the feasibility of business process behavior verification by means of the ontological specification of behavioral anti-patterns. Such feasibility study is based on the detection of anti-patterns in a BPMN process model by exploiting a set of standard ontological reasoning services, and a set of requirements that should be met when verifying business process behavior by means of anti-patterns. This work is structured as follows. Section 2 introduces the concepts of ontologies. Section 3 presents the business process verification with ontology-based anti-patterns. Finally, Section 4 establishes a discussion and presents future work.

2   Ontologies

Ontology is envisioned as a structure defining concepts used to represent knowledge and their relationships. An ontology model is composed of concepts, relations, a concept hierarchy or taxonomy, a function that relates the concepts non-taxonomically, and a set of ontology axioms expressed in a logical language. Breitman and Leite [15] present a formal definition of ontology.

OWL 2 language (OWL 2) is the latest version of an ontology language with formally defined meaning [16]. An OWL 2 ontology is a formal description of a domain of interest interpreted under a standardized semantics that allows useful inferences to be drawn. The Semantic Web Rule Language (SWRL) is a proposal aimed at extending the set of OWL 2 axioms to include Horn-like rules, enabling their combination with an OWL 2 knowledge base [17]. It defines an OWL model theoretic semantics to provide a formal meaning for OWL ontologies including such rules. The rules are of the form of an implication between an antecedent and a consequent. The intended meaning can be read as: whenever the conditions specified in the body hold, then the conditions specified in the head must also hold. Both the body and the head consist of zero or more atoms. Multiple atoms are treated as a conjunction. Atoms in these rules can be of the

form *'C(x)'*, *'P(x,y)'*, *'sameAs(x,y)'* or *'differentFrom(x,y)'*, where *'C'* is an OWL 2 description, *'P'* is an OWL 2 property, and *'x'* and *'y'* are either variables, OWL 2 individuals, or OWL 2 data values. The *sameAs(x,y)'* atom holds if *'x'* is interpreted as the same object as *'y'*, while the *'differentFrom(x,y)'* atom holds if *'x'* and *'y'* are interpreted as different objects. Additionally, SWRL provides a set of built-ins that allows to extend the language by means of predefined functions. Built-ins for comparisons, mathematical operations, string operations, and date, time and intervals manipulations can be cited among the most used ones.

3 Ontology-based verification of business process anti-patterns

The verification of business process behavior with anti-patterns must meet the following requirements:

1. *Formal specification*: anti-patterns must be clearly stated and must not contain ambiguities that could lead to different interpretations of the problem an anti-pattern represents.
2. *Performance*: response time for detecting anti-patterns in a process model must be performed in real-time with no delays.
3. *Response*: the verification of business process behavior must return the exact combination of elements leading behavioral errors, and a set of alternative solutions to fix them.
4. *Precision*: false negative cases must be avoided, whereas false positive cases should be minimized.

Figure 1 shows a BPMN process model with deadlocks and lack of synchronization. In order to describe errors, we employ the concept of token. A token traverses the sequence flows and pass through the elements in the process model. Dijkman, Dumas and Ouyang [5] present a detailed description of the behavioral semantics of BPMN constructs and how tokens are used to describe the behavior of process models. In the process of Figure 1, gateway *parallel1* diverges the control flow throw sequence flows *sf3*, *sf4*, and *sf5*, from which the process may reach five behavioral errors:

1. Gateway *parallel5* has a deadlock: the behavioral semantics of the parallel gateway establishes that it will be activated if there is at least one token on each incoming sequence flow. From *sf3*, it is possible to reach the exclusive gateway *xor1*. If sequence flow *sf10*, instead of *sf9*, receives a token, then end event *end1* will be reached. This means that sequence flow *sf22* will not receive a token, and hence, *parallel5* will not be activated, causing a deadlock.
2. Gateway *parallel5* has a deadlock: from *sf4*, it is possible to reach *subprocess1*. If the intermediate catch event *intermediate1* of this subprocess is activated, end event *end2* will be reached. This means that sequence flow *sf29* will not receive a token, and hence, *parallel5* will not be activated, causing a deadlock.

3. Activity *a11* may be a dead activity: gateway *parallel4* of subprocess *subprocess1* allows the parallel execution of activity *a11* and end event *terminate1*. This implies that activity *a11* may be dead, since *terminate1* will impede or abort its execution.
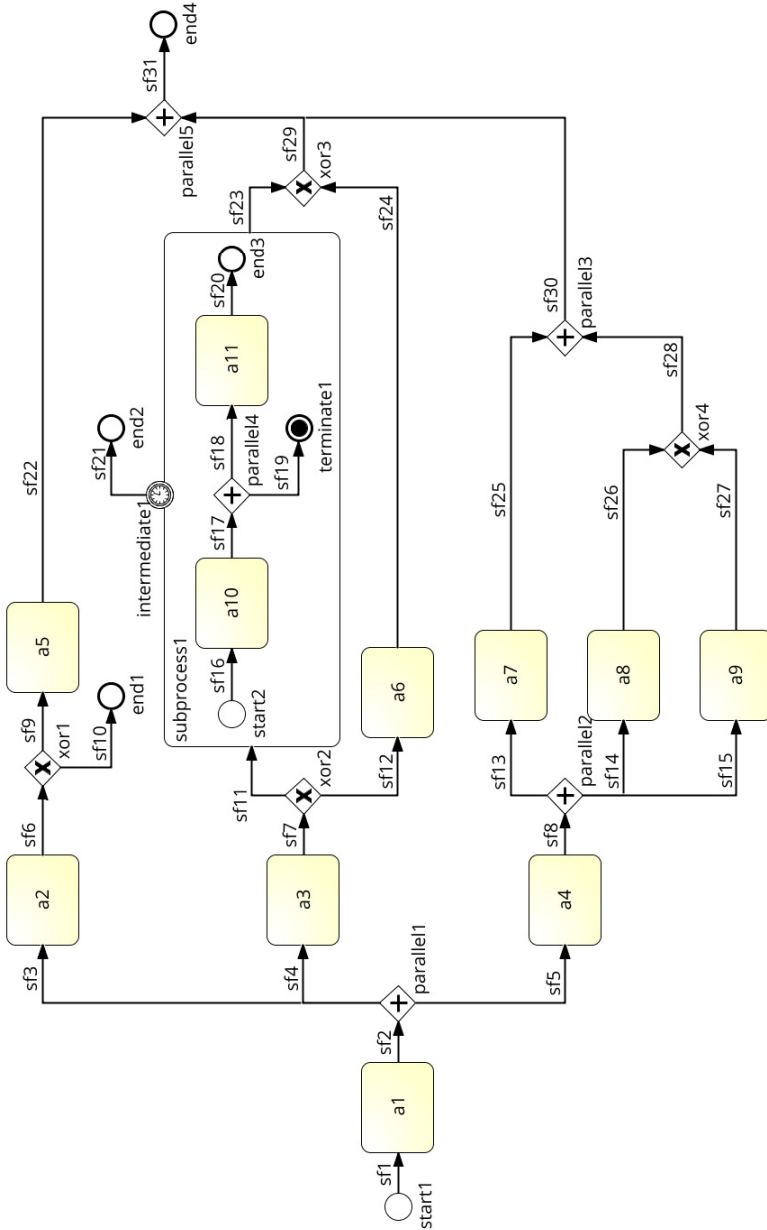
Fig. 1. BPMN model with behavioral errors.

4. Gateway *xor4* has a lack of synchronization: the behavioral semantics of the exclusive gateway establishes that each token arriving at any incoming sequence flow activates the gateway. From *sf5*, it is possible to reach gateway *parallel2*, which allows the parallel execution of activities *a8*, and *a9*. These activities converge with the exclusive gateway *xor4*. Since both activities are parallel, exclusive gateway *xor4* will be activated twice, generating multiple instances in the output of sequence flow *sf28*, which is usually an undesired situation that may cause collateral effects

5. Gateway *parallel3* has a deadlock: since exclusive gateway *xor4* produces two tokens in sequence flow *sf28*, once *parallel3* is activated a token will remain in sequence flow *sf28*, causing a deadlock in *parallel3*.

To support the verification of business process models, we propose that anti-patterns must be formalized with a formal ontological specification of a business process modeling language. The structure of a given process model must be represented as an instantiation of the ontological specification, enabling the specification and subsequent detection of specific constraints, i.e. the behavioral anti-patterns. An ontological formalization of the BPMN specification is presented in [14], where elements, attributes, and properties of BPMN are formalized by means of the OWL2 language. We extended this ontology for BPMN with a set of SWRL rules representing four behavioral anti-patterns. Following, an informal description of each anti-pattern is presented together with its corresponding formalization and implementation by means of SWRL expressions[1].

Anti-Pattern 1 (AP-1). *It is met whenever the flow diverges and converges by means of parallel gateways ('r', 'x') and one of the parallel paths has an exclusive gateway ('y') from which is possible to reach an end event ('t').*

SWRL implementation of AP-1

```
endEvent(?t),exclusiveGateway(?y),parallelGateway(?r),
parallelGateway(?x),isDirectlyReachableBy(?t, ?y),
isReachableBy(?x, ?y),isReachableBy(?y, ?r)
-> generateAP-1(?t, true)
```

Anti-Pattern 2 (AP-2). *It is met whenever the flow diverges and converges by means of parallel gateways ('t', 'x') and some of the paths has an intermediate catch event of type time ('z') from which is possible to reach an end event ('y').*

SWRL implementation of AP-2

```
endEvent(?y),intermediateCatchEvent(?z),
parallelGateway(?t),parallelGateway(?x),subProcess(?r),
isDirectlyReachableBy(?y, ?z),isReachableBy(?r, ?t),
```

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[1] A full ontology modeling the presented anti-patterns and the exemplified BPMN process model can be found in https://goo.gl/oLPIZD.

```
isReachableBy(?x, ?r),has_flowElement(?r, ?y),
has_flowElement(?r, ?z) -> generateAP-2(?y, true)
```

Anti-Pattern 3 (AP-3). *It is met whenever the flow diverges by means of a parallel gateway ('x'), and from such gateway, it is possible to reach an end event of type terminate ('y'), and the gateway has another parallel path from which it is possible to reach at least one activity ('z').*

SWRL implementation of AP-3

```
activity(?z),endTerminateEvent(?y),parallelGateway(?x),
sequenceFlow(?r),sequenceFlow(?t),has_sourceRef(?r, ?x),
has_sourceRef(?t, ?x),has_targetRef(?r, ?z),
has_targetRef(?t, ?y) -> generateAP-3(?y, true)
```

Anti-Pattern 4 (AP-4). *It is met whenever the flow diverges by means of a parallel gateway ('x') and two or more of the diverging paths converge by means of an exclusive gateway ('y').*

SWRL implementation of AP-4

```
exclusiveGateway(?y),parallelGateway(?x),
isReachableBy(?y, ?x) -> generateAP-4(?y, true)
```

Anti-pattern implementation was performed by means of Protégé - a free and open source ontology editor - and the Pellet inference engine, which provides sound-and-complete reasoning services[2]. Figure 2 depicts the chain of logical entailments involved on the automated detection of the AP-3 over the process illustrated in Figure 1. Due to space limitations, just the detection of AP-3 is presented. Anti-patterns AP-1, AP-2, AP-3, and AP-4 can be detected by using the ontology accompanying this article.

4   Discussion and Future Work

Existing anti-patterns for business processes [4,8,9,10] are informally described, which may lead to ambiguities. In practice, this implies that algorithms that implement anti-patterns may lead to erroneous conclusions about process model behavior. Furthermore, if a process model has an error it will not be possible to know beforehand whether the problem is in the algorithm, because of a faulty implementation, or in the rule because of a deficient design. This is a key issue, since some anti-patterns could be tricky.

By using semantic technologies, business process anti-patterns can be formalized with SWRL rules. The main advantage of using SWRL rules is that: (1) they formally

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[2]   Support, downloads and documentation about the integration of Protégé editor and Pellet inference engine can be found in http://protege.stanford.edu

describe anti-patterns, and hence, avoid ambiguities, and (2) they can be directly executed by standardized ontology reasoners. In practice, this implies that there is no need to implement a proprietary algorithm for anti-patterns in a given programming language. This is important, since the reasoner will never fail, whereas a proprietary algorithm may fail. If a process model has an error, and the reasoner does not detect such error, then it will be clear that the SWRL must be fixed. Although it is well-known that SWRL may have performance issues, ontologies can be stored on a graph-based database improving the performance of reasoners.

Fig. 2. Automated detection of the AP-3 over the process example.

Response returned by the reasoner provides information about the elements causing a given behavioral error, but it also shows how it came up to such conclusion. Figure 2 shows the inferences of the reasoner on the detection of the anti-pattern 3. Besides assessing the types of the involved elements, the row 7 of the response presents the rule that activated the detection of the anti-pattern.

The information provided by the reasoner is valuable to help designers fixing errors in the model. For instance, see error 5 in the example of Figure 1. The deadlock in *parallel3* is not rooted on *parallel3*, but on *xor4*. However, *xor4* is the cause of error 4. This means that error 5 is a direct consequence of error 4, and hence, fixing error 4 will fix error 5. The response given by the reasoner is key to cope with these type of issues. Such response will be considered in future works with the aim to provide a set of alternative solutions to fix them.

Finally, with respect to false positive and false negative cases, we expect that the formalization of anti-patterns with ontologies makes checking the correctness of anti-patterns easier, which could minimize false positives and false negatives cases. To confirm this, as future work, we propose an empirical evaluation considering different experiments with a repository of process models. Such study must be contrasted with results from existing verification methods [6,7]. In particular, false negative cases could be increased if the number of specified anti-patterns is insufficient to cover all possible errors that can occur in a process model. To cope with this issue, future work is also concerned with proposing a systematic approach to discover and specify behavioral anti-patterns of BPMN.

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Part XI
Computer Supported Qualitative Analysis

Building a Relationship with the Supervisor: An Exploratory Study

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Abstract. There is little knowledge regarding how the relationship between supervisors and subordinates is built. This study focuses on that process, according to the subordinates' perspective – cognitions, behaviours and emotions. We conducted a qualitative study, gathering data from 12 subordinates using the Critical Incident Technique. Results show there are four types of supervisors' behaviours that influence the process of building a relationship with the subordinate, including caregiving and fight (the two most stressed). The supervisors' caregiving behaviour is associated with the subordinates' positive emotion and careseeking behaviour. On the other hand, supervisor's fight behaviours are associated with negative emotions and the activation of the subordinate's self defence system. Consistently, we see that the first event that impacted the relationship were events where the supervisor had a caregiving or fight behaviour. It's important that supervisors understand the impact of their dominant behaviours particularly at the early stages of the relationship.

Keywords: Supervisors-Subordinates; Caregiving; Fight; Critical Incident Technique.

1 Introduction

This paper uses attachment theory to understand behaviour at work and focuses on the process of building a relationship with the work supervisor, considering the subordinate's perspective, behaviours and emotions. Literature has noted that a person's success or failure in a new organization (or work position) is largely dependent on the new member's social interactions since his first day at work, which can be a very stressful moment [1]. Several authors have identified the phases of a worker's integration process, distinguishing basically three sequential moments: setting in, breaking in, and settling in [2]. In a first moment the person accesses information regarding the organization but he isn't yet an effective member of the system. The second phase starts when he is admitted and becomes an organizational member; it goes from the first day at the organization until the end of the experimental period of work. The last phase happens when the member's self-concept has suffered changes, he has new relationships, values and behaviours [3]. When in the organization the new member will develop several work relationships, which are

fundamental to the success of his work role and well-being. Literature has stressed specifically the importance of the bond between supervisors and subordinates (e.g. [4] [5] [6] [7]). However, there is little information regarding the process of building a relationship with one's supervisor and which events influence this process [4].

Building on the literature that considers workplace events fundamental to understand attitudes and behaviours at work [8] our purpose in this paper is to explore the relational dynamics between subordinates and supervisors, identifying the work events that influence and shape this relationship. This knowledge may help to design organizational integration and development processes, creating more favourable conditions for a positive relationship between supervisors and subordinates.

The rest of the paper proceeds as follows. We begin reviewing the literature on relationships at work and on what attachment theory informs us regarding the supervisors-subordinates relationship. Next we explain the method used to explore the dynamics of this relationship, more precisely, the events that impact and shape it. The findings are then presented and the paper concludes with a discussion on the implications our findings may have for the research on the subject.

1.1 The Relationship Between supervisors and subordinates

People develop relationships with those with whom they work, establishing various work bonds that differ regarding the level of strength and direction [9]. These relationships are influenced by various factors [10] and result in functional or dysfunctional relationships. According to the Leader Member Exchange Theory, supervisors act differently with subordinates (e.g. [11] [12] [13]), according to their own availability, energy, time and resources [11]. Consequently, supervisors will develop high quality relationship with some members, demonstrating greater support and availability towards them. These subordinates form the endogroup and receive and exert a greater influence than those members who develop a low quality relationship with the supervisor, forming the exogroup [14]. Relationships with these members are more distanced and restricted to the organizational formal roles.

Subordinates in a high quality relationship display more physical and mental effort and reciprocation behaviours that benefit the leader and the organization [15] [13]. They tend to be autonomous, creative [16] [17], engaged, satisfied, loyal, and motivated and better performers [18] [19] [20]. Given their higher interaction with the supervisor, they receive more support, confidence and encouragement and they have a greater access to formal and informal rewards [11]. On the other hand, subordinates in a low quality relationship acknowledge they receive a differential treatment, and feel excluded. This has a negative impact in the relationship, on performance, satisfaction and motivation [18] [13]. When we consider these relationships in a developmental perspective, we can say that high quality relationships correspond to a more advanced developmental phase, and low quality relationships to a more initial phase. In this context developmental phase does not mean "time", but the quality of the process occurring between supervisors and subordinates. Despite considering it valid and very interesting, it seems to us that this approach isn't sufficiently dynamic, not fully addressing the developmental nature of individuals and groups in organizational

systems (which may be more or less mature) nor the leaders' and subordinates' idiosyncratic characteristics, such as attachment experiences.

1.2   Contributions of attachment theory to understanding the supervisor-subordinate relationship

Attachment theory is one of today's main theories regarding the social and emotional developing process of human beings [21]. It states that we develop attachment bonds with others, and that the need of security is fundamental in order for us to experience well-being throughout life. As adults we can develop attachment bonds with those with whom we interact the most, namely our friends, romantic partner and supervisor. The quality of these bonds can give us a subjective sensation of physical and/or psychological security [22] [23] or exactly the opposite.

Being a supervisor refers, first and foremost, to a process between two selves that influence each other and learn with one another [24]. The interaction between both creates a bond that several authors (e.g. [4] [25] [26]) consider that should be approached using Bowlby's attachment theory [27] [28] [29]. This perspective states that the leader, like the parental figure, plays a guiding, mentor and caregiver role, holding a higher position towards subordinates. Good supervisors, such as good parents, are responsive, supportive and seek to promote the subordinate's autonomy. They promote the necessary conditions for the subordinate's personal development, the acquisition of knowledge and his active participation; they set limits and rules; they are flexible and do not judge [30]. In our experience doing intervention with subordinates[1] we have noticed that it is not often that the supervisor acts as a fear free caregiver that supports the subordinate's reducing his fear system's activation. It is mainly the opposite; he acts as one of the main activators of the fear system. When those from whom we expect support and caregiving are the ones that activate our fear system, the result is extremely negative, reducing our self-esteem and creativity.

The experience of wellbeing and the capacity to explore is related with our sense of self. When our self-esteem is working we can ask for help and support and we have the energy and vitality to pursue our goals and the goals of the organization. There is a relationship/interaction between the feeling of self-esteem and the "self defence system" – how well we are able to protect the self from treats from the organizational experience, and how quickly we can recover from these. Our self defence system responds through our fear system and careseeking system. The fear system is helpful to survive, but it uses only our resources and we don't access resources of potential caregivers, for instance the leader or colleagues. When the fear system is aroused we can Fight (criticism, dominant ways of relating to others), Flight (withdrawal or submissive ways of relating to others) or Freeze (loss of our ability to think clearly).

When a worker acknowledges the supervisor competence and looks at him for help (careseeking) regarding a work issue (e.g. solving a problem or supporting a decision) a symbolic relationship develops between them, forming (ideally) an attachment bond between the subordinate (that seeks help) and a responsive supervisor as a fear free

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[1] In the context of MBA courses.

caregiver. The supervisor will act as a caregiver and the subordinate as a careseeker [4] [25] [26] [30].

According to Game [4] not only do we have a global relational model, but we also develop specific relational models, which (according to its designation) are specific to a parent, a romantic partner and, more relevant to this paper, the work supervisor. But we still don't know how long it takes to develop this type of relational model. And, in general, there is little knowledge regarding the construction of a relationship with the supervisor. Gabarro (1987, cit in [4]) found that broader working relationships develop according to one's trustworthiness and how open one can be in the relationship during the early weeks of acquaintance, and are then tested and confirmed over several months. Building on these ideas, we consider fundamental to explore how the relationship between supervisors and subordinates is built. Hence, we developed an exploratory and descriptive research study with this aim.

2   Method

Data was gathered from 12 participants, all working students, nine female. Participants' had a mean age of 37.25 years old (DP=12.37), an organizational tenure of M=10.52 years, and were in a relation with the current supervisor M=5.03 years (between one and 19 years).

Given our research questions (see Table 1) our gathering data instrument was the Critical Incident Technique [31] applied in the context of interviews.

Table 1. The Study's Research Questions

	Research Question	Goal
1st	Which events impact the building of a relationship between supervisor and subordinate?	Identify the events the subordinate considers that built the relationship with his supervisor.
2nd	How does the subordinate experiences the event?	Explore the subordinate's behavioral, emotional and cognitive reaction to the event.
3rd	What impact does the event have in the relationship building process?	Identify the event's impact on the building of the relationship

After testing the instrument, participants were presented an arrow drawn on a paper, which visually represented a time line. The beginning of the arrow, at the right, represented the present and it moved to the left, that represented the past (following [32]). We asked participants to think on their relation with the current supervisor and describe critical incidents (ci) that had influenced the building of their relationship, positioning those events in the time line. Regarding each ci the participants had to describe the context of the event (what was happening and who was involved), the supervisor's and the subordinate's behaviour, how the event ended, how the subordinate read the supervisor's behaviour, his emotions in the event and the event's impact on the relation. These items were adopted as quality criteria and only critical incidents that presented this information were considered in the analysis.

The interviews' transcriptions were sent to the participants by e-mail, and they were asked to enrich some of the data and validate the transcripts. Four participants gave us feedback. Data was analysed using content analysis [33], with the support of NVivo10 [34], given this software's potential [35]. After a first exploratory analysis of the data we developed a coding scheme with deductive and inductive categories associated to each research question. At this moment we considered in the analysis only the ci that met the quality criteria, resulting in 57 critical incidents, with a mean of 4.75 per participant.

3   Findings and discussion

Some of the events described by subordinates as having had an impact on their relation with the supervisor were events where the supervisor adopted a behaviour towards the subordinate and he reacted («*she offered me the job (…) I accepted with pleasure*», ci 44[2]). Others were events that didn't directly involve the subordinate, but had a behaviour towards the supervisor («*I told* [the supervisor] *"This is unacceptable (…) if I were you I would report on him"*», ci 40) or towards a co-worker («*I said (…)"beware,* [the supervisor] *told everybody that you were working."*», ci 15). And we also find events where the subordinate doesn't interact with the supervisor but listens to something regarding him, which had an impact on their relationship («*I heard that (…) when he ran for supervisor (…) [he] wasn't fair with other colleagues*», ci 17).

3.1   Which events impact the building of a relationship between supervisor and subordinate?

The analysis show that in 59,76% of the events (which influenced the building of the relationship between the supervisor and the subordinate) the supervisors adopted a caregiving behaviour. The second most frequent category was that of fight behaviours. Also of note is the fact that in some of the events the supervisor had a careseeking behaviour and there is also a case where he had a freeze behaviour (see Table 2). Caregiving behaviours were specifically in the form of supporting the subordinate in resolving issues, giving positive feedback, use of humour, defending, and sharing inside information. According to Kahn [9] the supervisor's caregiving behaviours are emotional acts that involve the transference of emotions through sharing information, giving counselling and being available. The fact that subordinates select events where the supervisor did caregiving in the form of positive feedback, instructions and use of humour, demonstrates the importance of these behaviours in the relationship. It also shows the importance for the subordinate to feel he is in a supportive relationship, where there is empathy, communication, collaboration and sharing. This not only shapes the relationship, but will also have an influence in the worker's individual performance [24].

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[2] Refers to the critical incident that integrates the excerpt and the number of that critical incident in our data base.

Table 2. Supervisor's behaviour in the event

Behavior	CI	%	Excerpt
Caregiving	33	57,89	*«He said he had read my CV and they were very interested in my work (...) He asked me if I was available to go to a job interview, that they would love having me working with them»* (ci 16)
Fight	20	35,09	*«a situation of making fun "ah I want to talk to the director, but maybe it's better if you go, since you are his sweetheart" (...) It was stupid, because it had nothing to do with me, it was her business, but she (...) said, like "oh I don't know, maybe the training center will grab your work theme and then, you sure are going to the director, since you are his sweetheart"»* (ci 13)
Careseeking	3	5,26	*«he began speaking about her* [a girlfriend]*, tears running... then he got up (...) spoke to me quietly, I told him (...) "let me work, this is urgent". After a while he gets up and goes by the window, we were working on the fourth floor, and he goes to the window and says he will throw himself»* (ci 57)
Freeze	1	1,75	*«She said "he was nervous ah... he* [man who insulted the supervisor] *is absolutely right"»* (ci 40)

It's important to consider the presence of the fight behaviour in these events, which refers to the supervisor adopting a dominant behaviour, mainly towards the subordinate. This behaviour was in the form of authority abuse, criticizing, and adopting an irregular conduct, for instance. It is also worth noting the excerpt referring to critical incident number 16 (in Table 2), demonstrating that the integration process does in fact begins before becoming an organizational member [2] and that events in this phase involving the [future] subordinate and the [future] supervisor will influence their relationship, being sort of a first building block of the relationship.

3.2. How does the subordinate experience the event?

Results suggest that subordinates tend to have their self defence system activated in the events that, according to them, impacted their relationship with the supervisor, adopting fight, freeze or flight behaviours (see Table 3).

Table 3. Subordinate's behaviour in the event

Behaviour	CI	%	Excerpt
Self defence			
Dominance (fight)	15	26,32	*«I said I would inform the union if she didn't do that to me (...) I even said to her "write whatever you want, I will talk with human resources"»* (ci 36)
Submission (freeze or flight)	11	19,30	*«I gave up, I pretended I did not hear (...) The more I valued it the more she would bother me»* (flight, ci 13)
Careseeking	14	24,56	*«I asked the supervisor's help, for him to be at the next opportunity* [with the client]*»* (ci 03)
Exploration mode	11	19,30	*«I had the need to get clarity as to what they wanted»* (ci 01)
Caregiving	6	10,53	*«I remained his confidant (…) I (...) said "it's not that tragic (...) you will fall in love again"»* (ci 59)

Fight, freeze or flight behaviours are adopted when the individual's sense of wellbeing is diminished [36] [37] and the subordinate acts in order to survive and recover from the situation, and, possibly, enter an exploratory mode, which will enable him to focus on work, look for information, try different solutions when facing challenges, etc. We stress this result, given the importance of the quality of the relationship between supervisors and subordinates. Careseeking behaviours are also worth noting, considering that subordinates tend to look at supervisors for support and guidance and it's fundamental that these remain available and responsive, so that in moments where subordinates look for help, supervisors are able to give support through caregiving.

When we consider the behaviour that was adopted by the subordinate according to the supervisor's behaviour in the event (Figure 1) it's interesting to note that subordinates adopted careseeking and exploration behaviours when the supervisor did caregiving. When the supervisor advises, when he shows he is available and helps the subordinate to manage stressful situations he acts as a caregiver, and this puts the subordinate in an exploratory mode, focusing attention on goals, challenges and the development of skills [37]. On the other hand, when the supervisor had a fight behaviour the subordinate did the same (fight) or entered a submission mode. Hence, the supervisor's fight behaviour seems to activate the subordinate's self defence system. Specifically regarding the submission mode, literature [38] points that hierarchical inequalities, social norms of emotional expression and sometimes a fear of retaliation may lead the subordinate to restrict his emotional expression in the workplace and avoid confrontation with the supervisor. Finally, we see that the supervisor's careseeking behaviour seems to activate the subordinate's caregiving system.
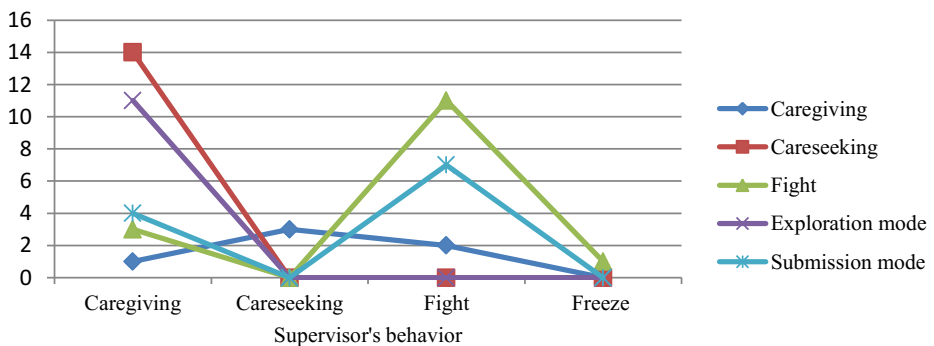
Figure 1. The subordinate's behaviour according to the supervisor's behaviour.

Research question two also focused on the emotions that the subordinate experienced in the event. Subordinates associated a positive emotion to 60,83% of the events («*Pride, surprise, satisfaction, happiness*», ci 19), whilst the rest of the events were associated to negative emotions («*I was angry, I was angry, I was upset because I thought it did not make any sense we were in that mess*», ci 11). Abusive and hostile behaviour adopted by a supervisor often results in negative consequences, particularly

in terms of subordinate's dissatisfaction and high levels of stress [38]. Despite subordinates sometimes avoiding confrontation, the frustration associated with abuse and injustice may lead to the direct involvement in conflicts with the supervisor [38] [39]. This may explain the subordinates' fight behaviours on some of the events, instead of being submissive.

3.3   What impact does the event have in the relationship building process?

Our final research question has to do with the impact that the event had on the relationship between the subordinate and the supervisor. We could identify positive and negative consequences, with the positive impact being slightly more frequent (57,89%). It meant a greater confidence and proximity with the supervisor, the subordinate being self-confident and motivated. The negative impact (observed in 42,11% of the events) was in the form of the subordinate's disappointment, conflicts and difficulties in the relationship, emotional detachment and moving to a state of alert regarding the relationship and specifically regarding the supervisor's behaviour.

It's also important to consider the impact of the event on the relationship according to the supervisors' behaviour (see Table 4) in order to better understand how subordinates experience the events in the relationship. When the supervisor supports the subordinates solving problems or constraints (caregiving) the event has a positive impact in the relationship. The supervisor acts as a safe haven, enhancing the subordinate's confidence that he will be there for him in a responsive way [25] [30]. On the other hand, when the supervisor has an abusive or hostile behaviour (fight) the event has a negative consequence. Note that, according to the subordinate, the supervisor's careseeking behaviour also had a negative impact in the relationship.

Table 4. Event's impact according to the supervisors' behaviour

Behaviour	-	Excerpt	+	Excerpt
Caregiving	1	«sometimes it comes to my mind, and I don't like it of course (...) disappointment perhaps» (ci 51)	32	«I felt that he trusts me (...)» (ci 19)
Fight	19	«It is not that I fear her physically, but sometimes I think, I don't know if one day (...) I try to be hyper-vigilant because I'm afraid» (ci 19)	1	«Indeed it at this point she does not get much from me. (...) She does not try to play me (...)» (ci 15)
Careseeking	3	«I was in a trap because I had no chance to get out, he was my supervisor» (ci 59)	0	---
Freeze	1	«I got angry (...) I was angry and I told her that, I told her» (ci 40)	0	---
Subtotal	24 (42,11%)		33 (57,89%)	

Note: negative impact is represented by "-" and positive impact is represented by "+".

As already mentioned we asked participants to consider the relationship with the supervisor in an evolutionary perspective, describing a first event that influenced the relationship. The analysis shows that participants when prompted to identify that first

event focus on caregiving and fight behaviours (see Figure 2). This is interesting since these behaviours are almost the opposite from each other. Caregiving is associated with the good leader [30]; fight behaviours are associated with the activation of the other's self defence system [37]. According to Figure 1 (above) in the events where the supervisor had a fight behaviour the subordinate's self defence system was activated, with the adoption of fight or entering a submission mode. We can speculate that these were the most influential events to the relationship, since these were the ones that subordinates decided to highlight.
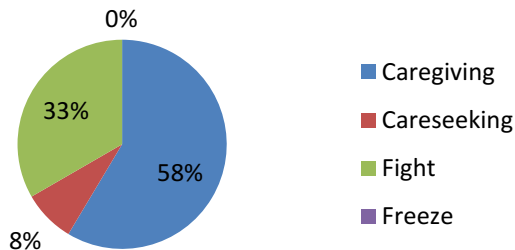
Figure 2. The behaviour adopted by the supervisor at the 1st event described by subordinates

4   Final ideas

It's important that organizations guarantee that in the first interaction with subordinates, supervisors have caregiving behaviours. The fact that these were the behaviours at the event that subordinates decided to describe first stresses their importance to the relationship supervisor-subordinate. Caregiving behaviours activate the subordinate's exploratory mode and have a positive impact on the relationship. On the other hand, it is crucial that careseeking and fight behaviours are absent particularly in this phase of the relationship. Attachment theory shows that these behaviours when adopted by parents, have a negative impact on children (e.g. [27] [28] [29]). We also see this in the relationship between supervisors and subordinates [9], with our study providing further evidence to that effect. Our work stresses the need to raise awareness among supervisors to the impact that their behaviours have on subordinates and the importance of the quality of their relationship to the subordinate's well-being and performance. This awareness could be accomplished through intervention using methods such as the Critical Incident Technique, where supervisors could learn to identify behavioural patterns and the activation of their fear system, understanding how to reduce it and be a more effective caregiver, creating conditions for subordinates to explore [37].

Authors (e.g. [37]) stress the value of understanding that someone may have different attachments styles in different relationships. Our results support this and the idea of the development of a relational model specific to one's supervisor. Future research should adopt qualitative longitudinal designs in order to better understand the relations between the different events on the supervisor-subordinate relationship and how these are experienced by subordinates and supervisors, gathering data from organizational members since their first day at work. Longitudinal designs would

make it possible for us to gain a better understanding of the timings in the process of building a relationship with one's supervisor. This is a promising and exciting area, as we realize the importance of considering people's attachment experiences in understanding how we experience work.

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Part XII
Human-Machine Interfaces in Automation, Robotics and Mechanics

On the present state-of-the-art of a component importance analysis for complex technical systems

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Abstract. The paper presents the present state-of-the-art of a component importance analysis for complex technical systems. We used a sea vessel as an example of the complex technical system. We showed selected statistics of ship operation losses. We highlighted a necessity of further development of importance analysis methods for machinery operation. We presented a description and diagrams of qualitative and quantitative importance analysis. We pointed out the most significant problems of complex technical systems modelling. We introduced a multi-criteria system component importance analysis. Basic criteria for a system component quality evaluation have been presented. We described some factors influencing importance of the technical system components.

Keywords: importance analysis, complex system, human-machine interfaces, machinery, quality criteria, multicriteria analysis.

1 Introduction

The main goal of the paper is to show the present state-of-the-art and possible ways of development in terms of applying the multicriteria analysis of components importance to evaluate the operation of complex technical systems (CTS) under risk and uncertainty, and especially to introduce system operation characteristics and describe its interaction with the environment. The proposed methods will enable a selection of important criteria to be made at the very beginning of the system analysis.

The chain which is as reliable as its weakest link is the symbol of reliability and safety for a technical system consisting of many elements/subsystems. This model, however, is seldom true for today's machinery where elements composing a whole are not connected in series but become a complex multifunctional structure [1, 2]. Moreover, it is all too often the case that taking into account different evaluation criteria it turns out that not always the "weak links" are the most significant for sustaining the proper quality of the operational process. High reliability of technical systems is certainly a precondition for their safe and effective exploitation [3, 4].

There is often a need for increasing system reliability by modifying the system structure or improving reliability of selected components [5, 6]. Reliability theory concentrates on intact system operation and allows for estimating measure values that

describe absence of susceptibility to damages, availability and exploitation safety [7]. With regard to a system as a whole, basic dependability measures are important information as for intact system operation but as far as system components go, these measures give very general information on their vulnerability and, except for a series reliability structure, are unable to describe the impact of a component on the whole system. The components impact on the system i.e. system tolerance for its components failure, is both connected with components dependability characteristics and system structure where a particular component is located.

For example in waterborne transport, applying modern technical solutions to improve exploitation safety by e.g. introducing the so called unmanned engine rooms, results in an increased construction complexity of a power plant but its higher reliability [8, 9, 10]. Additionally, progress in materials science and engineering [4, 11], new methods in technical diagnostics and improved maintenance procedures greatly contribute to higher ship reliability and durability and to shorter idle time in ship operation (mean time to repair). This in turn extends mean time between failures and decreases the overall costs of spare parts during ship operation.

Despite a significant improvement of ship technical systems reliability, safety and reduction of environmental impact [8, 9, 10], maritime disasters still happen and they result in: loss of life and health deterioration of passengers and crew and material damage connected with serious ship breakdown or sinking. For instance, according to the statistical data provided for year 2012 by the Allianz Group, by 25 November 106 ships had been reported lost - that is 16% more cases when compared to the previous year 2011 (91 ships) but 27% fewer in comparison to a 10-year average number of lost vessels equal to 146 ships reported in one year [12]. The statistics for industrial disasters show that most of dangerous situations are human-caused (70-90% of faults in a given population) to be followed by machinery failures during normal operation (8-30%) and 1-2% force majeure [13, 14]. The consequences of such events might be very serious, let the case of Costa Concordia, an Italian cruise ship running aground off an Italian coast, or Rabaul Queen, capsized near Papua New Guinea, be their most illustrative examples both causing loss of life.

Modern vessels are of increasingly bigger size to improve their deadweight tonnage. They often carry toxic and dangerous substances (crude oil, chemical substances, fertilisers, LPG, LNG) which are hazards for the natural environment. For example, oil tanker Exxon Valdez which ran aground in 1989 near Alaska, as a result of hull rupture spilt huge amounts of crude oil into the sea (at least 41.000 m3) and contaminated ca. 1.900 km of coastline. The biological consequences of this catastrophe are still visible. Similarly oil tanker Prestige, which sank near Spain in 2002, caused huge economic loss polluting thousands of kilometers of coastline in France and Spain and causing great harm to the local fishing industry [12].

Provided examples of disasters indicate that it is extremely significant to analyse the impact of the subsystem faults in complex systems (such as vessels and their propulsion systems) on the system operation. This analysis enables to locate the connected system components whose interaction might pose threat to safety and result in partial or complete system damage.

System sensitivity analysis (failure tolerance by the system), including components importance analysis in the structure of complex technical systems, is interdisciplinary and is part of fundamental research, more precisely - system theory.

It is also tackled by reliability theory, safety theory, exploitation theory and economics [15, 16, 17, 18].

The present state-of-the-art of a component importance analysis for complex technical systems will be shown in the next chapter. Additionally, a necessity of further development of importance analysis methods for machinery operation will be presented.

2 State-of-the-art

There are many definitions of the word *system* [18]. It can be assumed that system S is a given functional whole exposed to a two-way interaction with the environment and expressed as an ordered pair comprised of a set of elements E and sequence U described as system-formimg relations:

$$S = \langle E, U \rangle \tag{1}$$

Sequence U is defined as *system structure* in the literature. The structure may reflect a general system description (*general structure*), system construction (*construction structure)*, system operation (*functional structure*), evaluation process of the technical condition (*diagnostic structure*) and may represent the technical condition of the system based on the technical condition of its components (*reliability structure*).

The system reliability structure depends on [18]:
- the system composition level assumed for the analysis and method of its division into elements;
- functional relations between system components;
- the criteria taken to assume a given component or system technical condition to be in a down state;
- the function performed by the system.

Every reliability structure might be represented by means of sets of characteristic system components referred to as minimal cut-sets (system failure oriented analysis) or minimal path-sets (system intact oriented analysis). Some structures are not useful for the CTS analysis because of the existence of the so called *passive components*, i.e. the ones that do not affect the reliability system state. The structures containing passive components might be reduced because for the description of the system components state and the whole system state, the function of the argument number lesser than the total number of components is sufficient [19].

Among the reduction resistant structures we can indicate the ones where the component restoration might cause system failure or component failure might cause system restoration. Such structures, known as incoherent in the published literature [18, 19, 20, 21], hardly ever exist in real life and are not applied to a prevailing number of technical objects. For that reason, in the following work only coherent structures will be taken into account.

The CTS such as marine power plants are difficult to be described because:
- they are renewable or partly renewable;
- their functional and reliability structure is time-dependant;

- they are complex, have a hierarchical structure and multilevel feedback;
- their failures are partly- or totally dependent on each other;
- we know the response to a determined range and character of inputs and disturbances;
- they have many kinds of reservation (redundancy relations are unknown and form overlapping sets);
- their reliability structure, despite the existence of known and selected basic functional components in it, is often completely or mostly unknown.

System importance measures have been introduced to describe the influence that the change of the system component reliability state has onto the whole system reliability state [13, 20]. Usually during the analysis of the technical system reliability, an analyst concentrates on identifying the most sensitive components whose reliability must be improved to optimally increase the reliability of the whole system (components importance measures). The measures may be determined depending on:

- the system structure (Fig. 1a); then they are qualitative measures (e.g. minimal cut set order, Birnbaum's structural importance measure);
- the system structure and system components reliability characteristics (Fig. 1b); then they are quantitative measures (e.g. Birnbaum, Bergman, Lambert, Natvig, Barlow-Proshan or Vessely-Fussell reliability measures etc.).

Analogically the minimal cut-set importance is considered (local importance measures). It is connected with searching for the so called "weak links" in the system i.e. the most unreliable components and components groups (so called importance analysis). Importance measures express the reliability criterion above all as basic and only, so they do not directly express failure consequences for exploitation safety and maintenance costs (searching for "weak links" [18, 19, 20]). The authors' scientific interests concentrate on components importance analysis and simultaneous evaluation of failure consequence for selected criteria.

Although reliability theory goes back a hundred years, the concept of reliability in terms of its quality accompanies the civilisation of man for a very long time. It results from the fact that for man it is very significant to determine if the undertaken activities were successful or not [18]. In this sense, a reliable operation of CTS such as a marine power plant and its subsystems is a priority. Modern ships must meet growing needs of the goods market. Increasing the effectiveness of meeting the needs means here that bigger amounts of goods are transported, over longer distances, in shorter periods of time and possibly shortest ship loading and unloading periods. Simultaneously, the necessity to minimize the ship maintenance costs resulted in ship crew reduction which in turn brings about the necessity to implement additional automated systems insuring the continuity and safety of ship exploitation process.

a)

b)
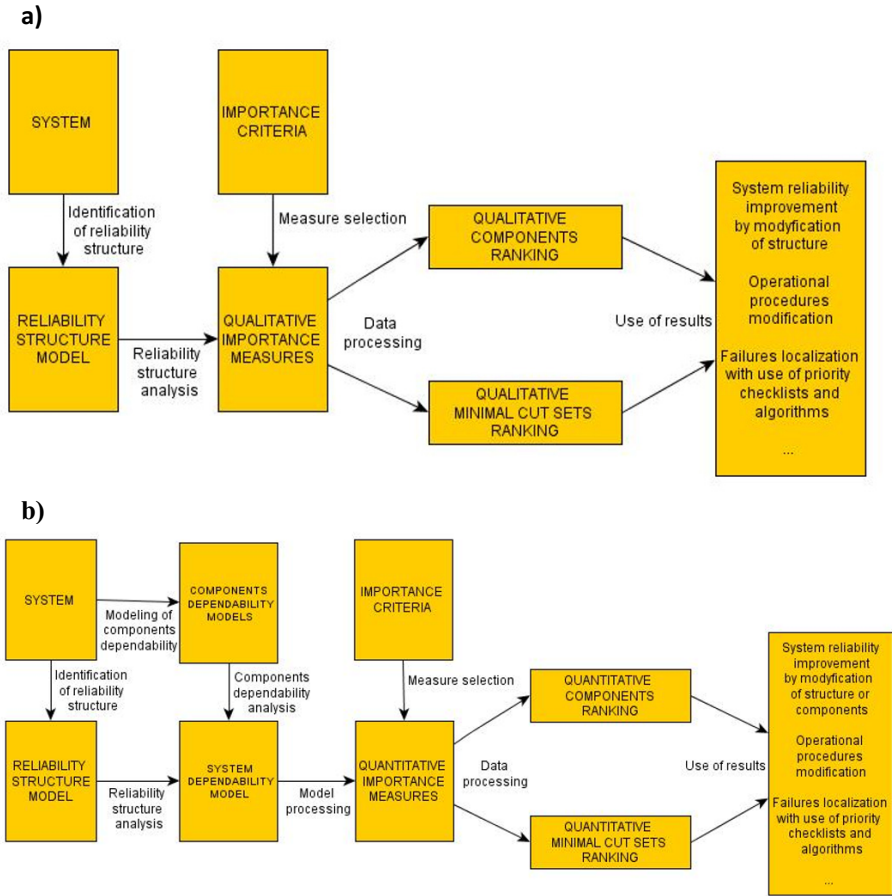
Fig. 1. Process of components importance and components groups evaluation in the system reliability structure [18]: a) qualitative analysis, b) quantitative analysis

Due to limited applicability of reliability importance measures and earlier specified characteristics of complex technical systems, it is obligatory to develop methods enabling to single out a set of important components in the system for selected importance criteria. It can be the main goal of the research projects. It is especially significant with reference to highly complex systems characterised by a big amount of information and high uncertainty of the analysis (Fig. 2).
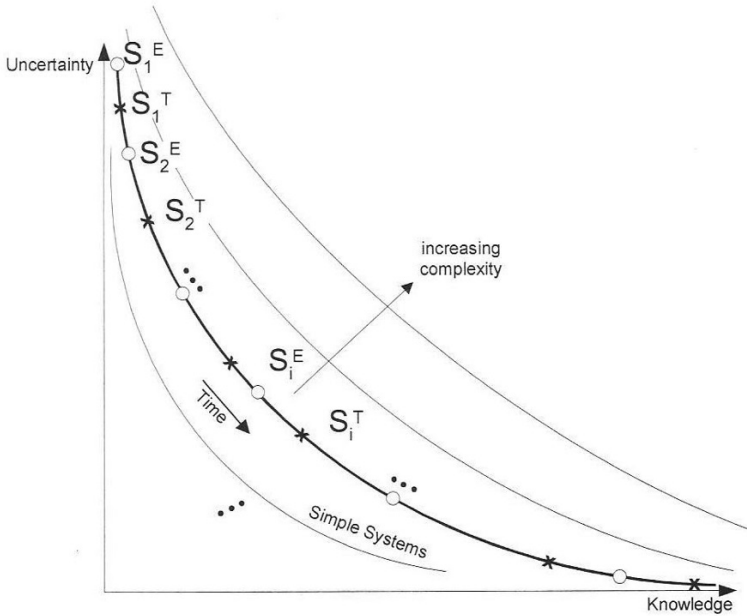
Fig. 2. Uncertainty - Knowledge Relations [22]

Components importance analysis is strictly connected with system sensitivity evaluation consisting

in [23]:

- separating parameters (factors) for which a small change of the value results in a big change of the value for external characteristics;
- studying the influence of sensitive parameters on the system effectiveness by verifying the influence of these parameters on the system characteristics;
- forced modification of harmful sensitivity influence and exposing useful sensitivity by changing the system structure.

A general index of system quality described by elements of set W in time T can be expressed by [23]:

$$I(\overline{W},T) = \int_0^T \rho_1(\overline{W},\theta)[\Delta f_1(\overline{W},\theta,t)]^{\chi_1} dt + \int_0^T \rho_2(\overline{W},\theta)[\Delta f_2(\overline{W},\theta,t)]^{\chi_2} dt + ... + \int_0^T \rho_m(\overline{W},\theta)[\Delta f_m(\overline{W},\theta,t)]^{\chi_m} dt \tag{2}$$

where:

t – short time understood as independent variable of system operation dynamics;

θ – long time understood as independent variable of system development process.

however:

$$\Delta f_1(\overline{W},\theta,t) = f_{01}(\overline{W},\theta,t) - f_1(\overline{W},\theta,t),$$

....

$$\Delta f_m(\overline{W},\theta,t) = f_{0m}(\overline{W},\theta,t) - f_m(\overline{W},\theta,t),$$

There are many kinds of sensitivity, including parameter, structural, structural and parameter, exploitation and dynamic sensitivity. The structural and parameter

sensitivity describes the influence of the size and quantity of components on system characteristics. The index (1) can be written as:

$$I(\overline{W},\theta,t)=\sum_{i=1}^{i=n_1}\int_0^T \rho_1(\overline{W},t)[\Delta f_i(\overline{W},\theta,t)]^{z_i}\,dt + \sum_{i=1}^{i=n_2}\int_0^T \rho_1(\overline{W},t)[\Delta f_i(\overline{W},\theta,t)]^{z_i}\,dt + \sum_{i=1}^{i=n_3}\int_0^T \rho_1(\overline{W},t)[\Delta f_i(\overline{W},\theta,t)]^{z_i}\,dt \quad (3)$$

Particular summants of the formula (3) describe successively the quality of system components, relation quality between the components and the sum of integrals expressing the quality of components and relations between them.

In general and from a given point of view, an important component is the one which has a proper set of parameters with values taken a priori within an allowed range of variation. Maciej Woropay [19] as *importance* understands the ability of "vertical interaction" (hierarchical relations: subsystem-metasystem) of subsystem failure and its influence onto the task performance of metasystems at a given decomposition level. The system importance is a function dependent on the level of conditions fulfillment which are determined by criteria k_q [19]:

$$I = f(k_1, k_2, ... k_q ... k_{n_k}), \ q = 1, \ 2...n_k \quad (4)$$

where:
n_k – number of criteria.

System components importance might be defined by a set of criteria. The bigger the number of criteria, the more detailed is the component (subsystem) importance evaluation for the system operation. In the published literature [19, 24] we can find the term "evaluation criteria weight coefficients"(hereinafter referred to as criteria relevance) which need to be distinguished from "importance criteria".

3   Final conclusion

Criteria relevance refers to a selection of given criteria and determining their weight coefficients to calculate a given importance measure. This approach is useful in the first stage of system components importance evaluation i.e. the selection of importance criteria and measures describing importance according to selected criteria. In [24] taking into account the process quality factor, many characteristics connected with criteria relevance have been pointed out in Table 1.

Table 1. A set of universal importance criteria [24].

No	Name	The criterion informs on
1	Safety	Protection or threat to life or health
2	Benefit	Gained benefits or achieved effects
3	Cost	Incurred costs
4	Reliability	Reliability, susceptibility to breakdown or absence of operation efficiency
5	Novelty	Novelty, fashion or time factors
6	Effectiveness	Proper task fulfillment
7	Exactness	Purpose and compatibility of application
8	Usability	Durability, running hours and operation time
9	Faultiness	Flaws, faults and fidelity
10	Appearance	Shape harmony, colour, aesthetic impressions

If $\Phi(f)$ is a numerical function of the system state which represents a given number for every function f of function space, then the condition concerning checking if value $\Phi(f)$ is within the arranged interval $[a,b]$ of the allowed variables is considered as importance evaluation criterion [19]

$$a \leq \Phi(f) \leq b \qquad (5)$$

Reliability importance analysis aims at determining which system component is the most important for its operation taking into account an optimal value of a given reliability measure, e.g. which component mostly affects the system availability, expected time-to-failure or which component most probably will bring about the system breakdown. The term *importance* is closely connected with *sensitivity* and sometimes they are used interchangeably in the professional literature. In [21] sensitivity is defined as a partial derivative of reliability function R with respect to reliability r_i of *i-th* system component. This definition is identical with Birnbaum's reliability importance measure:

$$P_i^D = \frac{\partial R}{\partial r_i} \qquad (6)$$

According to relation (6) components importance depends on two basic factors:
- system components reliability characteristics;
- system reliability structure.

In the presented approach, the more important the component is, the bigger is its absence of susceptibility to damages and the more its location in the reliability structure resembles an independent component in series reliability structure. The thesis is not confirmed in reality because, as said at the beginning, to comprehensively evaluate components importance it is necessary to determine the consequences of their failures. For instance, a crankshaft of a combustion engine has very high reliability but when it fails, the engine is out of use for a reasonably long time which qualifies this component as very important. Hence, CTS components importance depends on [18]:
- reliability characteristics of system components,
- system reliability structure,
- results of system components failure.

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On the possibilities of applying the AHP method to a multi-criteria component importance analysis of complex technical objects

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Abstract. The paper presents selected issues in the area of modelling a complex technical system structure. We presented the main types of a real technical system reservation. We showed selected proposals of a component redundancy description. We presented a black-box model of the system and described our own concept of qualitative-quantitative analysis of the complex technical system component importance. We also showed a possibility of applying the AHP method to a multi-criteria importance analysis. Some research achievements in this area and propositions for further development of a multi-criteria component analysis have been shown.

Keywords: importance analysis, complex system, human-machine interfaces, machinery, AHP, expert opinion, importance criteria, multicriteria analysis.

1 Introduction

During complex system operation, transformation of any component into a down-state leads to the whole system's down-state and is characteristic for systems with a non-redundant coherent reliability structure. It happens in the case of the series reliability structure. The series reliability structure usually reflects a real reliability structure and is theoretical which enables to determine the system reliability considering the most pessimistic scenario. In real technical objects there exist many redundant structures, both known and impossible to be identified. In practice we always deal with redundant structures [1, 2].

The definitions for redundant and non-redundant structures are not precise and will be made precise as a result of the carried out analysis. The imprecision is about many kinds of redundancies and increasing complexity of modern systems. Fig. 1 illustrates the most important kinds of redundancies. A detailed description of redundancies is presented in [3] among others. So far structural redundancy has been described most precisely. It consists in multiplying components in the system in order to improve its reliability. Making use of redundant components in the reliability structure is called *reservation*. According to [4, 5, 6] the component importance decreases together with its reliability increase and increase of reservation level of a given component.
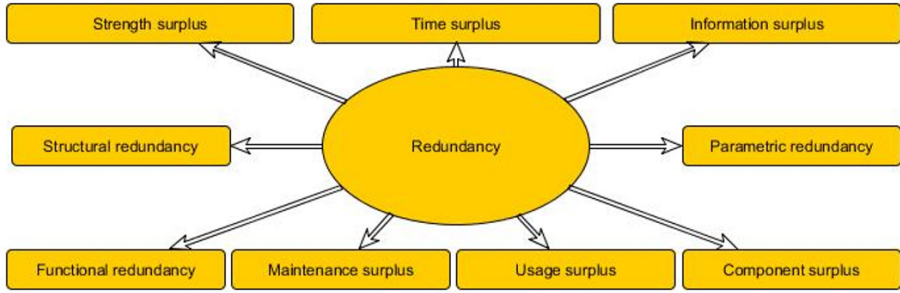
Fig. 1. Basic kinds of redundancies in complex technical systems [4]

The classification in Fig. 1 does not show other unidentified kinds of redundancies. Real systems are characterised by the simultaneous existence of many kinds of redundancies in them. Moreover, in every real system there exist time inertia as well as known and unknown feedback of streams of information, mass and energy, collectively affecting system characteristics as a whole. To describe systems of the kind, the *black box* is useful. It enables to model the cause-and-effect relations and according to [3] is a *default reliability structure*. [8] presents a redundancy measure based on the system model in the form of a black box (Fig. 2).
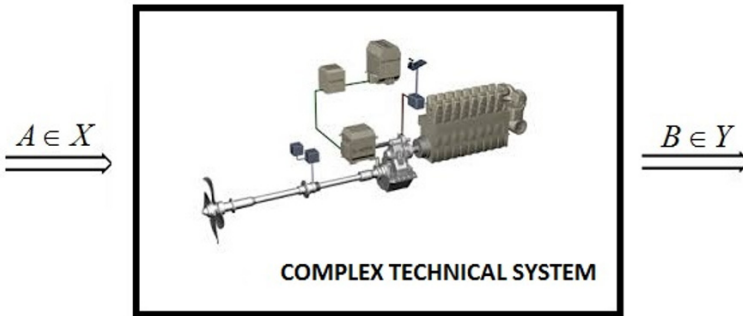
Fig. 2. System with redundant reliability structure as black box [8]

Every technical system contains some important components in its structure which need to be identified. 1941 Juran used the Pareto Principle in his studies on production quality and observed that 80% of the effects come from 20% of the causes. The research on components importance in technical systems have shown so far that important components make ca. 20% of all system components and simultaneously decide in 80-85% about the system reliability [9, 10]. Limited applicability of importance measures and difficulties in full and accurate description of complex technical systems causes the necessity to create methods which would select a set of important components in the system according to defined importance criteria.

It is advised to overview of modelling methods of CTS reliability structure [4, 11] and propose new solutions for:

- modelling the system reliability structure change during operation by means of an external event vector describing the change of the system configuration in different operational states;
- modelling the operational state change, analysing reservation in the system and comparing different reliability structures by means of a complex number plane.

In his research conducted so far, the authors have placed his main focus on the evaluation of components failure influence on the whole system operation, including the consequences of these failures with respect to reliability, exploitation safety [12, 13] and its costs effectiveness (profitability) [14, 15]. The usefulness of the most significant components importance measures (known also as relevance or sensitivity measures and describing the results of CTS components failure) has been analysed, including Birnbaum, Bergman, Lambert, Natvig, Barlow-Proshan or Vessely-Fussell reliability measures as well as Risk Achievement Worth (RAW) and Risk Reduction Worth (RRW) [20].

The authors have analysed in detail the applicability of qualitative and quantitative parameters as well as analytic and simulation measures. The results showed a limited applicability of the above mentioned measures because of some difficulties (lack of information about the form of function for system components reliability, lack of information about the real reliability structure of the system etc.) and insufficient consideration of failure consequences (concentration on the so called problem of "weak links"). As a solution, the authors have proposed and proved the applicability of a comprehensive qualitative and quantitative methodology of CTS components importance evaluation with regard to the criteria of exploitation safety, costs effectiveness and reliability and to do it used the AHP – Analytical Hierarchy Process [4, 26, 27, 28, 29, 30].

The research results and the data collected by the authors so far are extremely important for further research whose outcome will be an easy-to-apply methodology on importance analysis of CTS components taking into account available incomplete and uncertain data on the system structure and operation and making it possible to use quantitative data (failure statistical information, repair costs, accidents at work etc.) and qualitative data (expert methods: AHP, subjective probability). This research methodology will enable a system analysis to be made taking into consideration more importance criteria than have been taken so far and will contribute to the development of a method for selecting components which are important because of certain selected criteria.

2 Methodology

The system structure can be described as a relation between a cause (event $A \in X$) and an effect in the form of an unwanted event $B \in Y$ [8] and in this sense mutual relations between the events form a system structure. If event A is a cause (of e.g. a fault in the system with probability $\Pr(A) > 1$) and event B is an effect (of e.g. limited system operation), then conditional probability $\Pr(B|A)$ contains information about the redundancy in a given system. The system reservation can be expressed by a redundancy measure:

$$N = \frac{\Pr(A) - \Pr(B \mid A)}{\Pr(A)} \tag{1}$$

Measure (1) is within the interval [0,1], in extreme cases if *N=0* (event *A* always causes event *B*) then we deal with a lack of redundancy. In the case when *N=1* (event *A* has no influence on event *B*), the system shows full redundancy. There is a relation between measure $N \in [0,1]$ and more general measure $N_n \in (1, \infty)$ [3]:

$$N_n = \lim_{k \mapsto N} \left(\frac{1}{1-k} \right) = \frac{\Pr(A)}{\Pr(B \mid A)} \tag{2}$$

The overall importance evaluation should, because of the difficulties behind the quantification of criteria such as exploitation safety, consider qualitative and quantitative approaches i.e. when there is a lack of information on the relevance and importance measure values of given criteria e.g. exploitation safety, expert methods are proposed to be applied, including the ones which are based on subjective probability [16]. The formalism of determining the subjective probability distribution was proposed by DeGroot [16]. For a defined set of events *S* and σ-field of this set, for events *A* and *B* belonging to this σ-field, if the occurrence of event *A* is at least as probable as of event *B,* then every probability distribution *P* assigned to σ-field is in accordance with a weak possibility relation expressed as:

$$P(A) \le P(B) \Leftrightarrow A \sim \prec B \tag{3}$$

The determination of quantitative parameters describing components importance using expert methods is presented in [4] by means of AHP.

Using expert methods, such as subjective probability application, is one of the ways to collect information about the system. For research conducted so far showing importance analysis as its subject, simple theoretical systems with independent events and introduced elementary interactions with the environment have been used. The process of qualitative and quantitative analysis of CTS components importance is deeply described in [4]. According to this approach, as a result of the analysed technical system identification and modelling, we obtain its reliability structure representation (a model of the structure) and reliability models of system components which together create a system reliability model.

Preliminary components importance can thus be determined based on an unreliability function of a given component $F_i(t)$ and number of path-sets x_i that an *i*-th component is a member of. As *x* we define the total system path-sets number [4]:

$$I(t) = f[F_i(t), x_i, x] \tag{4}$$

Another step is to select quantitative importance measures in order to apply them to a system model as well as qualitative importance measures to apply them to a system structure model. Information about components reliability characteristics and failure consequences is completed by means of databases on reliability and expert knowledge [4, 18]. As a result of the analysis, selected importance measure estimators and a ranking of components importance are determined for every importance measure. On the basis of the results a conclusion is drawn about the analysed technical system construction and the effectiveness of the operational procedures in use.

The research results demonstrated in proved that accurate importance evaluation of components and groups of components in the CTS reliability structure is not possible when only quantitative or qualitative methods are used [19, 20]. The research

has been undertaken to develop the methods currently in use so that their application enables a more effective CTS components importance analysis to be made [4]. Moreover, it is significant to broaden the scope of the analysis and to analyse groups of components as well as their mutual interaction and its influence on the total consequences (seeking "disadvantageous coincidences"). It refers to the situation when as a result of the occurrence of two (or more) events (failures) *A* and *B*, the total severity (effect on the environment) is greater (negative coincidence) or much greater (catastrophic coincidence) than the sum of particular events effect:

$$S(A + B) > S(A) + S(B) \text{ or } S(A + B) >> S(A) + S(B) \tag{5}$$

For instance, the total effect of simultaneous failure of front and rear brake of a car will be much greater than the sum of their failure effects separately.

When there is a lack of information about components vulnerability and failure consequences, it is possible to obtain the missing data about the system operation from experts by means of a survey (Fig. 3). In this approach, the expert knowledge will be used to determine the relative relevance criteria for importance evaluation and to determine system components importance for the selected criteria. In the process of importance evaluation, the analyst is supposed to determine the analysis criteria and draw final conclusions from the components importance evaluation. Similar activities are planned to be used in an expert system to be developed under the following research.
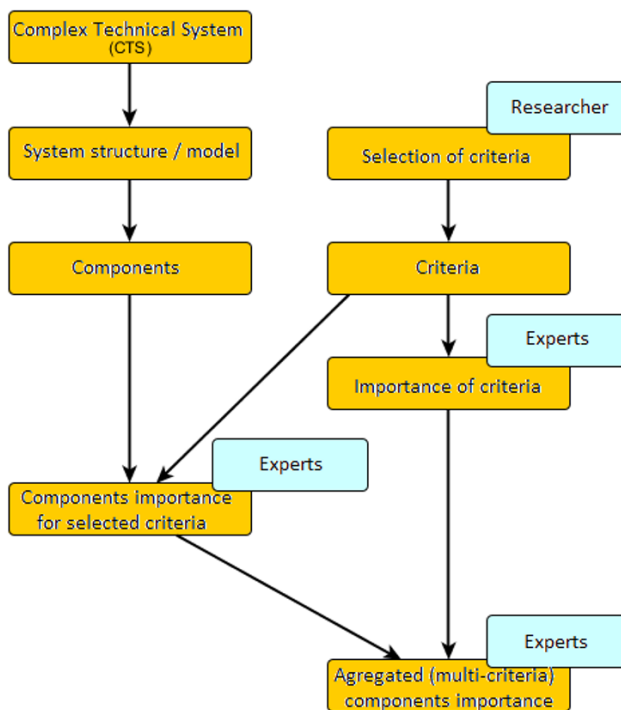
Fig. 3. Process of multicriteria components importance analysis with incomplete data about the system [4]

To determine the criteria relevance and components importance, the AHP method, developed in the 1970s by Thomas L. Saaty, will be used. The AHP is one of the multicriteria methods of hierarchical decision problem analysis [29]. It allows to decompose a complex decision problem and make a result ranking for the finite set of alternatives w_i according to selected importance criteria k_i. Fig. 4 shows an example hierarchical structure of a decision making process (according to AHP) for a problem of ordering five analysed alternatives in terms of six different criteria.
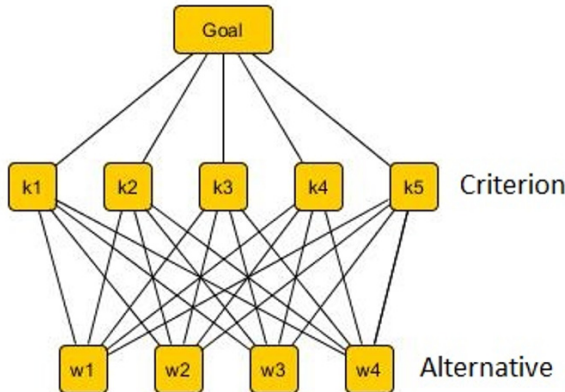
Fig. 4. Example hierarchical structure of a decision making process AHP [20]

The AHP method has been used in many areas such as: management, political science, transport, sociology or manufacturing engineering. It has also been used in the theory of decision making to select a given product from among a wide assortment according to selected criteria of product importance evaluation. As proposed in, the method may well be used to indicate the most important components E_i in a system, i.e. components belonging to many assortment groups. Such an attitude allows to indicate the most important components according to selected importance criteria k_i (Fig. 5).
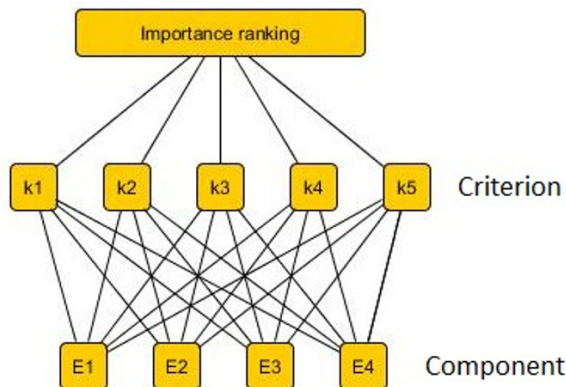
Fig. 5. Structure of evaluation process of system components importance based on AHP [4]

The AHP method can be applied in the components importance analysis for the system reliability structure by using it in two stages:

1. Determination of components importance criteria and their relations in terms of their ability to be quantified. This allows to build a multicriteria model of system components importance with calculated weight coefficients for the criteria of reliability, safety, repair costs of the component which failed and others.

2. Determination of mutual importance relation between system components according to all analysed criteria which allows to obtain the final importance ranking of system components.

After creating a hierarchical problem model by means of the AHP method and pairwise comparison, relative criteria (alternatives) relevance is determined as a level of their dominance relation. The range of the allowed dominance levels is between 1 and 9. The relative alternative relevance index - criterion k_i superiority over criterion k_j – is expressed by a_{ij} according to the formula:

$$a_{ij} = \frac{e_i}{e_j}, \quad i,j = 1,2...n \tag{6}$$

where: e_i – absolute criterion rank k_i,
         e_j – absolute criterion rank k_j,
         while $a_{ij} \in \{1,2...9\}$.

By means of grades aggregation in the model hierarchical structure, an aggregated values matrix is created and is the basis for the creation of a reduced grades matrix giving final grades determined for the main criteria, main alternatives and grading alternatives.

The fact that the AHP method gives a possibility to obtain importance measure values useful in practice and allowing to analyse the importance of CTS components and that the method is simple, it can be widely applied in dependability theory. Its particular advantage is the possibility it gives to quantify qualitative measures, such as the importance measures according to the criterion *safety* shown in the paper, which often are difficult to be described by means of numbers.

Using the AHP method requires to calculate the consistency ratio C_R every time which makes it possible to simultaneously evaluate the mutual relations matrix obtained on the basis of the expert opinions. When C_R is too high, obviously there are some conflicts in the analysed data which can be corrected at the very start. Owing to that, analyses carried out by means of other than the AHP methods, can be made on the basis of correct, reliable data.

In [4] an exemplification of methods has been provided by means of selected ship engine room subsystems. Importance rankings have been compared in terms of different measures and criteria.

3 Final conclusion

To evaluate the usefulness of the developed models of multicriteria importance analysis they can be implemented in an expert system supporting the system analysis (e.g. using mechanical characteristics of a system [21, 22, 23]). The system can support the work of experts and analysts operating complex technical systems. To develop the system in question, professional software supporting the multicriteria analysis will be used in research which is made by world-known companies such as: Isograph Software (Reliability Workbench, Isolib libraries), Sydvest Software (Fault Tree Analysis Academic Version) and Reliasoft Corporation (BlockSim, Weibull++, ALTA, xFMEA). Also the authors' own codes will be applied. Comparative analyses will be carried out by means of MS Excel. All the codes are in the possession of the auhor and so are the databases giving information about the structure and operation of marine power plants.

Methods and measures developed as a result of the following research will make importance analysis possible while there is a lack of full information about relations existing in analysed systems and about components dependability characteristics of CTS. What is more, the methods will enable to develop indicators useful in engine operation, including importance rankings of system components for different ranges of information about the analysed object, especially when:

- only basic functional elements of the system are known and there is a lack of information about the reliability structure;
- only the reliability structure of the system in known;
- dependability characteristics for selected components are known and relations between selected system components;
- system dependability structure is known and dependability characteristics for selected components.

So far the authors have done a group of activities necessary to achieve the goal of the research i.e.:

- identified factors justifying the need to modify the evaluation tools of components importance and groups of components in CTS;
- made an overview of well-known importance measures and structure models for CTS and (based on the published literature) critical analysis of other researchers' achievements in the topic area of components importance evaluation in CTS;
- standardised terminology in terms of components importance analysis and description of system reliability structure;
- collected statistical data about components failures in marine power plants systems;
- made an overview of selected, well-known in reliability theory modelling methods of reliability structure and reservation in CTS;
- developed qualitative and quantitative multicriteria methodology of CTS importance evaluation, the use of the AHP method included [20].

The future research is connected with a group of objectives to be achieved such as:

- applying in practice a modified reservation method developed in [3, 7, 8]; using methods proposed in [16] (subjective probability);
- developing an expanded approach to the evaluation of system components importance by means of qualitative and quantitative models;
- components importance evaluation for selected technical systems (exemplified by a marine power plant or shipyard systems) by means of the proposed methods [28, 30];
- building an expert system supporting the process of multicriteria analysis of CTS components importance, including the selection of methodology and measures to evaluate importance depending on the quantity of information [24, 25];
- evaluating the influence of the applied methodology and selected importance measures (qualitative and quantitative) on the obtained importance rankings of components and groups of components by a comparative analysis of these rankings [24, 26, 27];
- discussing the well-known and newly developed methods of components importance evaluation in system reliability structure with examples.

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Proactive Failure Prevention by Human-Machine Interface in Remote-Controlled Demolition Robots

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Abstract. The objective of the paper is to design an advanced Humane Machine Interface implemented in remote-controlled robot for demolition works. The paper includes the use of Design Thinking methodology in the conceptual design process for determined user-machine problems. The experimental testing with high-speed camera and vibrometer were performed to obtain the input data for numerical analysis. Then the finite element method simulations were carried out to provide the assumptions for HMI solution. Finally, a novel arm-mounted HMI status/caution/warning lighting was designed and executed in the robot controller. The system notifies the operator about the load capacity and warns the operator about leading the arm in resonant frequency, which is a main cause of the reported robot's arm fatigue failure.

Keywords: human-controlled machines, design thinking, demolition robot, HMI (human-machine interface), conceptual design, resonant frequency, Finite Element Method

1 Introduction

A demolition robot is a multi-functional, remote-controlled machine, which is designed to be operated in severe, work conditions such high temperature, dust, radiation or noise. It is widely used in demolition operations in concrete and metallurgy industries as well as transporting or handling the leakages of severe toxins or nuclear materials in emergency and rescuing works [1–4]. As complex as this kind of mechanical equipment, study on mechanical performance purely of individual part or component is not enough and it is necessary to research the dynamic performances of the basic machine. Taking demolition robot of a certain model as researching object, a 3D model is established with CAD/CAE i.e. Autodesk Inventor and NX Nastran.

The reconstruction and demolition of existing buildings are connected with the necessity of dismantling or demolition of a building element or parts of the structure. In these works, the most frequently used excavators are heavy machines with variable demolishing gear [5–7]. These works are considered as not workforce-demanding provided some heavy equipment may enter the place of demolition and range of work

does not lead to hazard for a machine operator. Progressively, thanks to the advanced technology used for demolition, there are some remotely-controlled robots [8–11]. Due to their small size, it is possible to demolition ceilings, and also difficult to reach places for large machines. Also the safety aspects of an operator (rollover, falling objects) are crucial – Fig 1.

Fig. 1. Demolition robot and its operator with a remote control during various works (courtesy of ARCAD Ltd [12]).

The radio-controlled demolition machines represent today's most advanced technology in this field. They provide a high level of safety and comfort while working through a completely remote and wireless control devices. The machine's operator can operate the robot outside its zone of influence, far from demolition site or crushed elements. In addition, through the use of electric power and the use of lightweight hydraulic hammers or jaw crushing, electric robots allow reducing noise and vibration [13–16].

Demolition robots, due to their small size and weight in the range of 1÷5 tons (depending on model), suite for limited space, where there are no heavy demolition equipment. However, the most important is that in narrowed areas where previously only men could work with hand tools, demolition achieve performance comparable with heavy equipment demolishing machines. Depending on needs, the robots can work with different demolishing hardware, including light hydraulic hammers, cutting heads or jaw crushing-cutting. Remote-controlled robots are designed for different types of demolition work in construction, but they are also effectively used in the cement industry and manufacturing.

However, unlike in cab-type machines, a remote-controlled machine does not transfer any force feedback to the operator. Therefore, an unbiased judgment concerning the work-load, forces or shock capabilities of a robot arm is a challenge. In addition, when the work conditions are dusty and noisy, a proper estimation about actual machine condition is hardly possible – even for an experienced operator. Basing on ARCAD Ltd reports, a company using various demolition robots, a wrong estimation about the conditions of the robot often leads robot's arm in its natural

frequency of vibration. It is reported, that working in the resonant frequency, even beyond the operator's awareness, has caused numbers of failure in the robot arm structure. The main problem occurring during operation of a demolition machine is fracture in second member of its arm system (Fig 2.). This construction defect excludes the machine from work and increases downtime and influences customer's opinion [17, 18].

Fig. 2. Fatigue failure on the robot arm due to works in resonant frequency during the demolition process.

2 Methodology – design process

Working machines as the demolition robot are the result of the technical engineering design process. Design process consists of main stages such as: Idea (input data – technical assumptions), Research, Conceptual Design, Concept Development (preliminary design, technical design), Prototyping, Documentation, that leads to Implementation. Apart of the stages of Idea and research, the conceptual design has become essential in the successful implementation of construction projects in industrial plants. Companies perceive that key decisions early in the design of conceptual engineering tasks faster and have a tremendous impact on the performance of the entire plant [19].

The most general definition of the design gives [20, 21], where the design is a process that leads to human activities, from the initial state (the problem to solve – the need to meet) to the final state, which is the desired result (system = an article, object, organization, process or computer program) that meets the established requirements.

It is also important at the conceptual design process to understand the problem and to define the requirements and restrictions [22]. This is crucial when we design with the interaction of the machine with the human. The assumptions to the design should

take into consideration not only the technical requirements of the client or the machine parameters, but also the requirements and standards of the main user – an operator. This sometimes is overlooked during the designing of the working machines.

The problem is not so significant when the operator is situated on the machine, because there is a strong connectivity between them as well as the interaction of the operator with the machine. The issue is where the machine is remotely controlled. As it was mention, the operator controls the machine by the remote controller but always from the distance. This reframes the operator's cognitive and sense perception during the operating process. Considering that during the designing of the machine, the interaction between the human (an operator) and the machine should be taken into consideration more preciously. One of the methodologies that focus more on the user – i.e. the operator – is Design Thinking.

Design Thinking methodology is a deeply human process, that taps into abilities we all have but get disregarded by more conventional problem-solving practices. The design thinking methodology consists of five stages presented in Fig. 3.
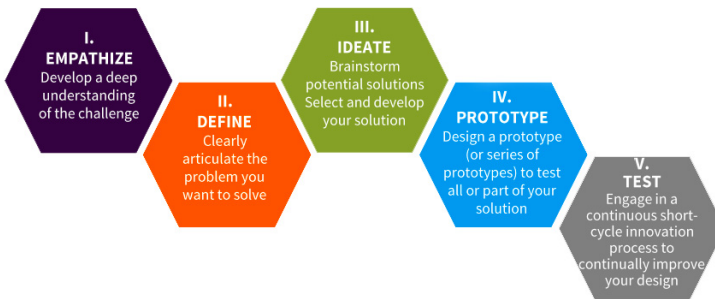
Fig. 3. Design Thinking process [23, 24].

The first stage of Design Thinking, Empathize is a deep understanding of user needs and problems. The key is to identify the hidden and intuitive factors that influence human choices and behavior. Subsequent there is Define, at this stage, the information gathered during the Empathy, should be summarize to define what the right problem is. This stage requires breaking the framework of thought and habits that restrict the field of vision.

In the next stage, which is Ideate, the activities should be focused on generating as many possible solutions to the problem defined. This requires not only the merits of a strong, but also above all the courage in the creation of new, unconventional solutions and containment evaluation and critique the ideas of other team members. Stage should be completed with the assessment and the democratic choice of the best idea based on which the prototype is created. The basic tool in this stage is a process of brainstorming.

In the next stage of Prototype, the physical prototype is formed, but its structure does not rely on the formation of complex models with characteristics similar to the final product. The main purpose of prototyping is the ability to present visually the idea of users and rapid feedback on solutions. At the next stage of Test, the selected solution is tested in the real environment. It is important first of all to define the parameters necessary to meet in order to clearly determine the outcome of the test.

Applying the Design Thinking into the conceptual design process of the demolition robot allows determining the crucial user-machine interaction problems, such as:

- user positioned apart of the machine structure,
- lack of the structure condition felt by user,
- there is no machine force feedback,
- user focuses on the working place not at the machine,
- user in the safety area (allows a user to go with the machine to maximum load),
- a machine is treated as a remote controlled toy.

In order to prove, that the operator during the operating process cannot see the high frequency vibrations, that are dangerous for the structure of the working arm, the experimental testing and finite element method calculations were performed.

3   Experimental testing

The motivation to carry out the research and implement the HMI into an existing demolition robot owned by ARCAD Ltd was frequent cracking of a machine arm. It must be notice this paper is not focused on the construction enhancement. Hitherto, it is to introduce a system which enables an operator to be notify about the load capacity of the machine and potential conditions which may lead to machine failure such as arm fatigue crack, extensive engine or whole structure vibrations [16, 25].

Speed selected points of the arm were examined by optical method using a high-speed camera Phantom V12 (Fig. 4). Modal analysis was performed using the vibrometer Commtest VB7. The results of the high-speed camera were analyzed by TEMA Motion, which allowed for the generation of waveforms displacement, velocity and acceleration points located on the arm during operation (Fig. 5-6).

Fig. 4. Tracked points in TEMA Motion photogrammetric software – footage recorded by high-speed camera Phantom (left) and standard camera (right).
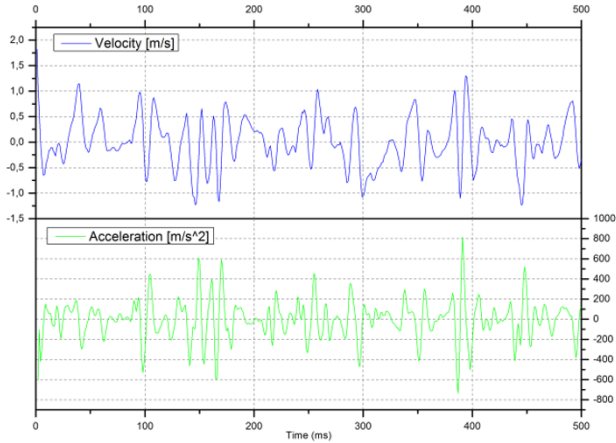
Fig. 5. Average velocity and acceleration runs for marker points (#1 and #2) during a 500ms interval.
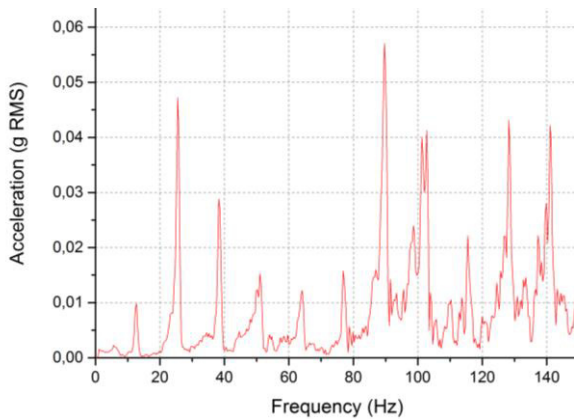
Fig. 6. Frequency amplitude spectrum from the recorded accelerometer attached to the robot arm.

The obtained data were used to determine the extortion system used in the study while numerical modal analysis [14]. The results obtained by numerical simulation were compared with those of the arm during the operation acquired from measurements made using the vibrometer.

4   Numerical simulations

The data obtained from experimental testing with high-speed camera were used for appliance of real life boundary conditions to the numerical model. Based on this data dynamic extortion acting on the working arm was applied. The analysis of numerical

model was carried out in NX Nastran. Basing on 3D CAD model of demolition robot a computational model was further constructed. First stage of creating discretized model was to create geometrical model of the arm system. Members of arm systems used for construction machines, therein demolition machines, are thin body elements so therefore authors decided to create thin shell model [26, 27]. Connections between parts of the model were simulated by 1D connections. The hydraulic pistons were exchanged for stiff rods and tubes to reduce computational time. In order to simulate hydraulic breaker SB145 the authors decided to replace it with 0D point mass element weighing 145kg. The mechanism connection is processed with node coupling manner so that a finite element model of the basic machine is set up. The model is solved with Lanczos method and then natural vibratory frequencies and modal vibratory models are obtained, which lays a basis for further dynamic analysis.

The biggest stress resulting from vibrations of the model are obtained for frequency of 89Hz. The maximum value of Huber-Mises-Hencky (H-M-H) stress in this case about 20MPa (Fig. 7).
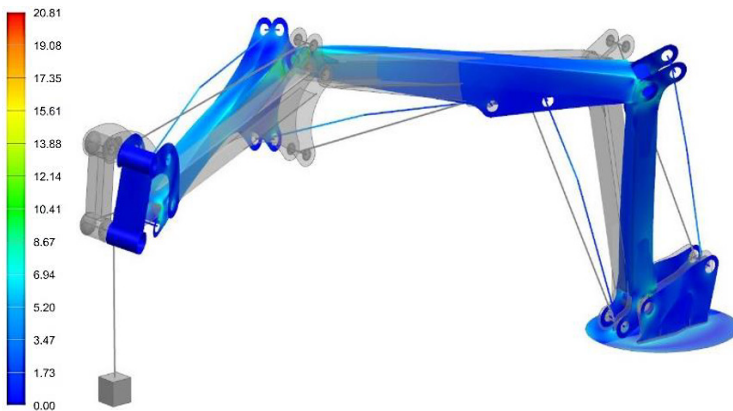
Fig. 7. H-M-H stress map [MPa] of the robot arm for the frequency of 89Hz.

Higher stresses can also be found on the top shelf of the second arm member of the arm system. Maximum H-M-H stress acting on arm members is 20MPa. The stress does not exceed maximum yield strength of the material. However, it has to be noted that impact nature of hydraulic breakers work causes fatigue fracture of steel elements of arm members as it was already mentioned.

5   Solution

Conducting the design process with use of Design Thinking methodology enabled the authors to specify the crucial user problems. Additionally, the combination of performed experimental testing and finite element method analysis provided the information about the unfavorable effort and frequency states of the machine in the operation process. The information gathered during the Design Thinking stage, was summarize to define what was the right problem. This stage provides the breaking the framework of thought and habits that restrict the field of vision. These activities should

lead in the creation of new, unconventional solutions that identifies the hidden and intuitive factors that influence human choices and behavior, of the machine operator.

The possible solution received from the Design Thinking methodology is the HMI application as the status/caution/warning visual system, which allows the operator to identify constantly the effort and frequency state of the machine (Fig. 8).
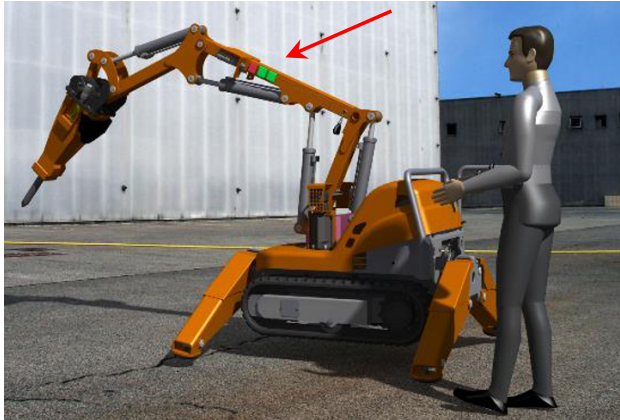
Fig. 8. Robot arm equipment with HMI lighting system (the arrow indicates) showing the work effort and overloading conditions

The robot operator is constantly informed about the load capacity and any hazardous state which may lead the arm to work in resonant frequency. This is executed by a compact strain gauge and 3-axis acidometer hermetically fixed on the inner section of the arm and wired-connected CPU next to the control panel.

The robot is featured with the arm-mounted HMI status/caution/warning lights and an LCD display on the remote panel and an optional audible alarm. The advanced warning is given when 90% load capacity is reached. At >99% of the load or working in resonant frequency there is an audible alarm, manipulator vibration (force feedback) and all red lighting start blinking to notify the operator (Fig.9). The LCD on operator's manipulator also shows load percentage and load status light similar to these on the arm.

			0-89% load
			90-95% load
			96-99% load
			>99% load or resonant frequency
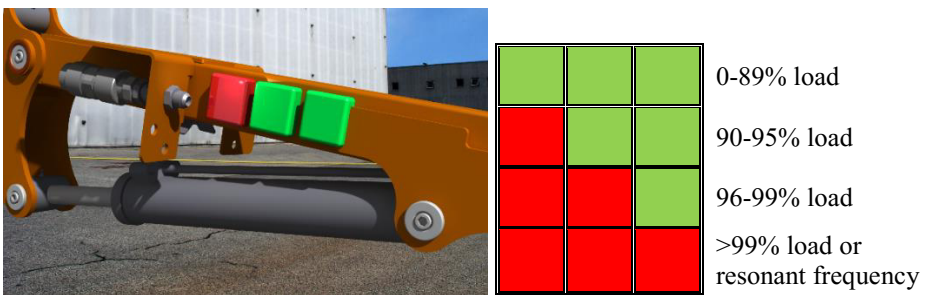
Fig. 9. Focus on the HMI lighting on the robot arm (left) and the established lighting code (right) for the work effort of the arm.

6   Conclusions

Unlike in cab-type machines, a remote-controlled machine does not transfer any force feedback to the operator. Therefore, an objective judgment concerning the workload, forces or operating frequencies of a robot arm is a challenge even for experienced operators. To determine the warning stages of the operating conditions of the demolition robot the experimental testing, such as high-speed camera recording and vibrometer measurement were conducted. The presented demolition robot is a multi-functional, remote-controlled machine using HMI, which is designed to be operated in severe work conditions.

Conceptual design process of the working machine as the demolition robot focuses mainly on the first stage of the designing of a concept in the verification of the design assumptions and regulations. The design thinking methodology, that was used, provides a set of common values that drive innovation: these values are mainly creativity, ambidextrous thinking, teamwork, focus on the end user curiosity. This activity allows better understanding of the problem that concerns the final customer.

The use of advanced numerical simulations to estimate the dangerous states of the structure of the machine, at the designing stage enables to elaborate the HMI warning control system of the machine operation. It is possible to apply at the simulation any possible varieties of boundary conditions to the machine, which allows estimating the behavior of any element of the machine. The results provide the information that is an input data to the designed status/caution/warning visual system.

Combination of different methodologies, such as Design Thinking, numerical simulations and experimental testing allowed the authors to more preciously determine the designing requirements and assumptions. That will definitely result in innovative and unconventional solutions that identify the hidden and intuitive need of the user – the robot operator.

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Gamota-Filisko model for Vacuum Packed Particles

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Abstract. In this paper authors would like to introduce a new controllable structure, in some aspects similar to MR fluids, which is composed on the basis of granular material. Loose material is initially placed in a deformable hermetic encapsulation (basically made of soft polymer), equipped in a special valve. In the next step, an internal pressure is pumped out of the structure and so called "underpressure" is generated.

Keywords: Vacuum Packed Particles, modeling, jamming, experiments

1   Introduction

At the present time more and more scientific works are dedicated to developing of modern materials and structures, which allow for controlling their global physical properties according to existing, unpredictable operational conditions.

Traditional meaning of a term "mechanics of materials", often encountered in engineering language as a strength of materials, now is changing. The fundamental objective of this scientific field, which is providing an endurance of selected parts of a whole construction or device, is more often achieved by applying the new group of materials, so called "intelligent materials" or also described as "smart structures".

In this paper the authors would like to present a new controllable material, in some aspects similar to MR fluids, which is composed on the basis of loose grains. Granular material is initially placed in a deformable hermetic encapsulation (basically made of soft polymer), equipped in a special valve. In the next step, an internal pressure is pumped out of the structure and so called "underpressure" is generated. This change in the structure, called as a jamming mechanism" appears as a considerable increase in the apparent stiffness. Vacuum Packed Particles (VPP), when a high underpressure value is applied, seem to reveal typical properties of solid (semisolid) state. The magnitude of this change is fully controlled by the range of generated internal underpressure.

A phenomenological model, developed for description of MR fluids nonlinear behavior, that is numerically tractable and additionally efficiently represents the behavior of a VPP testing specimen is considered.

VPPs are in some aspects granular analogs of ER and MR fluids [1]. Loose grains can be compared to polarizable particles. Internal pressure is an equivalent of a carrier liquid. The impact of an electric or magnetic field is replaced by underpressure. Pumping out an air from the granular systems results in increasing "inter-granular" frictional forces acting between single grains. Also some grains displacements are observable for greater underpressure values. Described phenomenon is comparable to application of an electric or magnetic field to ER, MR fluids resulting in chains forming [7, 11].

2   EXPERIMENTS

Uniaxial cyclic loading tests on granular structures placed in a tight space with underpressure have been conducted basing on the cylindrical sample, filled with four different types of granular materials (polypropylene, polystyrene, polymethacrylate, ABS). The scheme and dimensions of a testing specimen are depicted in Fig. 1.
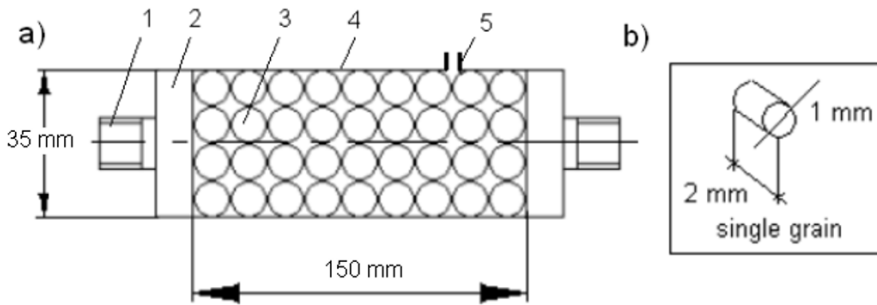
Fig. 1. a) Structural scheme of a testing specimen; 1-handles, 2-steel discs, 3-loose grains, 4-plastomer encapsulation, 5-vacuum valve.

In all cases the shape and dimensions of a single grain were the same (cylindrical; diameter 1 mm, length 1 mm). The range of applied underpressures was from 0.01 to 0.09 MPa.

To take full advantage of the unusual features of the VPPs in engineering applications, a suitable model has to be developed that can accurately imitate the behavior of a testing sample. The experimental stand was prepared for purpose of obtaining the VPP's response data fundamental for the identification process. In this setup, the MTS 809 universal tensile testing machine was employed to drive a specimen. The vacuum pump, made by AGA Labor, was used to control the internal underpressure value. The whole measurement apparatus is illustrated in Fig. 2.

Using this experimental setup, different types of dynamic responses can be measured and recorded for a wide range of prescribed displacement wave forms.
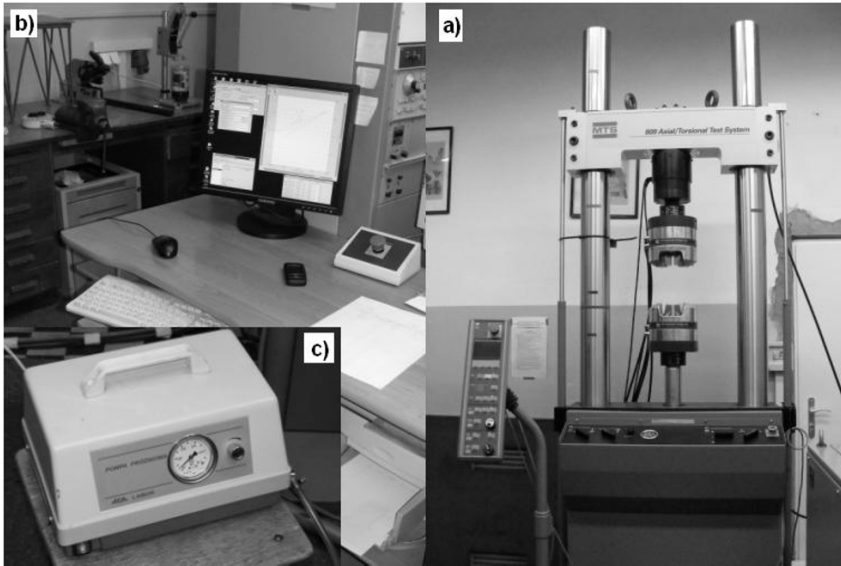
Fig. 2. Experimental stand: a) MTS 809 tensile testing machine; b) data acquisition system; c) vacuum pump AGA Labor

In this paper only triangle excitation rule was taken into consideration. Firstly, the sample was subjected to initial compression displacement x_0=8 mm. In the next stage, the proper value of internal underpressure was generated. Afterwards, the sample was mounted into the handles of universal testing machine and a kinematic excitation rule was applied. This stage is illustrated in Fig. 3.
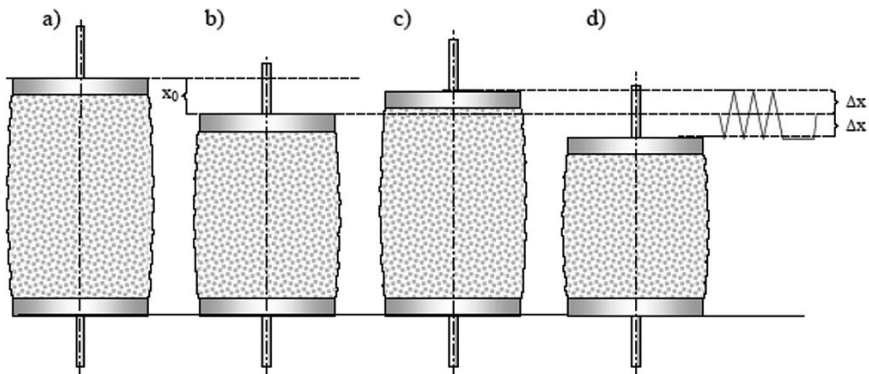
Fig. 3. Process of a sample displacement a) free sample; b) initial displacement; c, d) sample subjected to triangular excitation rule $\Delta x = \pm 7$ mm.

In this paper only results for specimens filled with polypropylene grains and various underpressure values (0.02; 0.04; 0.06; 0.08 MPa) are taken into consideration. Although the response of VPP on applied excitation strongly depends on strain rate,

the impact of this factor on mechanical characteristics is omitted. This problem is discussed in details in [10].

The response of the VPP sample do to 0.5 Hz trapezoid excitation with an amplitude of 7 mm and various underpressure levels is shown in Fig. 4.
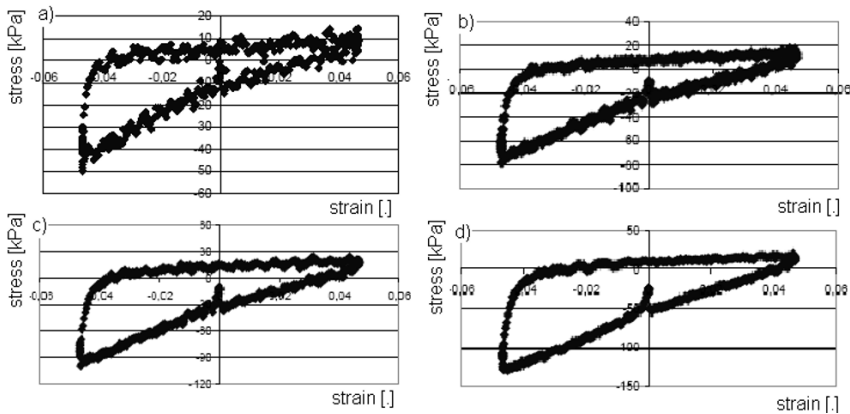
Fig. 4. Stress- Strain loops for polypropylene grains and a) 0.02 MPa, b) 0.04 MPa, c) 0.06 MPa, d) 0.08 MPa.

It is worth mentioning that the underpressure parameter is a very convenient factor changing considerably damping characteristics. In all cases depicted in Fig. 3, the cyclic loading loops have a kidney-like shape. It is strictly related to the non-symmetrical behavior of VPPs. Elongated samples behave totally different than compressed.

Basing on the data depicted in Fig. 4 it can be noticed that for compression of the testing specimen under underpressure p=0.02 MPa by Δx=-7 mm almost three times less force is required that for underpressure p=0.08 MPa.

3   Model

Former works of authors [11, 12, 13] were focused on modeling and experimental research of other, more commercialized, smart structures which are MR fluids. In some aspects, VPP are similar to mentioned fluids. Similarities and dissimilarities of both intelligent materials were discussed in [7].

In this paper to describe a nonlinear, non-symmetrical behavior of VPP, a modified Gamota-Filisko model was used [2, 4, 5]. This rheological model was firstly established for description of controllable electrorheological fluids (ER fluids). Than it was adopted to currently more popular magnetorheological (MR) materials. Having in mind some similarities between intelligent fluids and VPP, authors assumed, that

the Gamota-Filisko rheological model is a suitable tool for description the response of VPP on applied kinematical excitation.

The mechanical scheme of Gamota-Filisko model is depicted in Fig. 5.
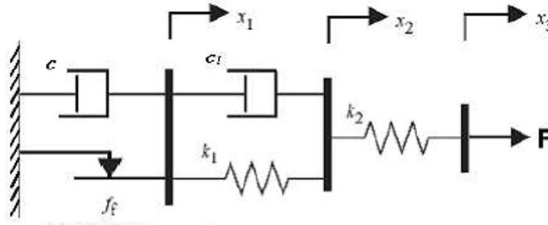
Fig. 5. Mechanical scheme of Gamota-Filisko model.

The model consists of the Bingham model (i.e., a frictional element in parallel with a dashpot) in series with a standard model of a linear solid [6, 9]. The governing equations for this model are given by

$$F = k_1 \cdot (x_2 - x_1) + c_1(\dot{x}_2 - \dot{x}_1) = c \cdot \dot{x}_1 + f_f \cdot \mathrm{sgn}(\dot{x}_1) = k_2(x_3 - x_2), \qquad |F| > f_f \qquad (1)$$

$$F = k_1 \cdot (x_2 - x_1) + c_1 \cdot \dot{x}_2 = k_2(x_3 - x_2), \qquad |F| \le f_f \qquad (2)$$

where c is the damping coefficient connected with the Bingham model and k1, k2 and c1 are associated with linear solid material. It is worth mentioning, that for $|F| \le f_f, \dot{x}_1 = 0$.

The Gamota-Filisko model given by (1, 2) is developed for description of symmetrical cyclic loading loops, typical for MR and ER fluids [4]. As it was observed in Fig. 3, typical experimental data acquired for VPP is strongly non-symmetrical.

In this paper the authors proposed some modifications in the G-F model to introduce the non-symmetric response of the tested specimen. Initially proposed parameters: c, c_1, k, k_1 and f_f have been changed into c_t, c_{1t}, k_{1t}, k_{2t}, f_{ft} and c_c, c_{1c}, k_{1c}, k_{2c}, f_{fc} . Lower indexes "t" and "c" are related to traction and compression responses of VPP respectively.

The modified Gamota-Filisko model for VPP is given by

$$F = k_{1t} \cdot (x_{2t} - x_{1t}) + c_{1t}(\dot{x}_{2t} - \dot{x}_{1t}) = c_t \cdot \dot{x}_{1t} + f_{ft} \cdot \mathrm{sgn}(\dot{x}_{1t}) = k_{2t}(x_{3t} - x_{2t}), \; F > f_{ft}, \qquad (3)$$

$$F = k_{1t} \cdot (x_{2t} - x_{1t}) + c_{1t} \cdot \dot{x}_{2t} = k_{2t}(x_{3t} - x_{2t}) , \; F \in \langle 0, f_{ft} \rangle \qquad (4)$$

$$F = k_{1c} \cdot (x_{2c} - x_{1c}) + c_{1c}(\dot{x}_{2c} - \dot{x}_{1c}) = c_c \cdot \dot{x}_{1c} + f_{fc} \cdot \mathrm{sgn}(\dot{x}_{1c}) = k_{2c}(x_{3c} - x_{2c}), \qquad (5)$$
$$F \le -f_{fc},$$

$$F = k_{1t} \cdot (x_{2c} - x_{1c}) + c_{1c} \cdot \dot{x}_{2c} = k_{2c}(x_{3c} - x_{2c}), \ F \in \left(- f_{fc}, 0\right) \qquad (6)$$

A schematic of this model is depicted in Fig. 6.
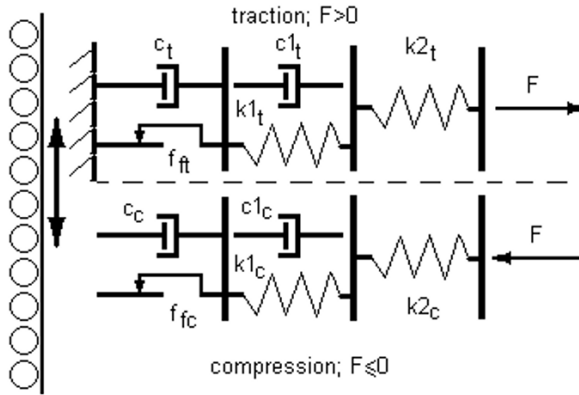
Fig. 6. Modified Gamota-Filisko model.

Parameters for the modified Gamota-Filisko model were determined to fit the 0.5 Hz kinematic excitation. Numerical results for considered values of applied underpressures are depicted in Fig. 7. Only stabilized cycles are taken into considerations. Numerical data correspond to the direct experimental results presented in Fig. 4.
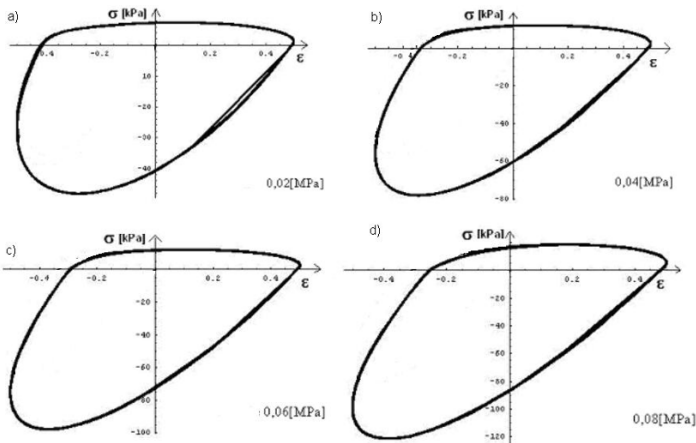
Fig. 7. Numerical stress-strain loops for polypropylene grains and a) 0.02 MPa, b) 0.04 MPa, c) 0.06 MPa, d) 0.08 MPa.

4   Conclusions

This paper presents a new type of controllable materials. Vacuum Packed Particles in some technical applications (damping of vibrations [14, 15, 16], noise reduction screens, impact loading dampers [8], composites [17, 18], or robots control [19, 20, 21]) can compete with well commercialized devices working on the basis of MR or ER fluids. The biggest advantage of VPP over the previously mentioned smart fluids is their price. From the economic point of view, easily accessible granular materials are much more attractive than MR or ER fluids.

The phenomenological behavior of VPP is more complex than intelligent fluids. Experimentally acquired cyclic loading loops for VPP are non-symmetric, which makes commonly used rheological models inadequate.

Modified Gamota-Filisko model has been used for description of the VPP behavior. Discussed model can portray the stress-strain behavior of the VPP quite well.

The biggest disadvantage of the numerical model is its stiffness. It makes Equations (3-6) very difficult to deal with numerically. This feature was also observed in [3] or [4].

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Designing process of the drone's passive safety system

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Abstract. In this paper the authors would like to introduce a new air-bag's prototype suitable for protecting valuable objects mounted on the drones. The experimental research results are presented for typical air-bag's textile material. Laboratory tests were a base for the material's model calibration process. The numerical simulations for proposed air-bag's prototype were carried out in the LS-Dyna environment. Proposed solution seems to be a reasonable device for prevent the drone's equipment from unexpected accidents.

Keywords: Air-bag, drone, modeling, experiments, LS-Dyna, air-bag prototype

1   Introduction

Drones are becoming more and more popular in army as well as in the industry. Such unmanned objects are very often equipped with advanced and expensive hi-tech devices or even weapons. The main objective of this paper is to propose the design concept of a special air-bag for valuable devices being carried by drones. This paper includes the experimental part aimed at obtaining the real response of the typical air-bag textile material. Basing on the experimental data, in the next stage, the FEM nonlinear model is validated. Having the reliable numerical model of the air-bag's material, the concept of the air-bag module mounted onto a typical unmanned aerial vehicle is presented.

2   Experimental tests and model calibration

2.1   Test

The objective of the experimental research was to obtain the data for numerical model using Finite Element Method. Because of orthotropic properties of the air-bag's textile material, two kinds of samples were prepared [4]. According to standards described in the literature devoted to experimental research of textile composites [6, 12], the first investigated sample (sample 0/90) was prepared for simple uniaxial tensile test, the second one (sample (45/-45) was tested by bias-extension test [7]. The 0/90 and (45/-

45) descriptions correspond to the directions of the fibers in the investigated air-bag's samples. Schemes of the testing specimens have been depicted in fig. 1 a,b.

a)   b)
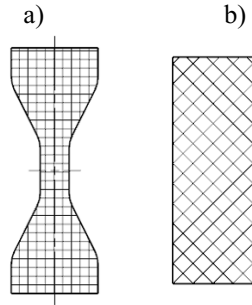
Fig. 1. Air-bag's material testing specimens: a) sample (0/90), b) sample (45/-45)

Samples were investigated using universal tensile testing machine (fig. 2). The strain in material was measured by 3D non-contact deformation measuring system – ARAMIS (fig. 3) [9]. Such system is a powerful tool for both statically and dynamically loaded objects [10] and seems to be the unique solution delivering complete 3D surfaces, displacement and strain results where a large number of traditional measuring devices are required (strain gauges, LVDTs extensometers, etc.)

Fig. 2. Testing machine
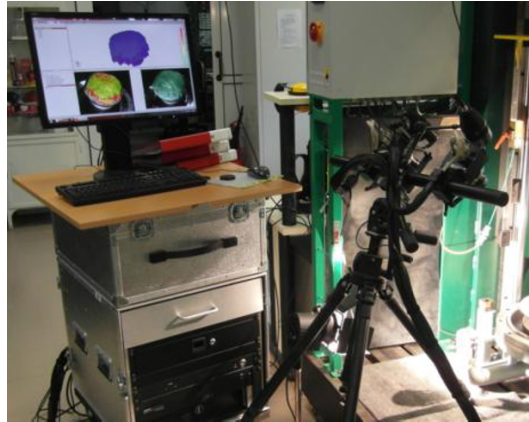
Fig. 3. ARAMIS system

During the test, the force was measured by testing machine sensors. The graphs showing force in function of strain F=f(ε) are depicted in figs. 4 and 5. The averaged and transformed to 2'nd Piola-Kirchoff stress versus Green-Lagrange strain characteristics were implemented to FE model prepared in LS-DYNA environment.
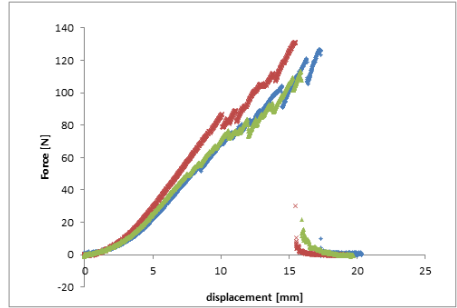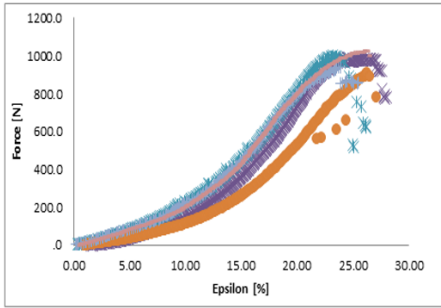
Fig. 4. Typical uniaxial results for (0/90) sample

Fig. 5. Exemplary results for (45/-45) sample

ARAMIS system takes a set of photos during a test and as a result the displacement and strain are calculated. Fig. 6 depicts the sequence of photos including strain fields recorded during a single uniaxial experiment.
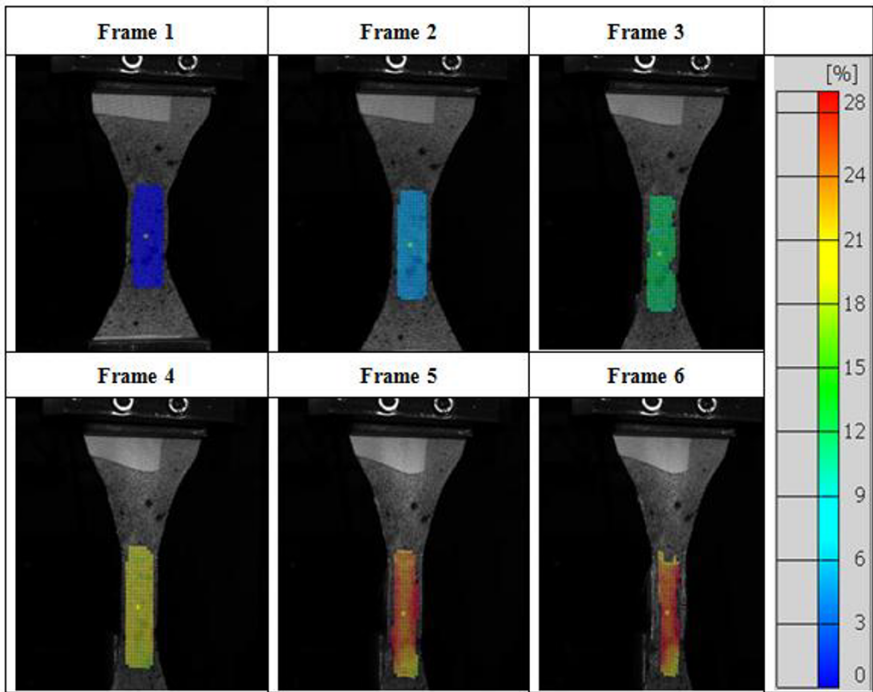
Fig. 6. Photos recorded by the ARAMIS system's

2.2   Validation process of FE model.

In the second step the FE model of the material sample was prepared to perform a validation process. Calibration process of the non-classical, multi-parameter and nonlinear materials' models is quite a complex task [18]. To recognize an original response of the tested material on applied loading a lot of complex laboratory tests have to be carried out [1]. On the basis of obtained results, in the next step the mathematical formulation is proposed to capture extraordinary features of the investigated structure [16]. In the final stage the classical inverse problem consisting of the selected materials' model identification has to be solved [19]. Investigated in this paper air-bag's material is a typical example of the non-classical structure. In the literature we can encounter many papers related to the modeling problems of such class of materials [5, 11]. In this paper the direct experimental characteristics (figs. 4 and 5) were implemented to the LS-Dyna environment, where all further numerical simulations were conducted [3, 15]. Considered model had the same dimensions as tested samples. Also the boundary conditions were applied according to the experiment (fig. 7). Material data used in the model as it was previously mentioned were taken directly from the tests. In the final stage the direct experimental results were compared to the numerical response of the material. The verification process is illustrated in fig. 8.
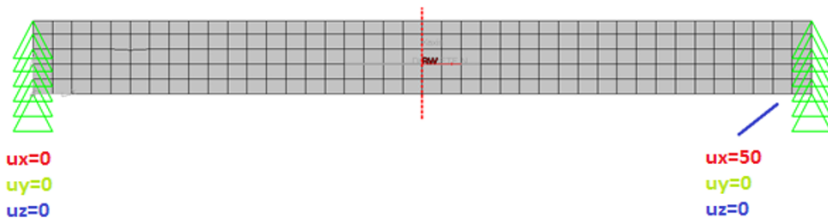
Fig. 7. FE model of the material sample
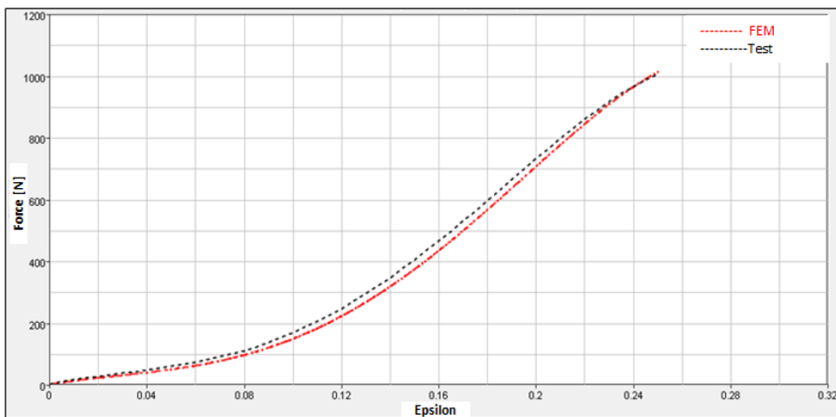
Fig. 8. Results of simulation and test

3   The drone's air-bag concept

To save humans or valuable objects from harmful vibrations or impact loadings [13, 14] very often sophisticated smart materials are used [8, 17]. In this paper the innovative air-bag concept is proposed to protect valuable camera mounted on the drone.

   After the air-bag's material identification process the design process of original protecting device was started. The requested air-bag was intended to secure the expensive thermal imaging camera mounted on a flying object in the case of accident.

   It was assumed that the flying platform breaks down and starts to falling down at the altitude of 2.5 meters. Two crash scenarios were assumed: perpendicular to the ground surface and at 30-degree angle to the ground. It was assumed that the construction of the drone can be destroyed but the camera must be protected and remain undamaged. The producer of the equipment claims that the camera is able to transfer an acceleration equals to 30g provided that the duration of the load will be no longer that 35 ms.

3.1   FE model

It was necessary to develop the FE model of the drone. The FE model was prepared in the HyperMesh preprocessor. The model consisted of 2D shell elements as well as 3D solids. An average elements' size was 4 mm. Construction was built of plastic as well as a metal parts. The material distribution in the construction is precisely described in Fig. 9. The thermal imaging camera was modeled in a conventional way as a rigid body.
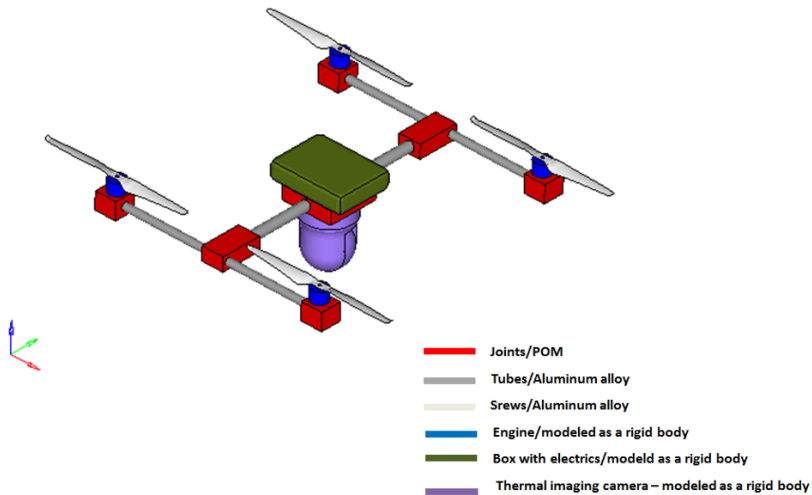
Fig. 9. FE model of the investigated unmanned aerial vehicle

Before calculation process was started a preliminary air-bag concept was essential. Due to the shape of the gyroplane and the fact that camera has to have a wide range of visibility, the air-bag prototype had to consist of two parts. It was necessary to fulfill all design assumptions. In the real construction two airbag parts could be connected, after launching, by Velcro fastenings. In FEM it was modeled by a special contact type. Parameters of the maximum force of the typical Velcro was based on the literature. The parameters of the air-bag's material were taken from experiments described at the beginning of this paper.

3.2   Numerical calculations – FEM

After completion of the model, the calculation process was started. To obtain an appropriate characteristic of the air-bag it was necessary to perform a lot of iteration loops. The most important parameter was an acceleration of the camera. An effort of the structure as well as air-bag's material behavior were analyzed. Because of the orthotropic properties of the air-bag's material, instead of the Huber-von Mises, the Hill Yield Criterium, was used in the evaluation process. Fig. 10 shows the behavior of the air-bag in the first crash scenario. Fig. 11 depicts the contour of the equivalent plastic strain of the drone's structure. The air-bag's stress contour is presented in fig. 12. As the final result the calculated acceleration of the camera is shown (figs. 13, 14).
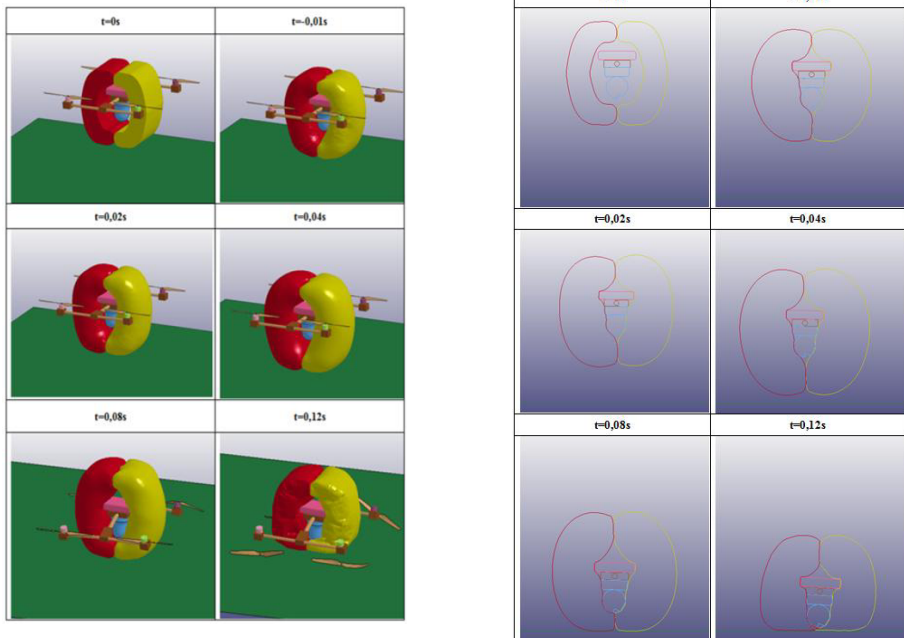
Fig. 10. Air-bag's behavior during the crash
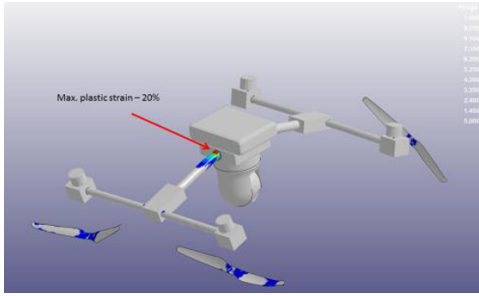
Fig. 11. Plastic strain
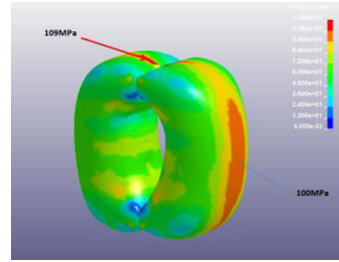
Fig. 12. Stress contour
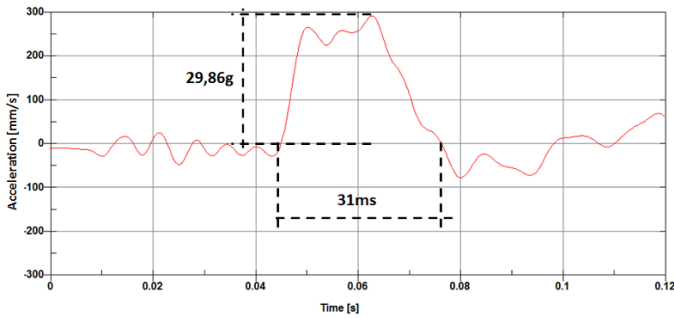
Fig. 13. Acceleration of the camera in the first crash scenario (perpendicular to the ground)
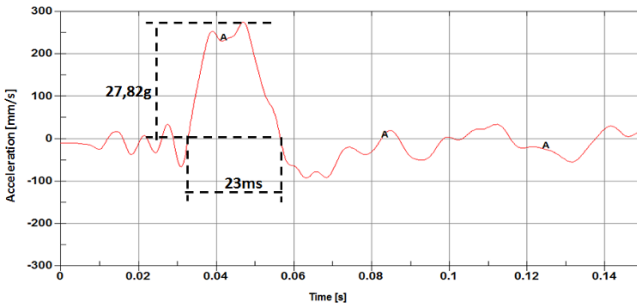
Fig. 14. Acceleration of the camera in the second crash scenario (30-degree angle to the ground)

Data depicted in figs. 13 and 14 revealed, that the calculated acceleration values do not exceed the assumed by the camera's manufacturer operational limits. In the author's opinion it proves that the proposed solution is realiable.

4   Conclusions

Conducted simulations revealed a technical capability of the proposed drone's air-bag project. All design assumptions were fulfilled. The project was developed basing on the models verified with the experiments, what exactly fits in the contemporary way of the design.

Proposed in this paper models of the drone and air-bag were in some way simplified. Real dynamics of such complex rotating systems is very complicated [23, 24]. Consequently, the real behavior of investigated system could be much more problematical. Contemporary control interfaces are aided by remote control methods e.g. [20-22].

To confirm the correctness of the proposed approach to the discussed problem more complex numerical simulations are required. In the final stage, the experimental research, carried out on the real object, is necessary to verify the proposed numerical approach and real composite material strength [25, 26].

5   Bibliography

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Machining interface and adapter for industrial robots

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Abstract. Comparing with existing market solutions the low budget solution for milling robots is presented in this work. For robot milling purposes the milling adapter was designed, modelled and manufactured. Some exemplary low cost conceptions of fixing adapter for milling ends were shown. Milling robots can be used for obtaining specific demanded structure by means of carving away material from any type of pattern. Unquestionable advantage of milling robots is easy integration with any type of manufacturing process and strong possibility of automation. Using a different robot made or a manufacturer's brand it is possible to obtain solutions providing high speeds, high level of automation, easy operation and maximum reliability together with increased performance and productivity.

Keywords: industrial robots, milling by means of robot, machining, interface, adapter

1 Introduction

Constantly increasing level of industrialization, the growth requirements of product quality and lower prices while maintaining the quality and competitiveness of the impact on manufacturers who increasingly are inclined to introduce robotic production systems. Machining by means of industrial robots can ensure better performance (e.g. increased rate of feed, automatic adjustment, flexible work conditions) than in the conventional machining method. It is possible to obtain significant decrement in cutting force in milling by means of robot in comparison with a conventional miller [19]. The major problem of milling by means of industrial robots is its accuracy, however it can be significantly increased by using a feedback loop between robot deformation and actual milling parameters. The main reasons for the accuracy problems are connected with insufficient robot stiffness.

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In [19] the direct end milling method using an articulated robot in the machining of aluminum building materials was presented. A small diameter of end mill (3mm) and a high-speed spindle were assumed to reduce the cutting force in order to reduce the effect of the low stiffness of the considered robot.

At present the remote control and media sharing of various home devices are popular standards and nothing special for home users. It is most common using these devices in the same local network [20]. In recent years this trend moved from home applications to industrial implementations. Some of those implementations are connected with industrial robots. Instrumentation of industrial robots is composed of various types of sensors for tracking information about any changes in the workspace. Manufacturers of robots are still looking more and sophisticated solutions searching the answer for increasing level of complexity of such a type systems. The manufacturers offer additional modules to increase its functionality but the costs offered by them are many times higher than the costs of their existing equivalents [26].

In practical industrial uses, there are the online and offline programming. In the online programming, the teach pendant is used to manually move the wrist or joints to the intended position and orientation at each stage of the robot task. Appropriate positions and orientations are sent to the robot control system and a robot programme is then written. [4, 6, 16, 26].

In SMEs a very popular technological solution is an automated flexible production cell. The main weakness of such a type cell is the complexity of maintaining. In the paper [5] authors provide a comprehensive review of the recent research progresses on the programming methods for industrial robots, including online programming, offline programming, and programming using Augmented Reality (AR).

Today many scientific research are focused on multi robot control, safe control, force control, 3D vision, remote robot supervision and wireless communication [26]. Brogardh in his work [4] discuss and present the technical challenges that the robot manufacturers meet. He claims that model-based control is now a key technology for the control of industrial robots and models. A very interesting idea of remote service of robots was described by Osch, Bera and others in [15]. Many theoretical and experimental studies concerning different control models can be applied in human-machine interface, some of them will be considered in future works e.g. [9, 11–13, 17, 23–25, 30–35]. Milling robots can be used for obtaining specific demanded structure by means of carving away material from any type of pattern. Unquestionable advantage of milling robots is easy integration with any type of manufacturing process and strong possibility of automation. Using a different robot made or a manufacturer's brand it is possible to obtain solutions providing high speeds, high level of automation, easy operation and maximum reliability together with increased performance and productivity.

2 Research stand

The aim of the paper is to present the idea and low cost implementation of the milling by means of industrial robots.

In Fig. 1 the simplified programming structure for industrial robots is shown.
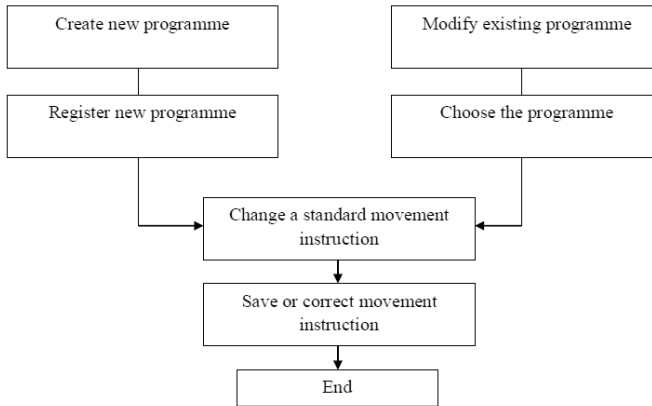
Fig. 1. Exemplary simplified programming structure for milling robots

Inside the control system of the FMS (flexible manufacturing system) communication protocols (OPC, MPI, Profibus, TCP/IP, WAP) were combined. Profibus DP (Decentralized Peripherals standardized in IEC 61158) was used to control sensors and actuators through a programmable logic controller (PLC). Profibus network was preferred to automatically adjust the communication between devices of dissimilar groups and types. The communication delivers more flexibility and no limitation according to the choice of supplier. In this approach all necessary devices could be combined each other. The OPC (Object linking and embedding for Process Control) protocol was used to convert a hardware communication protocol to process data. The MPI protocol was used to communicate the PC unit with the PLC (by PC USB ADAPTER). The concept and implementation of the online programming, controlling and monitoring of the industrial robot motion space is based on the integration of elements (hardware and software) of the flexible manufacturing system in the one laboratory stand (Fig. 2 shows the laboratory stand).

The laboratory stand (Fig. 2) consists of:

- R30iA controller equipped with: the Profibus slot, teach pendant, and network card.
- industrial robot FANUC ArcMate 100iC with the robot track.
- extension card PCI Softing Profiboard PB-IF-1MS.
- logic controller PLC Siemens S7-300 CPU 315 2DP,
- Simatic USB Adapter,

Fig. 2. Remote robot control stand. 1 robot controller, 2 industrial robot, 3 PLC controller, 4 communication adapter, 5 laptop, 6 tablet, 7 safety curtains [26]

- safety light curtains,
- tablet computer with WAN,
- PC unit.
- Wires (robot cables, Profibus cable, MPI to USB, Ethernet, etc.).

Three adapter conceptions were developed for the purpose of cooperation with a pneumatic milling machine of a standard type (e.g. Bosch model D-70745). A milling machine was automated using an electro-pneumatic system. Of course it is possible to use different type of miller. The chosen one was used only for presentation purposes (for milling in expanded polystyrene material). Exemplary miller working parameters are presented in (Tab. 1)

Table 1. Selected miller working parameters

Maximal compressed air pressure [bar]	6,3
Rotational speed [rpm]	2200
Weight as per EPTA [kg]	0,4

In (Fig. 3) the first conception of a robot adapter for a miller is presented. The handle consists of a rectangular profile rod welded to the adapter ring.
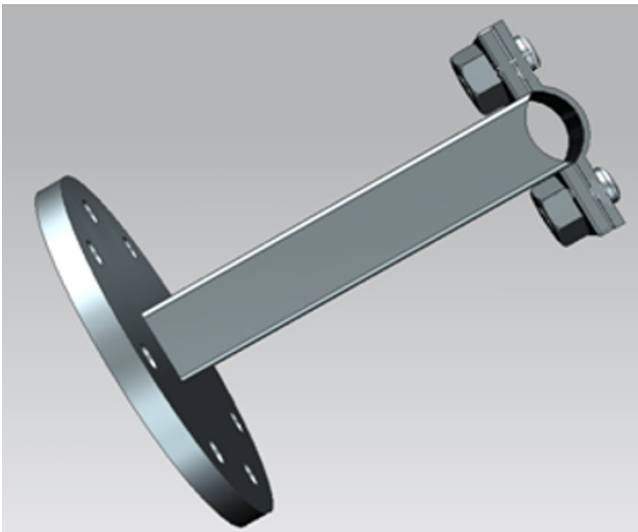
Fig. 3. First conception of a robot adapter for a miller [22]

In (Fig. 4) the second conception of a robot adapter for a miller is presented. The handle is made of round steel rods.
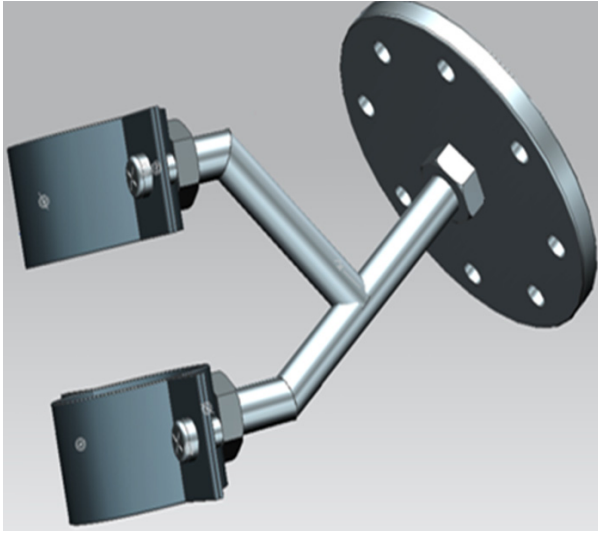
Fig. 4. Second conception of a robot adapter for a miller [22]

In (Fig. 5) the third conception of a robot adapter for a miller is presented. The ring is attached to a flexible material part by welding clamp. After inserting the miller the ring is clamped with two screws and nuts.

In combination with multi-objective optimisation, the best adapter conception have been developed. A human decision maker played an important role in the optimization process. Robot operators and field experts were asked for preference information concerning minimizing cost while maximizing reliability and safety while manufacturing an adapter, and maximizing operation performance whilst minimizing adapters flexibility. As important criterion construction simplicity, maximal range and distance from a robots end, perceived noise level, operating comfort and servicing facility were used. Multiple Pareto optimal solutions for a multi-objective optimization problem were obtained. After approximation and final calculation the second conception was selected for realization. In (Fig. 6) the final realized conception of a robot adapter for miller is shown.

In (Tab. 2) the calculated and assumed parameters for a milling robot are juxtaposed.

Table 2. Calculated and assumed parameters for milling by means of a robot

Type of a milling end	8 cutting edges	2 cutting edges
Feed rate [m/min]	150	75
Depth of cut [mm]	15	8
Maximal travelling speed [mm/min]	5000	1000
Robot velocity in the mode of T1=250mm/s [%]	10	10
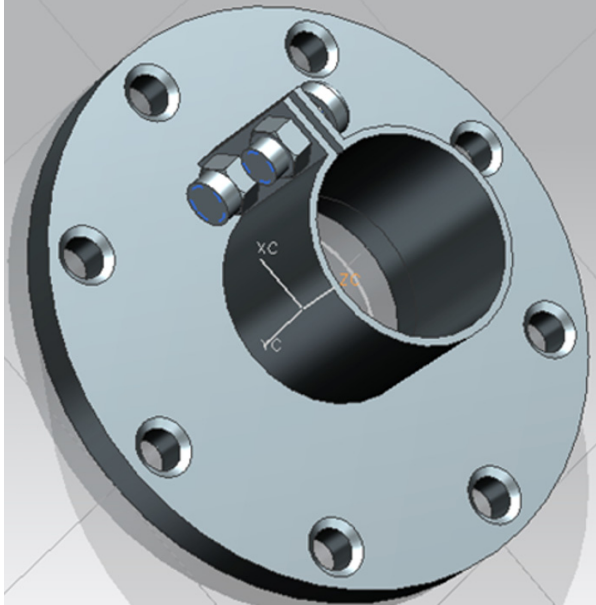
Fig. 5. Third conception of a robot adapter for a miller [22]
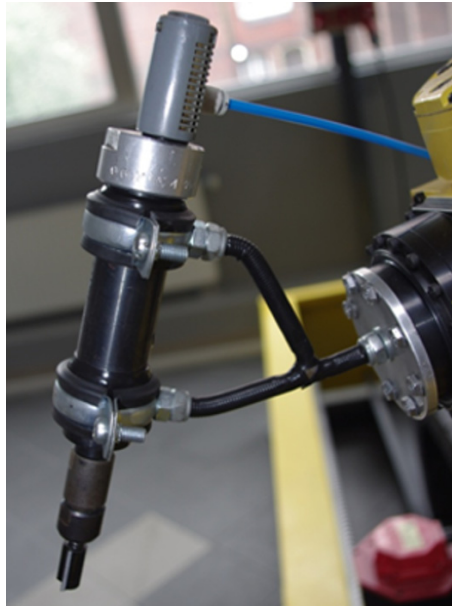
Fig. 6. Chosen milling end conception

In project's realization the following versions of applications and libraries were required: Windows 7 Professional, LabVIEW 2013 [14] (LabVIEW 2013 English, LabVIEW 2013 Control Design and Simulation Module, LabVIEW Datalogging and Supervisory Control Module, NI Vision Developent Module 2013, LabVIEW Internet Toolkit 2013, LabVIEW FTP Toolkit), S7/S5 OPC Server Deltalogic (Configuration: 3.4.2.0, OPC server - application: 4.10.2.9117, OPC server - service: 4.10.2.9.9117), Siemens Step 7, Hardware drivers (card PB-IF-1MS), Browsers (e.g. MS IE or Google Chrome). The following hardware and software were used for a human gestures control system implementation. The operator can control the miller intuitively using only his/her hands. The detailed information on the control system was depicted in [26]. More information will be presented in the future works.

Many scientific publications [2, 3, 27, 30–35] propose detailed mathematical methods and algorithms based on vector analysis as well as methods of signal analysis which were used to obtain the results of the following integrated robot control systems [26, 36, 37].

3   Final remarks

In this work, in order to present the low costs solutions (comparing with market offers) for milling end adapters of industrial robots the exemplary adapters conceptions were shown. The behavior of end milling with a high-speed eight and two cutting edges spindle were tested. Additionally, milling experiments, which especially paid attention to feed rate, milling depth, travelling speed, robot velocity and cutting accuracy were carried out. For controlling miller vibrations and diagnostics the Campbell diagrams can be used [28]. Composite materials can be used for adapters' parts. Some interesting composite solutions were tested in [1, 29, 38]. Modern damping systems could be also considered in the milling damping system such as [21, 23–25].

The future works may be to extend the action to cooperate with the capture technology, which would not only control the robot but also to see the robot. That could be also used as feedback signal during a milling process. A very important thing is to provide proper safety and reliability level in such a type of systems. In literature there are also some positions concerning qualitative and quantitative methods of evaluation the reliability structure for complex technical systems e.g. [7, 8, 10, 18].

When it comes to industrial implementations the proposed solutions are not perfect, but suffice to say that the milling by means of robots does not require a large financial outlay.

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Modelling of a moveable beamlike complex system

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Abstract. In this paper, the model of the beam with a variable geometry is considered. Thanks to a more accurate model and a better control of systems with variable geometry, one can get a significant reduction in maintenance costs and increase the durability and reliability of the entire system. This article presents a method for modeling the telescope beam of variable length and orientation. Changing the length of the extension element influences a change of the cross-sectional area of the external element and the total change in the stiffness of the system. During rotation, the slender structure vibrations occur, which may cause small relative movements. These local vibrations can change the direction of the resultant force. Because such small movements are not reflected in the geometry, this effect can be considered by changing the stiffness matrix. This effect is called *spin softening*. The global motion of a flexible beam is a composition of rotations and unwanted vibrations, which can be critical if the stiffness of the structure is not high enough, compared with the external dynamic load. The mathematical model of the considered beam is shown. In the model, damping, nonlinearly variable cross section of the component elements, and interactions between principal and relative motions are considered.

Keywords: variable geometry, variable cross-section, beam, vibrations, transportation

1   Introduction

The considered problem focuses on modeling and dynamic analysis of nonlinear beam systems in rotational motion within the context of damping. The major scientific aim of the paper was to elaborate the mathematical model of such a system. There are some commercial scientific descriptions and elaborations frequently used in practice by several companies (e.g., GE, Boing). However, detailed information is not available to the public as all rights are reserved.

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In the following literature [1, 8, 12, 15, 16, 21, 23, 31], it is claimed that the analysis of the given problem should be solved using the superposition method. According to the superposition method, the interactions between the main mechanism and its damping are omitted. What is more, one of the assumptions is that the main motion system is composed of stable elements and that these vibrations from the stable elements never influence the global motion of the mechanism. In addition, many scientific publications [6, 7, 17, 22, 24, 26, 28, 33, 35, 42, 45–47] propose detailed mathematical methods, algebraic and topologic, as well as methods of signal analysis that were used to obtain the results of the following systems.

The important problem in understanding the mechanical behavior of rotating systems such as propellers, turbines, helicopter rotors, and other similar mechanisms is the dynamic analysis of a rotating beam while taking into consideration the physical and geometric nonlinearities. To analyze such a system, many mathematical and numerical methods are used; for example, Yokoyama [34] used finite element methods, Lee and Lin [21] considered the vibration of nonuniform rotating beam by omitting the transportation effect, and Yang and Tsao [32] studied the vibration and stability of a blade rotating with various angular velocity. Free spatial vibration of a rotating beam with a nonlinear elastic constraint was studied by Pavic in [25]. Al-Bedoore and Hamdan [1] derived a mathematical method for a deformed, rotating, flexible element. To obtain the dynamic response of spinning tapered Timoshenko beams, Bazoune [5] used FEM. The specific behavior of rotating mechanical systems states the major problem in solid mechanics. Such systems should be controlled to guarantee the safety and reliability of the mechanisms and machines as well as to protect from overall damage. In the monograph [7], an algorithm and a method of determining the dynamic characteristics of linear systems were elaborated. In addition, the significant influence on local vibrations was considered.

The scientific publications that do not come from Silesian University of Technology (e.g. [4, 14, 23, 25, 29]) show the formulated problem in a slightly different way, and the problem of the dynamic flexibility of systems is not considered. Many theoretical studies concerning different mathematical control models can be applied in human-machine interface, some of them will be considered in future works e.g. [36–51]

2 Model of the variable geometry beamlike system in motion

In the paper a model of the variable geometry beam in transportation is considered. The model of the beamlike system is consisted of a rigid rotating hub and two flexible elements; the one beam (a moveable part of length l_1) with a variable cross-section and another (a shank of length l_2) with a round constant cross-section. The cross-section of the moveable beam of l_1 length can be considered both as the beam with a constant (the particular case) or variable cross-section (the general case). All the beams are assumed as the homogeneous ones.

The shank is fixed on the hub that is treated as a rigid one (Fig. 1). The hub is rotating round its axis and the movement is described in two reference frames, the global stationary one and the local one. The vibrations in the local reference frame are transferred into the global reference frame with taking into consideration the transportation effect. Formulation of the problem of vibrating variable geometry beams mounted on a rotor's hub is presented. The considered systems are the basis of a further dynamic analysis. The elastic systems are loaded by the transversal forces. The rotor rotates with the angular velocity ω. The orientation of the system is provided by a rotation matrix $\mathbf{Q}$.
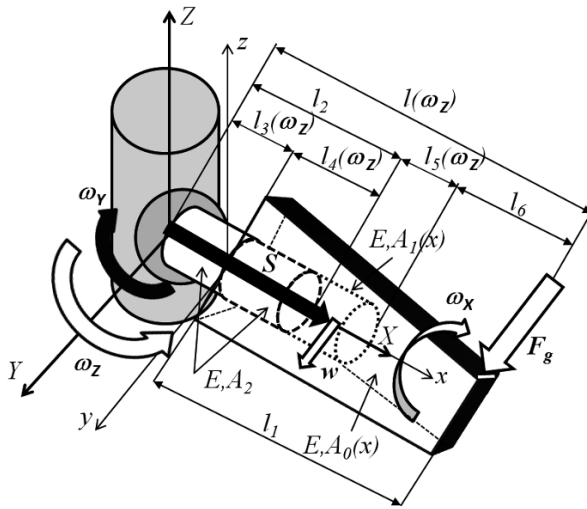
Fig. 1. Model of the variable geometry beamlike system in spatial motion

The beam parameters used here are: ρ - mass-density, A - cross-sectional area (A_0 - constant cross-sectional area of the beam's end, A_1 - changeable stepped cross-sectional area alongside the hole, A_2 - constant cross-sectional area of the shank), l - length of the whole beam as a function of the angular velocity, l_1 - length of the moveable part, l_2 - length of the shank, l_3 - shifted length of the shank outside the moveable part (dependent on the angular velocity), l_4 - length of the part slip into (inside) the moveable part (dependent on the angular velocity), l_5 - length of the unfilled part of the hole (dependent on the angular velocity), l_6 - constant length of the end part of moveable beam, x - location of analyzed cross-section, M - mass of beam, ω- angular velocity, Ω - frequency, $\mathbf{Q}$ - rotation matrix, $\mathbf{S}$ - position vector, F - harmonic force, E - Young modulus, I - geometric moment of inertia, $\mathbf{w}$ - vector of displacement.

The local displacement vector in the local reference frame along the y axis that is to say the amplitudes of vibrations are as follows:

$$\bar{\mathbf{w}} = \begin{bmatrix} 0 & w & 0 \end{bmatrix}^T. \tag{1}$$

$\bar{\omega}$ - the transportation velocity treated as the angular velocity of the rotational disk with the transversally vibrating beam and for the spacial motion is:

$$\bar{\omega} = \begin{bmatrix} \omega_X & \omega_Y & \omega_Z = \omega \end{bmatrix}^T. \tag{2}$$

The global displacement vector in the global reference frame is as follows:

$$\bar{\mathbf{w}}_{XYZ} = \begin{bmatrix} w_X & w_Y & w_Z \end{bmatrix}^T. \tag{3}$$

The analyzed cross-section is considered along the x axis in the local reference frame and for identifying the analyzed section the position vector is introduced analogous to the position vector of the rod:

$$\bar{\mathbf{S}} = \begin{bmatrix} s(\omega_Z) & 0 & 0 \end{bmatrix}^T. \tag{4}$$

The position vector is defined as dependent on the angular velocity and can be also treated as translational displacement. The initial system's configuration is assumed as the folded one. We are interested in the case when the component s of the position vector is: $s \geq l_3$. If s belong to a range between: $l_3 \leq s \leq l_3 + l_4$ then the analyzed cross-section is complete and equals $A(x) = A_0(x) = A_1(x) + A_2$. In the case of $l_3 + l_4 < s \leq l_3 + l_4 + l_5$ the cross-section is equal $A(x) = A_1(x) = A_0(x) - A_2$. Furthermore when $s > l_3 + l_4 + l_5$ the analyzed cross section is $A(x) = A_0(x)$ The length of the whole beamlike system is a function of the angular velocity in relation to the axis Z and can be written as follows:

$$l(\omega_Z) = l_3(\omega_Z) + l_1,$$

where l_1 is a constant length of the variable cross-section beam (blade) and l_3 is the length of sliding rod jut out the blade.

2.1 Formalization of the model

The displacement vector in the dynamic frame can be obtained by premultiplication with the corresponding rotation matrix:

$$\bar{\mathbf{r}} = \bar{\mathbf{i}} r_X + \bar{\mathbf{j}} r_Y + \bar{\mathbf{k}} r_Z = \mathbf{Q}\left(\bar{\mathbf{S}} + \bar{\mathbf{w}}\right). \tag{5}$$

The velocity vector of the analyzed section in the global reference frame obtained as the derivative of the displacement vector:

$$\dot{\bar{\mathbf{r}}} = \bar{\mathbf{i}} v_X + \bar{\mathbf{j}} v_Y + \bar{\mathbf{k}} v_Z = \mathbf{Q}\bar{\omega} \times \left(\bar{\mathbf{S}} + \bar{\mathbf{w}}\right) + \mathbf{Q}\dot{\bar{\mathbf{S}}} + \mathbf{Q}\dot{\bar{\mathbf{w}}}. \tag{6}$$

According to Genta [14] the kinetic energy can be written as:

$$T = \frac{1}{2} \int_V \rho \dot{\bar{\mathbf{r}}}^T \dot{\bar{\mathbf{r}}} dV. \tag{7}$$

The kinetic energy in accordance with the Koenigs law defined by the generalized coordinates and the generalized velocities is:

$$
\begin{aligned}
T &= \frac{1}{2}M\left(\bar{\mathbf{i}}\dot{r}_X\right)^2 + \frac{1}{2}M\left(\bar{\mathbf{j}}\dot{r}_Y\right)^2 + \frac{1}{2}M\left(\bar{\mathbf{k}}\dot{r}_Z\right)^2 = \\
&= \frac{1}{2}M\dot{r}_X^2 + \frac{1}{2}M\dot{r}_Y^2 + \frac{1}{2}M\dot{r}_Z^2,
\end{aligned}
\tag{8}
$$

where $\bar{\mathbf{i}}$, $\bar{\mathbf{j}}$, $\bar{\mathbf{k}}$ are versors in the global reference frame. M - the body mass of the beam with the volume V, the cross-section area A and the length s of the analyzed position vector can be described as:

$$
M = \int\limits_{V} \rho dV = \int\limits_{0}^{l} \rho A(x)dx,
\tag{9}
$$

The individual generalized coordinates and generalized velocities are orthogonal projections of the suitable coordinates and velocities on the axes of the global reference system and can be written as:

$$
\begin{aligned}
&q_1 = r_X, q_2 = r_Y, q_3 = r_Z, \\
&\dot{q}_1 = \frac{dq_1}{dt} = \dot{r}_X = v_X, \dot{q}_2 = \frac{dq_2}{dt} = v_Y, \dot{q}_3 = \frac{dq_3}{dt} == v_Z.
\end{aligned}
\tag{10}
$$

The generalized forces acting on the length s of the beam are assumed as follows:

$$
F_X = \frac{\partial F_g Q_{11} s}{\partial x}, F_Y = \frac{\partial F_g Q_{21} s}{\partial x}, F_Z = \frac{\partial F_g Q_{31} s}{\partial x}.
\tag{11}
$$

The potential energy is as follows:

$$
U = \frac{1}{2}\int\limits_{0}^{l} EI\left(x\right)\left(\frac{\partial^2 \bar{\mathbf{w}}^T}{\partial x^2}\right)\left(\frac{\partial^2 \bar{\mathbf{w}}}{\partial x^2}\right)dx.
\tag{12}
$$

If the damping of the rod is taken into consideration the dissipation of the energy should be introduced as:

$$
\begin{aligned}
D &= \frac{1}{2}\int\limits_{0}^{l} b\left[\bar{\omega} \times \mathbf{Q}\left(\bar{\mathbf{S}}+\bar{\mathbf{w}}\right)\right]^T \left[\bar{\omega} \times \mathbf{Q}\left(\bar{\mathbf{S}}+\bar{\mathbf{w}}\right)\right] dx + \\
&+ \frac{1}{2}\int\limits_{0}^{l} b(\mathbf{Q}\dot{\bar{\mathbf{w}}})^T(\mathbf{Q}\dot{\bar{\mathbf{w}}})dx + \frac{1}{2}\int\limits_{0}^{l} b(\mathbf{Q}\dot{\bar{\mathbf{S}}})^T(\mathbf{Q}\dot{\bar{\mathbf{S}}})dx = \\
&= \frac{1}{2}\int\limits_{0}^{l} b\left(\bar{\mathbf{i}}\dot{r}_X\right)^2 dx + \frac{1}{2}\int\limits_{0}^{l} b\left(\bar{\mathbf{j}}\dot{r}_Y\right)^2 dx + \frac{1}{2}\int\limits_{0}^{l} b\left(\bar{\mathbf{k}}\dot{r}_Z\right)^2 dx = \\
&= \frac{1}{2}\int\limits_{0}^{l} b\dot{r}_X^2 dx + \frac{1}{2}\int\limits_{0}^{l} b\dot{r}_Y^2 dx + \frac{1}{2}\int\limits_{0}^{l} b\dot{r}_Z^2 dx,
\end{aligned}
\tag{13}
$$

where $b = \frac{\beta}{\rho Al}$ and β is a damping factor.

The initial conditions for the considered system are as follows:

$$
\begin{cases}
\varphi_X (\omega_Z, 0) = \varphi_{X0}, & \varphi_Y (\omega_Z, 0) = \varphi_{Y0}, \\
\varphi_Z (0) = 0, & \omega_X (0) = 0, \\
\omega_Y (0) = 0, & \\
\omega_Z (0) = \omega_{Z0}, & l_3 (\omega_Z, 0) = l_5 (\omega_Z, 0) = 0, \\
l_4 (\omega_Z, 0) = l_2, & l (\omega_Z, 0) = l_1.
\end{cases}
\tag{14}
$$

Orientation of the blade is dependent on the working angular velocity assumed as $\omega_Z = \omega$. The blade's orientation can be changed during rotation (e.g. to optimize the system's performance and/or to provide stable work). The orientation can be changed during the working motion by additional rotations in relation to x or y axes with appropriate angular velocity or can be preset before using the system.

At the beginning the system can be preset by rotating at an angle of appropriate value that was presented in the initial conditions.

Apart from that the system can be folded (l_3=min =0; l_4=max=l_2; l_5=min=0) or unfolded (l_3=max=l_5; l_4= min=0) and the total diameter can be changed during the rotation. The range of the motion is limited in a span of l_3. Engineering practical application (with additional limitations) of such a type system can be found in the report "Updating of the Variable Geometry Rotor (VGR) Blade Diameter Change Mechanism Combined with the System of the Centrifugal Force Compensation and Extension of the Range of the Blade Twist Change ISTC Project Unrestricted Summary of Technical Report" [31].

$\mathbf{Q}$ - the rotation matrix has the well-known form:

$$
\mathbf{Q} = \mathbf{Q}_X \mathbf{Q}_Y \mathbf{Q}_Z = \begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}.
\tag{15}
$$

where:

$$
\mathbf{Q}_X = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\varphi_X & -\sin\varphi_X \\ 0 & \sin\varphi_X & \cos\varphi_X \end{bmatrix}
\mathbf{Q}_Y = \begin{bmatrix} \cos\varphi_Y & 0 & \sin\varphi_Y \\ 0 & 1 & 0 \\ -\sin\varphi_Y & 0 & \cos\varphi_Y \end{bmatrix}
\mathbf{Q}_Z = \begin{bmatrix} \cos\varphi_Z & -\sin\varphi_Z & 0 \\ \sin\varphi_Z & \cos\varphi_Z & 0 \\ 0 & 0 & 1 \end{bmatrix}
\tag{16}
$$

2.2 Equations of motion

The present subsection is devoted to coming to know of the main phenomena related to the variable geometry beamlike system consisted with the variable cross-section beam and the round rod. The presented technical case is the beam with the variable geometry for example the rotor with blades. The function describing the variation of the cross-section can be the linear and nonlinear ones. In cases where the cross-sections is inconstant on the whole beam's length, the

dynamic analysis is troublesome but the variation of the cross-section cannot be neglected, especially in terms of the rotational motion. In literature [29, 45, 47] some similar mathematical models (considering beams in motion) can be found. The presented mathematical model is the original approach to the considered problem formulation and formalization. The equations of motion of the analyzed beamlike systems are obtained following the classic method (Lagrange's equation). The derived equations of motion can be presented in the matrix form as follows:

$$
\begin{aligned}
&\rho A\left(x\right)
\begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}
\begin{bmatrix} \frac{\partial^2 s}{\partial t^2} \\ 0 \\ \frac{\partial^2 w}{\partial t^2} \end{bmatrix}
- \rho A\left(x\right)
\begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}
\begin{bmatrix} \omega^2 s \\ 0 \\ 0 \end{bmatrix} + \\
&- 2\rho A\left(x\right)
\begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}
\begin{bmatrix} 0 \\ \omega \frac{\partial s}{\partial t} \\ 0 \end{bmatrix}
+ b
\begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}
\begin{bmatrix} -w\omega \\ s\omega \\ 0 \end{bmatrix} + \\
&+ b
\begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}
\begin{bmatrix} 0 \\ \frac{\partial w}{\partial t} \\ 0 \end{bmatrix}
+ \rho A\left(x\right)
\begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}
\begin{bmatrix} 0 \\ \dot{\omega} s \\ 0 \end{bmatrix} = \\
&- EI\left(x\right)
\begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}
\begin{bmatrix} 0 \\ 0 \\ \frac{\partial^4 w}{\partial x^4} \end{bmatrix}
- 2\frac{\partial EI\left(x\right)}{\partial x}
\begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}
\begin{bmatrix} 0 \\ 0 \\ \frac{\partial^3 w}{\partial x^3} \end{bmatrix} + \\
&- \frac{\partial^2 EI\left(x\right)}{\partial x^2}
\begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \\ Q_{31} & Q_{32} & Q_{33} \end{bmatrix}
\begin{bmatrix} 0 \\ 0 \\ \frac{\partial^2 w}{\partial x^2} \end{bmatrix}
\end{aligned}
\tag{17}
$$

in each point of the range $D = \{(x,t), x \in (0,l), t > 0\}$ the solution of the equation (17) coincides with the boundary conditions and the initial conditions.

3 Final remarks

This work is the consideration of the vibration problem of beams fixed on a rotational rigid hub. The most interesting elements of the analysis determine the dynamic state of the system and present the mutual coupling of vibration amplitudes, eigenfrequency, and transportation velocity. Analysis of systems moving with low velocities or vibrating only locally treats the systems as already known models in literature. Due to the obtained results it is possible to confront mathematical models with the known stationary and non-stationary systems.

In mathematical models the internal damping was taken into consideration. The damping forces were assumed as a function of velocities of displacements. The dissipation was defined as a function of angular velocity so transfer was provided in vibrations direction. It also means the damping forces were rotated with the beam. There are many technical applications where the beams fixed on

the rotation disk are implemented. Such system types can be put into use for example in turbines, pumps and rotors, etc.

There are many numerical applications dedicated to the dynamic analysis of rotational systems, e.g. DynRot described by Genta [14] or Modyfit [43, 44]. These applications give a possibility of analyzing running systems or designing such types of systems, making modulation of dynamic characteristics possible by changing working parameters or changing geometrical or material parameters. Many scientific publications [3,30,42–47,51] propose detailed mathematical methods and algorithms based on vector analysis as well as methods of signal analysis which were used to obtain the results of the following integrated remote robot control systems. Apart from robot implementations the shown system will be tested in applications connected with transport [11,20,27]. A very important thing is to provide proper safety and reliability level in such a type systems. In literature there are also some positions concerning qualitative and quantitative methods of evaluation the reliability structure for complex technical systems e.g. [2,9,10,13,18,19].

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Part XIII
Innovation in Information Management

Public Relations in Ecuador: exploratory and descriptive research about career development

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Abstract. In this digital era, the efforts of the organizations to design a symmetrical and bidirectional model of relation and interest management with the public require the projection of a certain image and prestige as a result of the strategic planning of communication. However, this systemic perspective, where communication becomes a key cross-cutting theme along the organizational process, and which assigns the communication professional an executive role –Dircom–, is not a fixed element on the reality of Ecuadorian companies. This work is the result of research carried out by the Observatorio de la Comunicación Estratégica del Ecuador of the Universidad Técnica Particular de Loja, set up in 2013 to explore the professional profile of business communicators (Dircom).

Key words: public relations, communication, corporate, and corporate social responsibility.

1. Introduction

In Ecuador, large companies are gradually including communication in their strategic planning as an inbuilt structure, especially in the capital cities. In small and medium-sized cities, we can still notice an empirical approach to communication which might lead to puzzling and dysfunctional situations, since it works on an individual basis and shows no clear-cut identification of roles. Public Relations as a comparatively young discipline lacks a large body of scientific research or literature which would allow an expansion of understanding in relation to its status in the country but above all to provide useful and accurate information applicable later in a professional atmosphere. However, in Latin America and Ecuador, in particular, not much research is being done to explore the current status of the profession and its growth and development trends [1]. What has previously been advanced in the field is related to multiple studies, which –over the last few decades– have gone through analysis to determine the career development in strategic communication and public relations worldwide. One of the most important is European Communication Monitor (ECM),

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a series of reports designed from 2007, on an annual basis, by the European Public Relations Education and Research Association (EUPRERA) and the European Association of Communication Directors (EACD). This study, which is the most representative of the field in Europe, identifies the main features of the European public relations professionals and the organizations where they work, connecting the contextual situations with the disciplines, the communication tools and the strategic topics, as well as their influence on corporate decision-making and their executive roles. In 2014, the Latin American Chapter was put in place (Latin American Communication Monitor), which will present its results in 2015.

In Ecuador, educational institutions have developed several studies researching along the lines of corporate, strategic, organizational and public relations communication. Robles and Yaguache [2]. argue that communication in Public Relations is very incipient in Ecuador compared to other countries in Europe and the continent itself such as in Argentina, Chile and Brazil. If we analyse the historical and current context we only find some limited Public Relations, in most cases social and corporate events, which has led to shortcomings in the potential of the profession.

In effect, in the practice and development of the profession we are facing an environment marked by the absence of literature, ignorance of the profession, limited practice of public relations in social events, the role of public relations personnel being assumed by people outside the required profile and no active professional guilds to foster relationships and identification of lobbyists in the country. It has however managed to find a late interest from the business sector in recognizing the importance of public relations departments and communication as drivers of development within companies, especially those that have public spaces and require the development of internal and external communication strategies.

There have been previous efforts to the *Observatorio*. Those initiatives were developed by the Organizational Communication division of the Technical University of Loja, emphasizing the history of Ecuador in connection with public relations and its current status (mapping of the communication companies in the country, doctoral dissertations developed in the fields of branding, persuasion, social responsibility and social network management) [1] [2]. To that end and within the same field, the Technical University of Loja developed this research -the first *Observatorio*-, whose primary objective is to systematically study the current status and trends of the profession and strategic communication in Ecuador.

2. Theoretical Framework

In November of 2012, in Australia, the 2012 World PR Forum Summary gathered around 800 representatives of 29 countries, with the signature of "The Melbourne Mandate" [3], an statement of functions, responsibilities and principles for the revaluing of public relations and communication management. This effort was promoted by the Global Alliance for Public Relations and Communication Management –representing 160,000 professionals– which aims at advocating for, showing and improving the value of public relations and communication in their organizations, communities and the society at large.

Communication in organizations is becoming more and more paramount. Thus, when analyzing organizations by means of a systemic model [4] the person in charge of the communication role should plan, implement and assess the relations with the public in connection with the mission and goals of the organization, monitoring and interacting the whole time with the different current economic, political, cultural, social and environmental settings [5].

When this happens, communication becomes strategic, gets involved in the management processes and turns into a competitiveness factor that adds up essential value to the organization, as long as the results are measured and assessed. To that end, it should be directly related to the strategic planning in public relations (Capriotti, 1999; Xifra, 2005; Matilla, 2008 y 2008b). Large companies gradually include communication as an inbuilt structure in their strategic planning of communication. In small and medium-sized cities, we can still notice an empirical approach to communication which might lead to puzzling and dysfunctional situations, since it works on an individual basis and shows no clear-cut identification of roles.

This reality is not accidental, but rather a causal inheritance of the scientific field of communication itself in organizations. Paradoxically, the relevance of communication charges in the professional field as the total of its scientific and academic standing is still without epistemological agreement or broad consensus, with its various theoretical and research trips a constant and cyclical discussion [6]. Along these lines, back in 1990, the IPRA (International Public Relations Association) published its Gold Paper Nº 7 entitled "Public Relations Education-Recommendations and Standards" related to the profile of the person in charge of strategic communication, where the disciplines necessary for the training of a public relations professional are graphically described in a three-concentric circles.

3. Methodology

Research was carried during 2014, along two stages:

a) Exploratory research by means of a background study and the definition of variables and units of analysis;

b) Descriptive research, by means of a digital self-administered closed survey oriented to Public Relations professionals in the country. The sample includes 107 cases, and it was taken at the most well-known public and private companies in the country (Ekos magazine).

Given the framework of this research, an exploratory methodology was selected, since, as expressed by [8], it allows the study of under-researched topics and questions to offer a general outlook on them. This methodology will allow the conceptualization of the key question, the definition of variables and the units of analysis (sampling), all which will eventually be the foundation for the field work towards the next stage.

Descriptive research collects information to identify the status of strategic communication in Ecuador. The report from Ekos Magazine about well-known public and private companies in the country determined the companies that contacted

communication professionals by various means, such as reminder e-mails, telephone calls, training courses offers and research outcomes sharing. 107 answers were received. Having tabulation of data being completed, data was processed through SPSS statistical software.

3.1. Variables of analysis and sampling

Variables taken into account for the online survey included age, academic degree, working city, company type, rank, internal communication management, goal fulfillment, lines of action, external suppliers –agencies–, assessment tools, effective communication tools, use of web 2.0 and 3.0. Furthermore, Dircom skills and knowledge, influence factors, position within the organizational structure, the different areas of the organization and the priority lines of action are included in relation to Dircom.

The question under consideration is the communication professionals for the online survey in the descriptive methodology. The Ekos Magazine report about well-known public and private companies in Ecuador identified the organizations that contacted communication professionals to complete the online survey. Out of a database including 212 communicators, 107 complete answers were selected to work on the sampling.

3.2. Data collection tools

For data collection, Survey Monkey tool was used, which allow for open surveys to be carried out via e-mail invitation. Results were collected in a variety of formats (xls, csv, pdf, spss), which provided for the treatment of gathered information of the selected sample (107 complete surveys) with SPSS, a statistical analysis tool which helped to get the results comparing the different related answers.

4. Results

Public relations is a discipline that in Ecuador has evolved slowly, largely due to the lack of academic support, weak empowerment of the profession, ignorance of what it actually is and entails, positions in organisations being assumed by professionals outside of communication and historical linkage of public relations with social events. We are facing a sparse landscape in the practice of the profession, where each individual or entity is performing their activities in a very distant manner. Although the political, business and government sectors have been the main areas for the development of the profession, in the last decade technological convergence, business growth, the inclusion of NGOs in Ecuador and other digital communication have opened workplaces.

Research results helped to analyze 14 study variables and their interconnectedness. Most relevant data include the presence of "Communication Departments" in just 61.1% of the main Ecuadorian companies and institutions. The organizations that actually have a specific department for this purpose have various denominations for it and these are usually related to Marketing activities, institutional image and Public

Relations. In the public sector, many of these departments are the result of a communication strategy imposed by the National Communications Secretariat of Ecuador, in order to publicize the activities and projects of the government of the day. This strategy has produced excellent results and has even become the baseline for the media agenda in the country.

In many organizations, Corporate Communication is understood as an activity involving only external communication with business purposes, excluding internal communication, which in many cases is considered a Human Resources-specific task. Yet another characteristic is that Corporate Communication is administered as an activity of the Marketing and Advertising Departments of the organizations. We will discuss below the results achieved in the different variables.

4.1. Profile of the professionals in charge of communication

The first group of variables and indicators help us approach the profile of the professionals in charge of communication in Ecuadorian companies and organizations. On that account, the median is 35,9 years old. As regards academic education, most of the responders hold a Higher Education degree (43%) in the academic fields of Journalism, Public Relations and Advertising. 23% of the responders hold a Master degree in the areas of Marketing, Communication, Social Sciences, Administration and Human Resources. Also a percentage, albeit minor, addressed the job without a university degree but with a wealth of important experience.
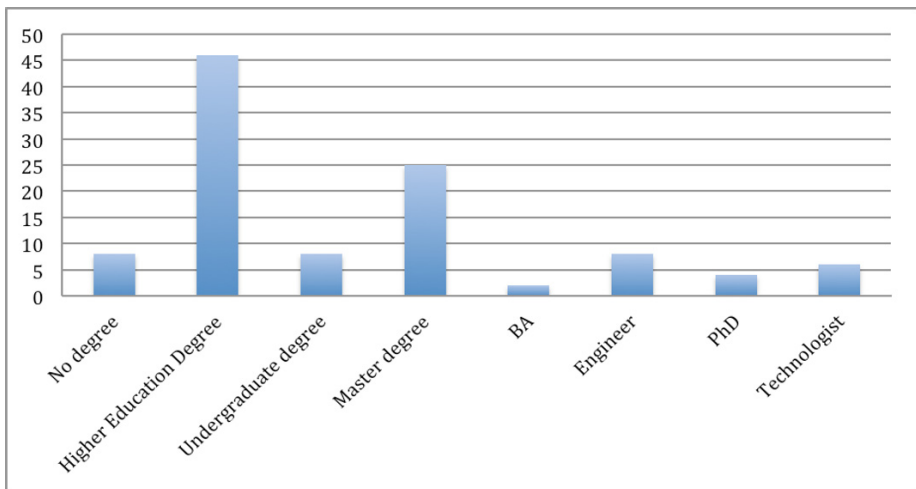
Fig. 1: Academic degrees. Own source

In terms of the geographical distribution, 50% belong to the city of Quito; 12,1% to Guayaquil, the remaining percentage to Esmeraldas, Ibarra, Loja, Machala, Manta, Riobamba, Santo Domingo, Tena, Tulcán, Zamora, Cuenca, among other cities.

Previous research conducted by [9] states that "62.5% of PR agencies are concentrated in the coastal region, specifically in the province of Guayas, and 37.5% in the province Pichincha, Sierra region "; however, the largest number of public sector institution matrices are based in the capital, this being the reason for a higher percentage of communication managers working Quito.

4.2. Work areas

One of the exploratory goals of the *Observatorio* is to investigate the formal environment where Communication and Public Relations activities take place on a daily basis in organizations. In terms of designations (Table 1), in 81,3% of the cases, the designation (regardless of the type of organization) is related to the "Department of Communication". Only 0,9% of the responders made reference to their work area as the "Department of Public Relations".

Table 1: Work areas. Own source.

Designation of the work area	Frequency	Percentage
Department of Communication in a private company	43	40,2
Department of Communication in a public institution	36	33,6
Department of Communication of a private-public company	3	2,8
Department of Communication of an NGO	5	4,7
Freelance Advisor	12	11,2
Marketing Department	7	6,5
Public Relations Department	1	0,9
Total	107	100,0

Regarding the current position the communication professionals hold in the company/institution, according to the precise designation of the position, the results show a great variety of different findings: 56,1% of responders perform executive roles -at least according to their designation: Communication Coordinator, Communication Director, Manager, and Department Head. In a far lesser extent, 6,5% designate their position as "Public Relations Consultant". The types of organizations involved, 58% are private, 36,4% are public and 4,7% are from the third sector.

Even when it turns out to be exceptional that in 16% of the cases, among the specified areas that constitute the Communication Department "Public Relations" is indicated over "Marketing & Advertising" with 13,5% or even "Protocol" with 7,2%, and the area of "Digital Communication" in the Communication Departments accounts for 13% of the cases.

4.3. Communication Management

The third group of variables was designed to explore the activities of communication management. Like in other regions, internal communication is an area that has developed in relation to other areas of the organization, not necessarily related to communication. In the case of Ecuador (Fig. 4), 45% of responders said they establish and put into practice the strategies with the internal public from the area of Communication itself. In 41% of the cases, these actions are carried out along with the area of Human Resources.
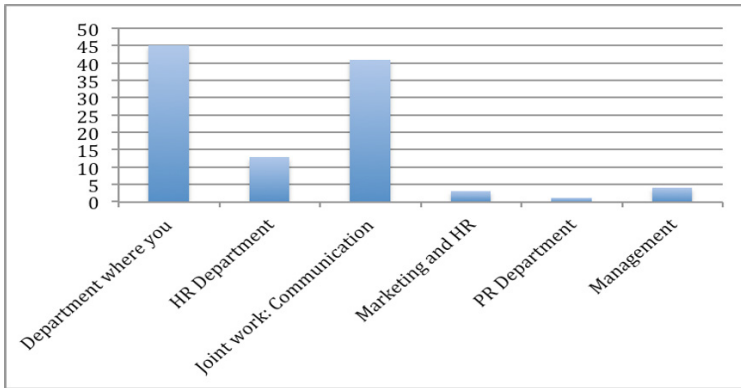
Fig. 2: Digital communication strategies. Own source.

The contribution of communication towards the objectives of the organization is determined by checking whether communication is actually put into practice or not during the strategic planning of the assessment step. Along these lines (Table 2), results show a great diversity of methods and measurement variables, a significant number of which are related to impact assessment, linked to the business objectives of companies (sales or income, and ROI).

Activities with higher assessment are related to digital communication strategies, with 39,9% of cases. 2,6% of responders said that carrying out assessment activities was not important. Meanwhile, impact research in relation to advertisement accounts for a significant 15%, as well as media impact, with 17,6% of the cases.

Breaking down the option "Others", there appear interesting measurement variables, which in certain cases lead to lack of precision in terms of tools, devices and indicators: "no measurement indicators at this moment"; "surveys"; "external surveying"; "market position study"; "fidelity + working environment + brand prestige"; "impact on ATL media"; "impact on public opinion through mass media monitoring"; "increase of patients with knowledge of Nuclear Medicine"; "quality indicator of media corporate image"; "increased prices" and "productivity, motivational level, behavioral changes of the organizational culture, decreased quality errors, service, number of affected people".

Table 2: Result assessment. Own source.

Variable	Frecuency	Percentage
Sales or income	23	8,4%
Return on investment (cost-effectiveness ratio)	34	12,5%
Advertisement impact research	41	15,0%
Number of impacts	48	17,6%
Impact measurement on the website and social networks (followers, fans, likes)	59	21,6%
Audience measurement on the web (number of visits, stay time on the website)	50	18,3%
Measurement is not considered of importance	7	2,6%
Other	11	4,0%
Total	273	100,0%

4.4. Management challenges.

The last group of variables under consideration is related to the prospects of professional performance of communication in Ecuador over the next three years. The main lines of action (Table 3) include digital communication/social media with 22,4%, followed by PR activities, with 20,3%.

Among the factors which will consolidate the position of the communication director in the organization, one particularly stands out with 28,4%, where "Their strategic role will increase in support of decision-making by senior management".

Table 3: Management prospects. Own source.

Variable	Nº	Percentage
Consulting, advisory and coaching services	19	6,6%
Lobbying with strategic groups	16	5,6%
Internal communication	55	19,2%
Marketing, branding, consumer communication	49	17,1%
Digital communication/ Social media	64	22,4%
RP Activities	58	20,3%
Sponsorship	7	2,4%
Corporate social responsibility	15	5,2%
Others	3	1,0%
Total	286	100,0%

5. Conclusion

In Latin America and Ecuador, in particular, not much research is being done to explore the current status of the profession and its growth and development trends. Results have been compared against some of the results of the work done by the European Communication Monitor 2014 and the Report about the use of social networks in Spanish companies (*Informe sobre Usos de Redes Sociales en Empresas*) in 2014.

Research included 107 professionals from 13 Ecuadorian cities, much fewer than the 2710 professionals from the 43 European cities. Surveyed professionals were 35, 09 years old average, younger than Europeans, with an average of 40,9 years old. Regarding professional training, 43% hold a Higher education degree and 23% a Master degree in Ecuador, while in Europe, 92,8% of the professionals hold a professional degree ranging from Higher education degree to PhD.

In Ecuador, 40,2% of the professionals work in the department of communication, in private companies, and 33,6% in public companies; 20,6% hold a communication coordinator position and 19,6% are communication directors, 16% work in the PR area, 13,5% in Marketing and Advertising, and 13% in digital communication. While in Europe, three out of four professionals work in the department of communication in organizations, 25,2% are communication consultants who work as freelancers or for agencies; out of this percentage, 43,2% hold a manager or communication director position or they work in only one communication discipline; 28,4% of them are team leaders and 22,5% work in consultancy agencies.

In Europe as wells as in Ecuador, there is an upward trend in the use of the information technologies for the various tasks and activities in the communication area, as shown in the [11], where impact of new technologies and the importance of strategic communication is assessed. It is necessary, then, to find some grounds for dialogue and contributions towards a common goal, moving away from a one-directional behavioral sense and heading to a well-balanced and symmetrical relationship with people.

The results show that the business sector in Ecuador has generated interest in using communication for management development and promotion to achieve selling intangibles such as reputation, credibility and trust; these being the factors to consider when looking at public relations as a strategic asset for executives.

New trends are marked by global demands, transitioning from traditional management to communication cabinets made with clear objectives, setting aside the concept of public relationer to employ the concept of DirCom, as a manager of integrated communication for both internal and external communication.

Finally we must consider that the technological tools and digital environments require a working methodology that knows how to reach a dynamic public and which is permanently connected to the web because in communication, the internet is a vital means of communication as much as traditional media.

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