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Paolo Nesi
Raffaella Santucci (Eds.)

Information Technologies for Performing Arts, Media Access, and Entertainment

Second International Conference, ECLAP 2013
Porto, Portugal, April 2013
Revised Selected Papers

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Preface

Welcome to the proceedings of ECLAP 2013, the second international conference on Information Technologies for Performing Arts, Media Access and Entertainment.

Information technologies have made possible many unexpected changes in the field of cultural heritage and performing arts; they continue to provide dynamic and exciting media platforms through which new possibilities perpetually emerge. This wave of changes has been particularly significant for the field of the performing arts, where a wide range of possibilities for digital exploitation continue to present itself to users, constantly opening the doors to new and as-yet-unexplored synergies. Many technological developments concerning content access and fruition, the renovation of digital libraries, the creation of new ways for media entertainment and the facilitation of education are proposed, applied, and utilized by the public.

ECLAP is a best practice network co-funded through the ICT Policy Support Programme of the European Commission. ECLAP aims to stimulate exploitation of new ICT technologies for digital content access to performing arts resources, and to provide guidelines on the adoption of metadata standards for indexing, searching, and browsing content. ECLAP is providing access to performing arts collections and archives by means of social media tools and content aggregation tools derived from research activity. The performing arts institutions involved are prestigious and leading in the field. An ever-growing fund of digital resources is becoming accessible through a common, multilingual, easy-to-use ECLAP service. The ECLAP metadata are progressively being made available on Europeana, a European multilingual online collection of millions of digitized items from museums, libraries, archives, and multimedia collections.

The ECLAP conference aims to function as a forum in which progress-oriented individuals and institutions find a place to collaborate and present results. It also aims to provide an overview of the state of the art for performing arts digital collections within the framework of the following best-practice themes: digital library tools, education and research facilities, IPR issues, cultural heritage and technologies.

The ECLAP 2013 event comprised a set of sessions and panels conforming to our standard of excellence. We hosted a keynote speaker line-up consisting of some of the most salient voices in the field: Luis Ferrão, European Commission — DG Communications Networks, Content and Technology — Creativity Unit; Bertha Bermudez, Researcher, performer and project manager education at ICK Amsterdam; David Giaretta, Director of Alliance Permanent Access to the Records of Science in Europe Network; Amanda Rigali, Director, Combined arts and touring, Arts Council England.

The ECLAP 2013 conference international committee selected only the best proposals. Thus, only the 40% of the submitted contributions were accepted as full research papers. ECLAP 2013 featured more than 25 presentations coming from several countries: USA, Israel, UK, The Netherlands, Italy, Spain, Germany, Hungary, etc.

The conference is open to researchers, professionals, industries, institutions, technicians, and practitioners in the area of performing arts and information technologies, media-based entertainment, technology-enhanced learning, intelligent-media systems, acoustic systems, cultural heritage, and digital libraries.

The ECLAP 2013 conference aimed to be a place in which institutions, industries, the European Commission, and Europeana family projects in the areas of cultural heritage could find a wealth of opportunities for networking, debating, and sharing ideas and best practices.

As General Chair, it is a pleasure to express my gratitude to the keynote speakers, the dedicated Program Co-chairs, committee members, and conference support staff who contributed to making ECLAP a success. We hope that you will find the conference proceedings interesting.

Paolo Nesi

Message from the Organizing Chair

This second international ECLAP conference in Portugal was an exciting and stimulating experience for both the organizers and the participants.

The event served as confirmation that the ECLAP community, after almost three years, continues to grow steadily in strength and quality.

Interest in the project is high and growing: we received strong proposals from many excellent candidates, and were thus forced to turn down some very worthy and interesting submissions.

All the talks presented during the conference confirmed to us our belief that an interdisciplinary approach to the application of IT to the performing arts is both challenging and necessary.

It is difficult to meaningfully study all the ramifications of the sometimes-troublesome marriage of IT with performing arts. On the one hand, the risk is that humanities scholars may ignore, overlook, or oversimplify technical issues; on the other hand, IT professionals are not necessarily aware of the unique problems and needs facing the performing arts.

Our hope is that gatherings such as the ECLAP 2013 Conference will further promote dialog between specialists in the different fields, and spark fruitful future collaborations.

Other stated goals of the conference are the promotion of networking and knowledge transfer between the various EC projects belonging to the Europeana family.

I wish to thank those who enriched the ECLAP 2013 Conference through their contribution, as well as Springer for the publication of this volume.

Finally, I wish to thank all those who made the conference possible through their dedication and work.

Raffaella Santucci

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General Chair

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Sarah Whatley	Coventry University, United Kingdom
Andrea Zanni	Wikimedia Italia, Italy

Culture and Creativity in the Digital Realm: A Boost from the Past

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Biography

Luis Manuel Chaves da Fonseca Ferrão, 59, university studies in Economic and Social Sciences (ULB, Brussels, 1969-1970), Law (University of Lisbon, 1971-1976), First graduate of the Portuguese Training Centre for Judges (Centro de Estudos Judiciários, Lisbon, 1980-1983), Judge in various courts in Portugal (1983-1987), LL.M. European Judicial Law (EIPA/Maastricht-Luxembourg, University of Nancy, University of Thessalonica, 1994), Member of the First Board of Appeal of the OHIM in Alicante (1996-1999), Principal Administrator of the European Commission, in charge of the EU digital libraries and re-use policies and related intellectual property issues (2003-2012), currently in DG Communications Networks, Content and Technology of the European Commission, Creativity Unit, in charge of i. a. the legal and policy aspects connected with digitisation and online accessibility of cultural heritage through Europeana and similar platforms.

Multimodal Glossaries: A New Entrance to Artistic Insights of Dance Praxis

Bertha Bermudez

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Abstract. Through different multimedia examples, of websites, DVD-ROM titles and the description and aims of the research project Pre-choreographic elements based on the work of Emio Greco — PC, this lecture focuses on the potential of multimodal glossaries as tools for representation of choreographic praxis.

The role of practitioners is key to this proposal, where special emphasis is placed on the terminology used by the artists within their own creative process. Terms reveal the way concepts and ideas are appropriate to the artist, they provide an entrance into their artistic cognitive map while offering a resourceful content from which to derive interfaces and semantic relations. This approach aims at opening the artistic processes of creation from the perspective of those involved, dancers, dramaturges, and choreographers.

The collection of different media such as text, images, and sounds linked to specific principles used by choreographers in their praxis can become a fruitful way of displaying, teaching, acquiring, browsing, and sharing dance knowledge.

Keywords: dance, multimodal glossaries, terminology, cognition, transfer.

Biography

Bertha Bermúdez Pascual was a dancer in some of Europe's leading dance companies, including Frankfurt Ballet, Compañia Nacional de Danza in Madrid, and Emio Greco — PC. In 2005 she stopped performing and started working for Emio Greco — PC, transmitting their work and doing research around dance notation. Having turned toward research work, Bermudez has coordinated the interdisciplinary research projects (Capturing) Intention and Inside Movement Knowledge, both focusing on new modes of notating, documenting, and transmitting dance. Between 2007 and 2011 Bermúdez became an associate researcher at the Art Practice And Development Research Group, headed by Marijke Hoogenboom. Since 2009, Bermúdez has coordinated the academy pillar of ICK, which encompasses all research and exchange projects of the center. She is currently coordinating the research project Pre-Choreographic Elements and the development of the Performance Documentation Model.

The Space Project, a Partnership between Arts Council England and the BBC: Update and Initial Findings

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Abstract. Amanda Rigali presented The Space, the innovative digital project initiated by Arts Council England in partnership with the BBC. Dr. Rigali drew upon her experiences as Business Manager for The Space since November 2011 to discuss the impact of the project on the performing arts sector to date, and some of the issues faced by the delivery team and organizations commissioned to deliver work. Dr. Rigali discusses this within the wider context of her role as Director of Combined Arts and Touring, running a national touring programme and holding a strategic overview of key major live performing arts events that took place across England as part of the Cultural Olympiad.

Biography

Amanda's career in the arts began in research and teaching, first at Exeter University and then with an MA from King's College London and RADA. While studying for her PhD., she taught English and drama courses for the Open University and London University.

After working at the Almeida Theatre, Amanda became General Manager of Sphinx, a touring theater company that profiled work by women writers. She then became General Manager of the dance company DV8, Physical Theatre. While at DV8, Amanda worked on an international tour, a site-specific performance at Tate Modern, and an award-winning dance film for Channel 4, "The Cost of Living".

Amanda joined the Arts Council in 2004, first working within the Touring Department and then taking on the wider remit of combined arts and touring within the Head Office Arts Team. Amanda developed and launched the Arts Council's £45 million Strategic Touring Programme in 2011, and manages the Arts Council's national Artistic Assessment Programme. She has also acted as Business Manager for The Space, the innovative digital project Arts Council England launched in 2012 in partnership with the BBC.

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Bringing New Life to Video Narratives for Exploring Cultural Heritage

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Abstract. In this paper we present a project of creating a web based interactive encyclopedia of historical knowledge related to the history of the religions, the Bible and the history in general. The main source of information in the project is a film made by the Israel Museum that accompanies the exhibition of the Dead Sea Scrolls the oldest remaining copies of the Bible and extra Biblical documents. The film is describing the life of the members of the ancient community of Qumran that was behind the creation of the Dead Sea Scrolls. In order to annotate the video we developed a data repository for creating and for linking various types of digital information to the video. Data stored in the repository is then used to develop tools for exploring the film and related annotations.

1 Introduction

Cultural heritage is an important aspect of our lives. It can be seen as a common storage of all the experiences and knowledge that is acquired over the time, and is stored in the results of various activities of human life. With the advance of digital technologies new means of experiencing our heritage emerged, resulting in many research initiatives aiming at improving the ways we are dealing with the experiences of the past. By creating digital data representation and making these representations available over the Internet and by providing various tools for interacting with data, information technologies brought important change to the way we are experiencing our heritage. Information can now be accessed anytime anywhere solving the important issue of accessibility of heritage information. Another aspect is that with digital data representation new ways of interaction with information emerged. With these new ways of interaction, we may be able to understand this information in new ways and to acquire new ideas and understanding that were difficult to obtain using traditional means of accessing and exploring cultural heritage collections. The combination of new technologies and highly informative heritage content can not only shed a new light on our culture and society but can also open up new ways for implementing this knowledge in every day life.

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Video is a media format that is used in cultural heritage for a long time. It is used to present stories, ideas or knowledge about certain topics by combining visual audio and textual information. The combination of different types of information into a single medium made videos a popular choice for communicating information to the users. By presenting the information in the form of the story big amount of information can be presented in short time and with little or no effort from the user side. However there are some drawbacks of such an approach. Information presented in the video can only be accessed in linear manner. Users have no freedom to access and explore the information based on their goals and needs. This can especially be problematic when the presented information is complex. With the advance of digital technologies many new possibilities are being open for combining external information with the video and for enabling various new ways to interact with the information stored in video material. In order to present complex ideas and information users should be able to access the information in a video in many different ways. Instead of just by following the story of a video, they should be able to access any segment based on their information needs. In order to be able to do so a video should be accompanied by additional information helping users to easily navigate through the video and access information they need. Also the additional information should be used to help users understand topics presented in the video.

In this paper we present a project supported by a grant from the Dorot Foundation, aiming at creating a web based interactive encyclopedia of historical knowledge related to the religion and the Bible studies. The 20 minute long film made by the Israel Museum in Jerusalem, used as a central information point is combined with the set of annotations, to describe and explain the life of the Qumran community that is behind the creation of the Dead Sea Scrolls. The idea for the project came from the need to enrich the film and explain various historical, social and religious aspects that were in place during the time the Dead Sea Scrolls are created. Related work is presented in the section 2 that is followed in the section 3 by the explanation of the information space used as a basis for interacting with the film. In section 4 we present data repository used to annotate the film and in section 5 we present tools for interacting with the film and annotations. We conclude in the section 6 by discussing insights we got from the work on the project and discuss some ideas for future work.

2 Related Work

Cultural heritage - our shared legacy from the past - is a unique and irreplaceable source of identity and inspiration [1] Necessitated by both the quantity of information, as well as the burdens of archiving, organizing, and disseminating it, researchers and heritage managers have deployed a broad array of tools and methods to store their records. Over the time digital technologies proved to be invaluable tool in sharing the richness of cultural heritage content by using its heritage data in new ways. Recent trends, particularly in science museums, have been toward supporting visitors to actively learn rather than passively receive information. In [2] authors showed how a narrative designed with the help of digital technologies could be used to construct explanations and make sense of the world. Digital objects have become a vehicle for inspiration and source for exploring potential new meaning of heritage objects [3]. Framework that enables composition of diverse aspect of culture into a coherent representation is presented in [4]. Authors proposed mechanisms to build rich immersive narrative, and showed the importance of user interaction and modular composition of multimedia experiences. In [5] authors proposed a unified framework that enables the integration of disparate representations of heritage elements into a holistic entity. Their approach was tailored towards a compelling and engaging narration that affords a unified user experience. The proposed solution supported both active (user controlled explorations) and passive (watching pre-orchestrated narrations) user interactions.

The advancements in user interfaces on the web have increased number of potential applications that can be served over the Internet. Many types of technology platforms (mobile, wearable, tangible, web, kiosk etc.) have been used for the design of applications for communicating contents, either to support understanding or to engage visitors in the exploration of the museum exhibition [6]. By integrating the design elements, such as graphics, color, layout and animation effect, etc, content can be presented in a concrete and determinate style, which is tightly related to end user [7]. However current web based information systems often restrict the degrees of freedom of the. In most of the cases they only support a few search activities well and other search activities have to be performed using external means for support, making the search less integrated and less pleasant for the user. The emergence of interfaces with more advanced capabilities, such as faceted browsing and result clustering, can go some way toward addressing such problems [8]. Well-designed visual representations can replace cognitive calculations with simple perceptual inferences and improve comprehension, memory and decision-making [9][10]. The design of usable user interfaces for digital libraries is a complex task that requires knowledge and guidelines on user-centered design. It requires knowledge about the users, their tasks, the context of use, and what is technically feasible [11]. User studies are necessary not only for planning and designing information systems but also for their efficient and effective operation [12].

An example of novel interactive interface for browsing of large-scale video collections is presented in [13]. It visualizes underlying structure of the dataset by the size and spatial relations of displayed images. Interaction with digital information can be seed as a channel for accessing and sensing information in virtual environments. Relation Browser [14] is a tool for understanding relationships between items in a collection and for exploring an information space. Users can explore datasets using a mixture of searching and browsing, supported by keyword search and dynamic queries using facets. In another similar example [15], authors developed two interfaces that combined search and browsing, supported dynamic exploration of conceptual structures of a thesaurus, and provided dynamic term relation features to give overview of data. They showed that browsing through thesaurus improved users understanding of the relationships between materials and catalogue resources.

Rich media is a new media concept. It is different from traditional media such as audio, video etc. It is composed of text, graphic, image, animation, audio, video and other media objects in the time and space to provide a rich form of expression and interaction. [16]. Interactive video is a digitally enriched form of the original raw video sequence, allowing viewers attractive and powerful interactivity forms and navigational possibilities. Interactive video presentation is a form of interactive video document that is centered on enriched video but is not exclusively video. [17]. The *video collage* is an example of interface for dynamically summarizing and presenting mined multimedia information from video collections. Collages are presentations of text and images extracted from multiple video sources. They provide an interactive visualization for a set of analyzed video documents, summarizing their contents and offering a navigation aid for further exploration [18]. Another example of a tool for interacting with video collections is FreeEye [19]. It is a tool based on the efficient image clustering method and interactive hierarchical interface. It is based on an analysis of the captured video for the purpose of automatically structuring into shots or higher-level semantic units like TV news stories. A novel video browsing interface called TAV (Temporal Annotation Viewing) that provides the user with a visual overview of temporal video annotations is presented in [20]. TAV enables the user to quickly determine the general content of a video, the location of scenes of interest and the type of annotations that are displayed while watching the video. The TAV user interface consists of a traditional video player vertically adjacent to our novel-browsing interface. Below the video player multiple timelines are displayed. Each timeline refers to a specific type of video annotation, in this case goals or penalties in a hockey game. Each timeline consists of a visual identifier on the left side followed by a scrub bar with annotation icons. With all the advances in content-based analysis and proliferation of user interfaces the video is still mostly viewed in a passive way as a non-stop medium where the user's interaction with the content is somewhat limited. Hence, the viewing of the video is performed in a linear fashion where the only way to discover what is next is to follow the narration and move through the video guided by seconds and minutes. Such conventional techniques for video viewing and browsing seem to be inefficient for most users to get the crux of the video.

3 Human Sanctuary Project

In order to improve the experience and understanding of museum visitors, curators at the Shrine of the Book of the Israel Museum in Jerusalem, where the Dead Sea Scrolls [21] are exhibited decided to create a 20 minute long film (called a "Human Sanctuary" that deals with the lives of the members of the Qumran community [22] that was behind the writing and preservation of most of the Dead Sea Scrolls. creation of the scrolls. The film focuses on the life of two young members of the community, as well as of a young priest from Jerusalem Temple, covering various aspects of the communal life and everyday activities, whose understanding is important for social, historical and Second Temple Judaism studies. Writing techniques, community rules, religious rules and everyday life are just some examples of the topics covered in the film. Even though the film is short, it contains large amount of complex information that needs to be explained in more details. Over the time the curators at the museum

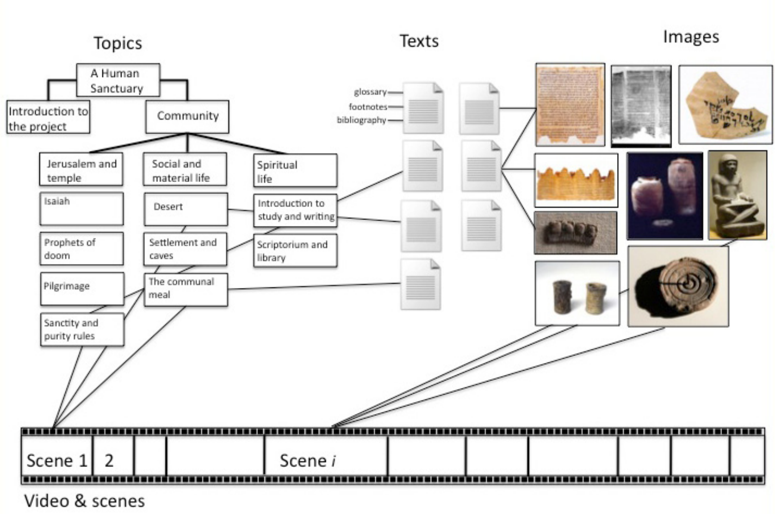

Fig. 1. Information space. The video is segmented into scenes. Each scene covers one or more topics. Each topic is described with the combination of text and images. Together with being part of the topic explanation each image is also linked to one or more scenes. All the relations between annotations are used as navigation paths through the information space, enabling users to move at their will.

realized that there is a need for explaining the film in more details to the general public. These explanation tools should help bring the content of the movie closer to the public and will help visitors better understand the importance of the Scrolls and the impact they have on our time. It was also realized from the experience in the museum, that the film could also be used as an educational tool that will provide researchers and scholars with valuable material on various topics. The idea of the Human Sanctuary project then emerged, with the main goal of annotating the film, with descriptions of various topics and developing web based tool for exploring and interacting with the movie and associated information.

The film is seen as a starting point of exploration and as a source for attaching additional information. The first step towards annotating the film was to create the hierarchical list of topics that is covered in the film. The hierarchical topic structure is meant to facilitate easier navigation through the information space constructed over the film. We use the term information space to denote the knowledge space that consists of all the available information (see Fig1). In this sense the goal of the project can be seen as creating the tools that will help users navigate through the information space and acquire new knowledge. The main source of the information, the film, is manually segmented into scenes. Each scene covers one or more topics that are fully described and explained using the combination of text and images. Together with text, explanations contain literature references for further reading, number of footnotes and glossary terms that are used to further explain various terms used in the texts. Images or real world objects related to the story of the film are used to enrich the descriptions. Also, images may be seen as a bridge between "fictional" side of the movie, where the reconstructed scenes and objects were used to tell the story and the real world objects as they were found in the site. There are three main groups of images used in the project. Images of the objects and other archaeological remains found at the site, images related to the excavation process, and images of the scrolls. Each image is linked both to the text and directly to various scenes of the film. In the same way as each scene is linked to one or more topics, each scene is also linked to one or more images. All the available information together with links between them forms the information space that will form the basis on which users will navigate and explore the content.

4 Data Repository

Setting up of a data repository was the first stage of the project from the technical point of view. At the beginning of the project, the only content that was available was the film, the initial list of topics and a small number of images. Complexity of the content, in terms of ideas and topics presented in the film resulted in difficulties not only in the presenting phase, i.e. how to present these topics and ideas to the users, but also on how to create the appropriate annotations. This meant deciding how to describe each topic how to link different information, what images to used for each topic, and so on. All the information used to annotate the film is highly interconnected and related which means that it was important to have the complete view of the content while working on details, which was not always easy. For the purpose of collecting and generating digital records that will be used in combination with the movie we developed an interactive web based content management tool, named Metadata Collector. The Metadata Collector provides basic upload, edit, search and browsing functionalities for generating and accessing of the content.

In order to link various external information with the movie, we defined metadata structure that assigns number of properties to every data record. All these properties will be used to build the information space, and to establish connections between stored data and the movie. At this stage users can fill in necessary form fields, and assign each object a number of time stamps, a number of topics, and a number of scenes. In this way the specific descriptive object is linked to the movie. Every object can then be described with key word labels and free text description. After each object is uploaded, users can browse the set of available records and edit them if needed. As the work on data collection evolved, we identified number of possible interaction tasks that could help curators in the process of content creation. One example of such interaction tool is an interactive data table where data records are displayed in rows, with data properties displayed in columns. Content creators needed a way to quickly inspect uploaded information with respect to specific metadata fields. Instead of browsing each individual items at a time, or browsing data in a data grid, where only small number of metadata properties may be displayed, information table gave content creators a chance to compare items on a single page, while having the overview of all properties. This proved to be very useful for understanding the current stage of the project and to get fast overview of the uploaded data.

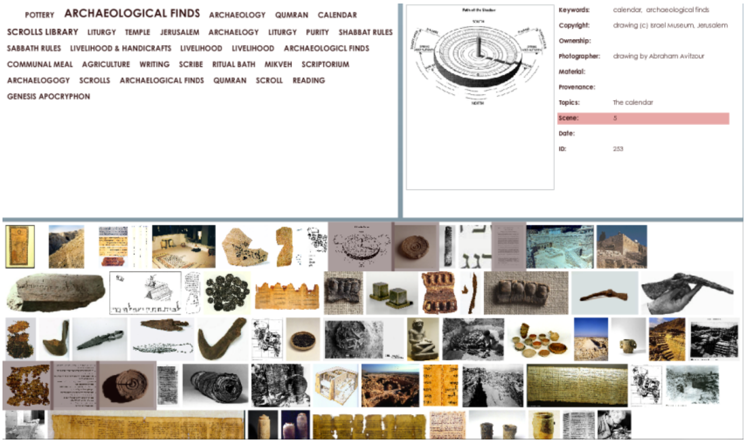

Fig. 2. Exploring relations between tags and images. Screen is divided into three parts, tag cloud, metadata panel and image panel. By clicking on any information item, set of related data is marked. For example by clicking on a tag set of images related to that tag is masked. By clicking on an image, metadata describing that image is showed and related tags are marked in the tag cloud. Users can also click on any metadata field, and set of images related to the value selected is marked in the image panel.

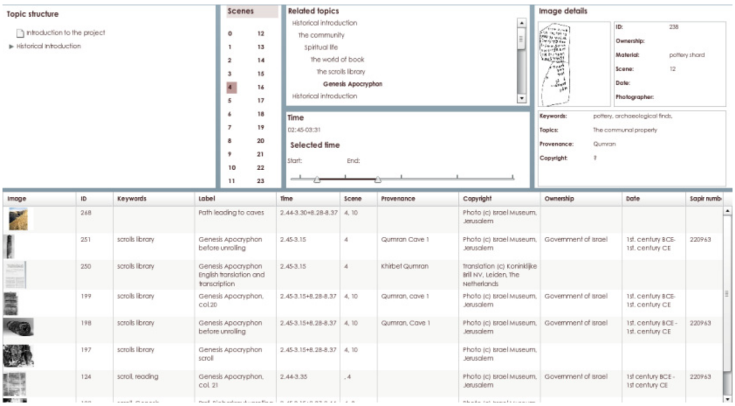

Fig. 3. Metadata exploration tool. Information panels show topic list, scene coverage, time intervals and image list and details. By clicking on any information presentation, set or related items is showed in all the other panels. For example users may select time range and set or images related to the selected time interval will be shown in the image table, set of covered topics in the topics panel and set of covered scenes in the scene panel. User can also explore each image in detail and edit the metadata values.

In order to focus on a specific data property like key word tags, we developed a data visualization tool showed in Fig. 2. This tool helps users understand relations between images and tags. The screen is divided into three parts, tag cloud, metadata panel and image panel. A tag cloud shows all available tags, and displays them based on the appearance frequency. By clicking on a tag, images that are assigned with the selected tag are masked. Next, user can click on any image and explore its properties in details. Another way of using this tool is to select any metadata property by clicking on a specific field in the image description. This will again mask all images that are related to the selected image with respect to the selected criteria. Another tool that we have developed for interacting with content is shown in the Fig 3. This tool is used to interact with more properties at once. It uses hierarchical topic's tree, scene numbers and time intervals as queries and displays results in the image table. By selecting single criteria as a query, all other available properties are used to show relations between the query and given properties. For example if users select specific topic, set of images related to this topics is shown in the data table. Together with data table, criteria's that are not used in query such as scene number, and time intervals are used to highlight properties related to the chosen topic. Also user can investigate images in details, and edit them if needed.

5 Exploring the Content

After all the information have been carefully created, checked and stored, we moved to the next stage of the project, the creation of the tools for exploring and interacting with content. At this stage, again, the museum professionals were highly involved by testing the early prototypes, and providing the feedback to the developers on how they want to interact with the content, and what should be achieved by the interaction. This collaboration proved to be very useful since it gave both sides a chance to see the project from different perspective, and to come up with useful ideas and solutions. The goal of the users interface design was to find the balance between the amount of information presented in the screen, and the complexity of individual information units that are shown to the user. The most basic functionality gives users a chance to simply watch the movie without any additional information.

First real challenge we faced was how to notify the user that additional information is available, and how to present this information in a way that wont obstruct users natural flow of actions on one side, and enable users to explore this information at their will. Also, the way information is presented in the screen plays important role on how this information is perceived and processed by the users. On the long run it directly influences the ability of users to understand presented information and to use this information to produce new insights and knowledge. The goal of the good interface should be to help users in their journey through the information space, and also to help them to understand the places visited, help them discover new information places, and finally help them create and develop their own personal information points of interests.

The first functionality we developed was a tool that gives users a chance to explore the set of annotations dynamically while watching the film. Initially this was one of the most important tools that needed to be developed, see Fig. 4. The idea is that while watching the film users get the information about the available annotations.

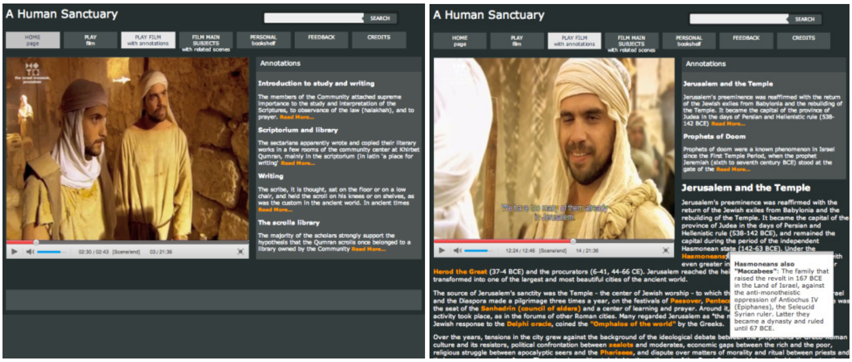

Fig. 4. Example of the user interface for watching the video and exploring the set of annotations. Annotation notifications automatically appear when specific video segment is played and are removed after the segment is finished, left image. User can then choose if they want to access the annotation (right image) or continue watching the movie.

The way users are notified about the available information while watching the video needed to be implemented in a way that will enable users to easily select next action. Whether it will be not to pay attention to the annotation and continue watching the movie or to explore the content of the annotation in more details, users actions should be smooth and not influenced by the appearance of new visual elements on the screen. This means that the way in which users are notified about the annotations should not lead users to actually access the annotation. Instead it should only open up the possibility for users to access the annotation if that is of interest to them. The main challenge for this task was the organization of visual elements on the limited screen space. There were three main groups of information that needed to be displayed. First, there is the film that should be at the center of the users attention. Second, annotation notifications should be presented to users together with the film, notifying the user when an annotation is available. The notification area should be shown in a way that enables users to continue watching the film without distractions, or enable users to explore the annotation in more details. Third group of information are complete texts of the annotations displayed after the users have responded to the notification by clicking on it. When a specific segment of the video is played, and there exist an annotation related to the specific segment, there is a short paragraph displayed on the right side of the video, with a short text of the annotation. If the user wants to explore the annotation in more details, they can click on the paragraph and get the full text with all the additional information displayed, and video stopped. After the video is played, and a segment for which the annotation exists is finished the notification for that specific annotation will be removed from the notification area.

The annotations itself are complex information units consisting of textual information and images where text is composed of the textual describing the topic, bibliography, footnotes and glossary terms. One of the finding of the early testing of the interface was that the screen that overfilled with information is not too helpful to users. On the contrary it proved to be distracting and often it resulted in users leaving the page

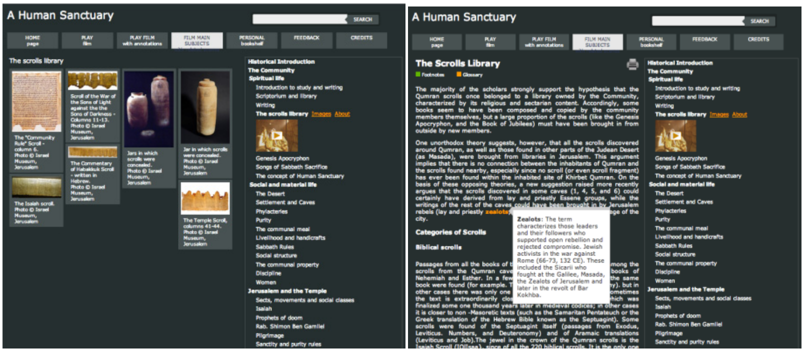

Fig. 5. Exploring the content from the list of topics. Users can choose a topic of interest and then watch all the video segments related to the selected topic, read the textual description of the topic or explore the set of related images.

without going through the content. This was an important fact to be taken into consideration, as we had to decide what information to display and how. The solution that we found to be satisfactory is to display the basic text as it is, and all the other additional textual information should be shown only upon the user action. The same solution is applied for footnotes and bibliography. Parts of text that can give additional information is shown in different color from the rest of text with the legend at the beginning of each text explaining the meaning of each color, and the type of information presented.

Another way of exploring the film is to start from the list of topics and then choose the next action. Users can watch individually all segments related to a certain topic, or may choose to read the textual description or explore set of related images see Fig. 5. In this case, users start from the annotation and come to the film, exploring the relations between data in different way. The film in this case can be seen as an annotation used to enrich the textual information. In this way we can see how the idea of information space comes to life, where all pieces of information are seen as individual information points, and the goal of the application is to enable the navigation through such a space. Instead of treating the annotation as an addition to specific information, in our approach the annotation is used at the same level of importance in the information space. Practically it means that the annotation is used to describe some information, but also the information can be used to describe the annotation. This two-way relation between the annotation and associated data is used by the interface to enable seamless navigation and exploration of the content.

6 Conclusions

We showed in this paper how the video material could be used to enrich the experience of cultural heritage. Instead of accessing a video in a traditional linear manner we proposed solutions for interacting with video material in a way that will give users more freedom while exploring the content. We also presented a data repository used to annotate the video and store the annotations. In order to control and evaluate the content, we developed number of tools. These tools give users a chance to interact with the content in a way that can help them understand and improve the existing information. Important aspect of our work is that the cultural heritage professionals were involved in the software development process from the start of the project. This proved to be very helpful since it gave us a chance to understand the needs of end users better. Currently the project is in the phase of intense user testing. First results of the user evaluation are very positive since most of the users liked the idea of combining different information in a way that enables them easy navigation through different types of information. The ability to watch the film and at the same time explore descriptions about various topics proved to be very useful especially for scholars interested in Biblical studies. At the moment we are working on developing additional set of tools that will enable users to add comments to the film and texts. In this way the information space of the move will grow by including user's ideas and findings.

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A Linked Open Data Service for Performing Arts

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Abstract. Linked Open Data (LOD) is a new way of sharing information about digital/physical resources allowing connected computers to better use information related with the resources. LOD allows to enrich information about resources possibly improving the user experience when using the resources or on finding them. This paper presents the experience in publishing as linked data the information which is present on ECLAP portal about multimedia content on performing arts. The system provides access to information about content, the terms of the taxonomy used to classify the content and also structural information like connections with groups managing the content, use in playlists and collections. Moreover information about annotations on audio/visual content is provided and also information about users is available (e.g., the 'friends' graph). The enrichments made on geographical information present in the content metadata (e.g., city/country of the performance) allowed to link content with the GeoNames database that is available as liked data.

Keywords: Linked open data, performing arts, metadata enrichment.

1 Introduction

The Web is a big source of potentially relevant background information, for example Wikipedia or WordNet provide detailed information about terms, concepts and relations among them, that can be used to enhance existing content metadata descriptions and improve the user experience in the access or while searching content [1][2]. However in the Web of Documents the information is not so easy to be extracted from HTML pages, for this reason in recent years the Web of Data is born to provide a machine friendly representation of the information on the Web.

Linked Data is a technique for data publishing that uses common Web technologies to connect related data and make them accessible on the Web. It is based on identifying resources with HTTP Uniform Resource Identifiers (URI), and, using standards like the Resource Description Framework (RDF) to provide data about these resources and to connect them to other resources on the Web [3].

Regarding the description of resources the best practices for publishing linked data suggest to reuse vocabularies already available. Reuse can be done by using classes and properties as they are or by creating a specific vocabulary and defining sub

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classes and sub properties of the ones already defined. Some well known basic vocabularies are present:

- *Dublin Core* (http://purl.org/dc/terms/) for the description of human-created artifacts,
- *Friend of a Friend* (http://xmlns.com/foaf/1.0/) for the description of persons, organization and relations among them,
- *Creative Commons* (http://creativecommons.org/ns#) for the representation of legal information about works,
- *Basic Geo Vocabulary* (http://www.w3.org/2003/01/geo/wgs84_pos#) for basic properties for the representation of geographical coordinates.

In the field of performing arts, there are some contributions, not all the aspects are covered by a single vocabulary. The *Music Ontology* [4] used by BBC programmes and music [5] and DBtune covers only the music related information, the *Linked Movie Database* has a vocabulary specific for the film domain and other ontologies like DBpedia [6] and Freebase are quite generic.

Another relevant aspect is the description of annotations of multimedia content, the Annotea project [7] was one of the first to adopt semantic web technologies for annotations but it was originally designed for annotations of web sites and therefore offers limited capabilities for annotating multimedia objects. The LEMO annotation framework [8] built on top of Annotea model supports annotations of media fragments [9]. Recently the Open Annotation Collaboration [10] model has been proposed and it is designed for the use as linked data.

The paper is organized as follows: Section 2 presents and overview of the ECLAP portal and project, Section 3 presents the ECLAP Semantic model describing the entities and the relations supported. Section 4 describes the linked data implementation, in Section 5 a tool used for the display and navigation of the semantic information is presented. Conclusions are drawn in Section 6.

2 ECLAP

ECLAP is both a Best Practice Network and provider of Content and User Services. As **Best Practice Network**, ECLAP consists of working groups that analyze the state of the art and identify the best practices and guidelines to cope with technical and strategic problems of the performing arts sector. To this end, three main ECLAP Working Groups (with corresponding blogs and forums) have been set up to cover the areas of: digital libraries and models for performing arts content, intellectual property management and tools, and digital content based tools for teaching and learning of performing arts in the new era. For facilitating the networking and discussions, ECLAP is also a repository of technical documents, demonstrators, best practices and standards that can be used to better understand the sector problems and find corresponding guidelines, state of the art solutions as well as future activities and project proposals.

The **ECLAP Content and User Service** exploits the use of advanced social media and semantic computing technologies and solutions for the content enrichment, aggregation and distribution of rich multilingual performing art content towards PCs and mobiles. Presently, ECLAP distributes more than 110,000 distinct objects (video, audio, images, texts, 3D), from 31 content providers, in up to 13 major metadata languages, towards a community of about 2000 registered users, world-wide distributed.

3 ECLAP Semantic Model

In Figure 1, the general ECLAP semantic model is shown where almost all the mayor entities managed by the system are reported.

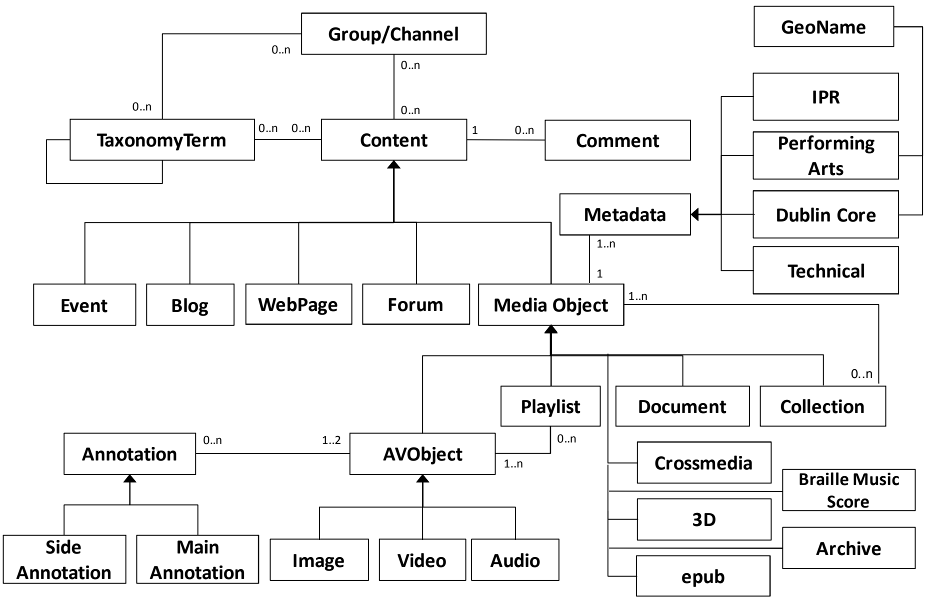

Fig. 1. ECLAP Semantic model

The *Content* elements that represent the content managed by the portal are associated with *Groups/Channels* providing the content (each ECLAP content provider has a group). Moreover each content can have *Comment*s and can be associated with terms taken from a taxonomy. *Content* is specialized in *Events*, *Blogs*, *WebPage*, *Forum* and *Media Objects*. Blogs, WebPages and Forums are used for providing news, general unstructured information and for stimulating users discussions on specific topics while *Media Objects* represent the multimedia content and their aggregations that are accessible from the ECLAP portal. The *Media Objects* are specialized in *AVObjects* (Image, Video, Audio) that can be used in *Annotations* and in *Playlists*. *Playlists* aggregate *AVObjects* in a sequence allowing to use even a fragment of the Audio/Video. *Collections* aggregate a set of *Media Objects* and in this case can include also *Documents*, *Playlists* and also other *Collections*. *Annotations* are used to associate a textual description with an audio visual object or to its fragment, moreover

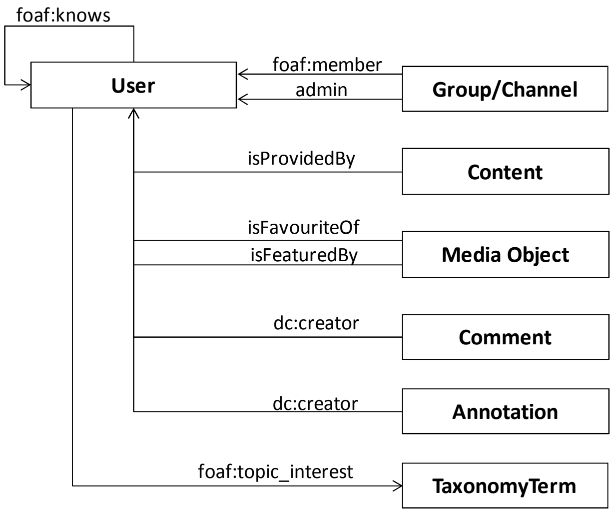

Fig. 2. Relations of users with other entities

it is possible to associate with another audio visual object (or its fragment) allowing to link two audio visual contents or even different parts of the same content. This kind of annotations are presented to the user via the MyStoryPlayer tool [11][12].

In Fig. 2, the relations among *Users* and other entities are depicted. A user may be a member of one or more groups and he/she can be the group administrator. Each content is provided by a user and each *Media Object* may be marked as favorite (similar to the facebook “Like”) by an user, moreover a group administrator can mark the content as to be featured on the featured object list on the portal. *Comments* and *Annotations* are linked to the user that created them. Finally users are linked with other users with the ‘knows’ relation that builds the classical ‘social graph’ and each user can specify the topic of interests among the taxonomy terms.

Each *Media Object* is associated with different sets of metadata, the general *Dublin Core* metadata (e.g. title, subject, type, description), the *Technical* metadata related to the content and its management (e.g. audo/video duration, workflow type), the metadata per IPR management and specific metadata for performing arts information (e.g., performance place, performance date, performing arts type, etc.). To be noted that some of the Dublin core and performing arts metadata elements (e.g. coverage, spatial, performance place, performance city and country) can be associated with GeoNames entities to allow to link to the GeoNames linked data service.

In Table 1, some of the properties specifically defined for performing arts are reported. These properties are defined as specialization of Dublin core properties and they were identified analyzing the metadata schemas used by ECLAP partners as well as schemas used by other projects and metadata standards. Among the properties identified information about the performance depicted in the resource (place, city, country and date), the premiere of the performance (place, city, country and date), the contributors to the creation of the performance each with the specific role (actor, dancer, light designer, hairdresser) is present.

Table 1. Some performing arts metadata properties

property	*sub property of*	*description*
performancePlace	dcterms:spatial	theatre or venue of the performance
performanceCity	dcterms:spatial	city of the performance
performanceCountry	dcterms:spatial	country of the performance
performanceDate	dcterms:issued	date of the performance
firstPerformancePlace	dcterms:spatial	venue of the premier of the performance
firstPerformanceCity	dcterms:spatial	city of the premier
firstPerformanceCountry	dcterms:spatial	country of the premier
firstPerformanceDate	dcterms:issued	date of the premier
plotSummary	dcterms:abstract	summary of the plot
performingArtsProfessional	dcterms:contributor	person involved in the performance realization
dancer	performingArtsProfessional	
actor	performingArtsProfessional	
director	performingArtsProfessional	
…		

A complete description of the ECLAP metadata fields is reported in [13] while indexing is described in [14].

3.1 Linking to Geonames Dataset

In order to link content record with Geonames, the data fields containing geographical information were analyzed to find matches with names that are present in the Geonames dataset. The fields considered are the (first)performance place, city and country and dublin core spatial and coverage. Since exact matching does not produce sufficient results the matching was done using full text search of the metadata field over the geographical names, the results have been filtered requiring that the words of the matched name have to be present in the metadata field. Moreover, when the country field is indentified for the identification of city or place the search is limited to names of that country. The matching is not perfect and it can be improved and compared with other techniques [15][16][17].

4 ECLAP LOD Service

The ECLAP portal allows to access RDF descriptions of digital resources that are available on it using specific URIs, the RDF description of the resource is provided in case of a LOD enabled browser otherwise the standard web browsers are redirected to the usual HTML page with a human readable description. Also the taxonomy terms used to classify content are accessible using LOD as well as the content annotations that relate them, the groups to which the content is bound (e.g., the group of the provider) and the ECLAP users.

The URIs currently supported are in the forms:

- http://www.eclap.eu/resource/object/<axoid>
- http://www.eclap.eu/resource/term/<tid>
- http://www.eclap.eu/resource/annotation/<aid>
- http://www.eclap.eu/resource/group/<gid>
- http://www.eclap.eu/resource/user/<uid>

where *<axoid>* is the identifier assigned to the content when uploaded (e.g., urn:axmedis:00000:obj:04e0caef-b33b-4f4a-ba50-a80d96766192), *<tid>* is the identifier of the vocabulary term (e.g., 501 for Dance), *<aid>* is the identifier assigned to the annotation, *<gid>* is the identifier of the group (e.g., 3160 for the Development group) and *<uid>* is the identifier of the user (e.g., 1 is the portal administrator).

The following links are present among:

- the content and the vocabulary terms,
- a content and the aggregated content (e.g., collection, playlist) containing it,
- the content and the groups that are used to provide the content (each ECLAP content provider has a group),
- a content and the annotations that describe it,
- the users and content, groups and annotations,
- the content and the GeoNames vocabulary for the places where performances were held, they are provided as a result of an enrichment made on the metadata.

In Figure 3, an example of how a content is related with vocabulary/taxonomy terms, collections and annotations is reported. For the description of the entities a specific ontology has been designed, this ontology is available as a linked data. All URIs used

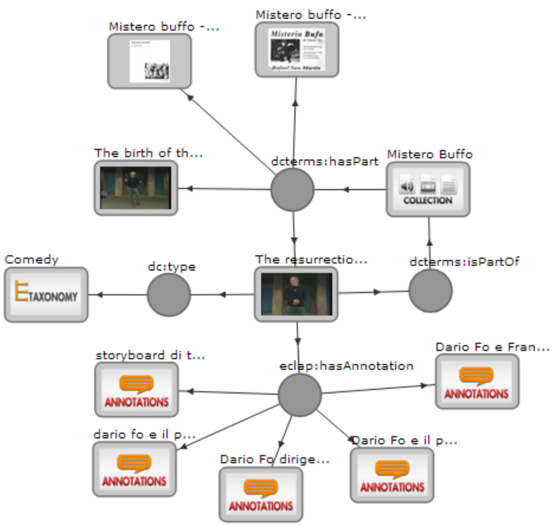

Fig. 3. Example relation among a content with collections, taxonomy terms and annotations

for properties and classes are dereferenceable and point to the ontology description (e.g., http://www.eclap.eu/schema/eclap/performancePlace) both as RDF and human readable documentation in HTML.

4.1 Content Description

Each content is described using RDF, the fields that are already Dublin Core terms in the ECLAP model are provided as they are, while the specific fields for ECLAP are provided by using specific properties (e.g., *eclap:performancePlace*) that are declared refinements of more generic properties taken from standard schemas (e.g., dcterms:spatial).

The relations with the vocabulary are provided by using specific properties (e.g., *eclap:genre* for the terms of the genre hierarchy) linking the LOD URIs to the terms. Also these properties are declared as sub properties of Dublin Core terms.

The relations with other aggregated content like collections are provided using *dcterms:isPartOf* and *dcterms:hasPart* properties. Relations with the group of the content provider that is giving the content are offered by specific properties, *eclap:isProvidedBy* and *eclap:provides* (both sub properties of *dc:relation*). These relations allows to link all the content, in particular it can be useful for crawlers allowing them to harvest all the content of a provider. The following is an example:

```
<rdf:RDF …>
  <rdf:Description
rdf:about="http://www.eclap.eu/resource/object/urn:axmedis:00000:obj:04..">
    <dc:title xml:lang="en">you PARA | DISO</dc:title>
    <dc:description xml:lang="en">In July 2010 Emio Greco and Pieter C. Scholten
presented their perormance "you PARA | DISO" at Salle Garnier de l'Opéra de Monte-
Carlo. You PARA | DISO is the last performance around Dante’s Divina Commedia. …
</dc:description>
    <dc:publisher xml:lang="en">iTheatre</dc:publisher>
    <dc:subject xml:lang="en">dance</dc:subject>
    <dc:format>video</dc:format>
    <dc:rights xml:lang="en">erik lint</dc:rights>
    <dc:rights xml:lang="en">emo greco &amp; pc</dc:rights>
    <dc:creator xml:lang="en">emio greco &amp; pc</dc:creator>
    <dc:creator xml:lang="en">erik lint</dc:creator>
    <eclap:performancePlace>Salle Garnier de l'Opéra de Monte-
Carlo</eclap:performancePlace>
    <eclap:performanceCity>Monte-Carlo</eclap:performanceCity>
    <eclap:performanceCountry>Monaco</eclap:performanceCountry>
    <eclap:performanceCountry rdf:resource="http://sws.geonames.org/2993457/"/>
    <eclap:performanceDate>July 2010</eclap:performanceDate>
    <eclap:choreographer>Emio Greco</eclap:choreographer>
    <eclap:choreographer>Pieter C. Scholten</eclap:choreographer>
    <eclap:historicalPeriod
      rdf:resource="http://www.eclap.eu/resource/term/567"/>
    <eclap:performingArtsType
      rdf:resource="http://www.eclap.eu/resource/term/501"/>
    <eclap:managementAndOrganization
      rdf:resource="http://www.eclap.eu/resource/term/514"/>
```

```
    <dcterms:isPartOf
       rdf:resource="http://www.eclap.eu/resource/object/urn:axmedis:00000..."/>
    <eclap:hasAnnotation
rdf:resource="http://www.eclap.eu/resource/annotation/SideAnnotation_130..." />
    …
  </rdf:Description>
</rdf:RDF>
```

4.2 Taxonomy Description

ECLAP provides six thesauri of terms for the classification of content (for a total of 231 terms):

- Subject (e.g., Teaching, Philosophy, Multiculture)
- Genre (e.g., Comedy, Comic, Drama)
- Historical period (e.g., Contemporary, Classical, XX Century)
- Movement and style (e.g., Experimental, Theatre of the absurd)
- Performing arts type (e.g., Dance, Ballet, Music, Rock, Theatre, Noh)
- Management and organization (e.g., Performance, Choreography)

Each term in the thesauri is described using SKOS [18], the relations among the concepts are provided using the *broader/narrower* properties, and each term is described with multilingual labels in 13 different languages. Moreover, each term is linked with all the content items that use that term using a specific *isSubjectOf* property. The following is an example:

```
<rdf:RDF>
  <skos:Concept rdf:about="http://www.eclap.eu/resource/term/501">
    <skos:prefLabel xml:lang="it">Danza</skos:prefLabel>
    <skos:prefLabel xml:lang="en">Dance</skos:prefLabel>
    …
    <skos:broader rdf:resource="http://www.eclap.eu/resource/term/664"/>
    <skos:narrower rdf:resource="http://www.eclap.eu/resource/term/540"/>
    <skos:narrower rdf:resource="http://www.eclap.eu/resource/term/539"/>
    <skos:narrower rdf:resource="http://www.eclap.eu/resource/term/507"/>
    <skos:narrower rdf:resource="http://www.eclap.eu/resource/term/506"/>
    <eclap:isSubjectOf
       rdf:resource="http://www.eclap.eu/resource/object/urn:axmedis:000... "/>
    <eclap:isSubjectOf
       rdf:resource="http://www.eclap.eu/resource/object/urn:axmedis:000... "/>
    …
  </skos:Concept>
</rdf:RDF>
```

4.3 Annotations Description

The annotations are used to describe the whole content or its fragment associating it with it a textual description and with another content or fragment. The annotations can be also associated with a classification term (e.g. scene, gesture, character).

The annotations are described using the Open Annotation Collaboration ontology (http://www.openannotation.org/) that is currently in working draft, the *hasTarget* property refers to the object being annotated, the *FragmentSelector* class is used to specify the temporal fragment of the annotated resource that is subject to the annotation and the *hasBody* property refers to the annotation body that can be the reference to another content or a text description. The *annotatedBy* property is used to relate the annotation to the user that created it and the *annotatedAt* indicates when the annotation was created. The following is an example:

```
<rdf:RDF xmlns:oa="http://www.w3.org/ns/oa#"
        xmlns:cnt="http://www.w3.org/2011/content#">
   <oa:Annotation
     rdf:about="http://www.eclap.eu/resource/annotation/SideAnnotation_13010...">
     <oa:hasTarget>
       <oa:SpecificResource>
         <oa:hasSource
            rdf:resource="http://www.eclap.eu/resource/object/urn:axmedis:0.."/>
         <oa:hasSelector>
            <oa:FragmentSelector>
             <rdf:value>t=npt:10,60</rdf:value>
             <dcterm:conformsTo rdf:resource="http://www.w3.org/TR/media-frags/"/>
            </oa:FragmentSelector>
         </oa:hasSelector>
       </oa:SpecificResource>
     </oa:hasTarget>
     <oa:hasBody
        rdf:resource="http://www.eclap.eu/resource/object/urn:axmedis:..."/>
     <oa:hasBody>
       <cnt:ContentAsText>
         <cnt:chars>this is an annotation</cnr:chars>
         <dc:format>text/plain</dc:format>
       </cnt:ContentAsText>
     </oa:hasBody>
     <oa:annotatedBy rdf:resource="http://www.eclap.eu/resource/user/1"/>
     <oa:annotatedAt>2013-02-28T20:00:00</oa:annotatedAt>
  </oa:Annotation>
</rdf:RDF>
```

4.4 User Description

Considering the privacy implication of publishing personal information about the user, minimal personal user information is provided, namely only the nickname is provided. However other relations are available such as:

- the ‘knows’ relation that connect with ‘friends’ users,
- the featured content,

- the favorite content,
- the uploaded content,
- the annotations created,
- the subscribed groups,
- the taxonomy terms of interest to the user.

The following is an example of the description of an user:

```
<rdf:RDF …>
  <foaf:Person rdf:about="http://www.eclap.eu/resource/user/45">
    <foaf:nick>bellini</foaf:nick>
    <foaf:knows rdf:recource="http://www.eclap.eu/resource/user/1" />
    <foaf:topic_interest rdf:resource="http://www.eclap.eu/resource/term/501" />
    <eclap:isMemberOf rdf:resource="http://www.eclap.eu/resource/group/3160" />
    <eclap:isAdminOf rdf:resource="http://www.eclap.eu/resource/group/3160" />
    <eclap:createdAnnotation
      rdf:resource="http://www.eclap.eu/resource/annotation/SideAnnotation..." />
    <eclap:hasFavorite
      rdf:resource="http://www.eclap.eu/resource/object/urn:axmedis:000..." />
    <eclap:hasFeatured
      rdf:resource="http://www.eclap.eu/resource/object/urn:axmedis:000..." />
  </foaf:Person>
</rdf:RDF>
```

The property *isMemberOf* is the inverse of the *foaf:member* property and the *createdAnnotation* property is the inverse of *oa:annotatedBy*. The *hasFavourite* property is defined as a sub property of *foaf:interest*.

5 Relations Display and Navigation

The ECLAP portal allows to display and to navigate the relations present among the entities managed by the portal. The 'Social Graph' of a Media Object is shown when a content is played or at user login. This graph is a simplification of the information that is available via Linked Data and the terminology used for relations is not always the same used in LOD.

The graph is made of two kind of nodes, rectangular shaped nodes represent entities (content, terms, users, etc.) while circular shaped nodes represent relations. Directed edges connect an entity node to a relation node and a relation node to an entity node. Examples of relations are shown in Figure 3. Regarding the user interactions the user is able to:

- **Expand** an entity node with its relations adding them to the graph
- **Focus** on an entity, in this case the graph is cleared and only the focused node is shown with its relations
- **Open** the page associated with the node
- **use the Back button** to go back to previous states of the graph (e.g. after a focus)

- **Zoom/Pan** the view
- **Hide/show** types of relations to reduce the complexity of the graph

A special node is the 'More' node that is presented when in a relation are present many nodes (e.g., the content associated with a group). In this case, providing all nodes could be infeasible thus a limited number of nodes is provided and a 'more' node is added to the relation. Clicking on it other nodes are added to the relation in a way similar to classical pagination used to present long lists in HTML.

In Figure 4, an example of ECLAP social graph of a content is shown after expanding some nodes.

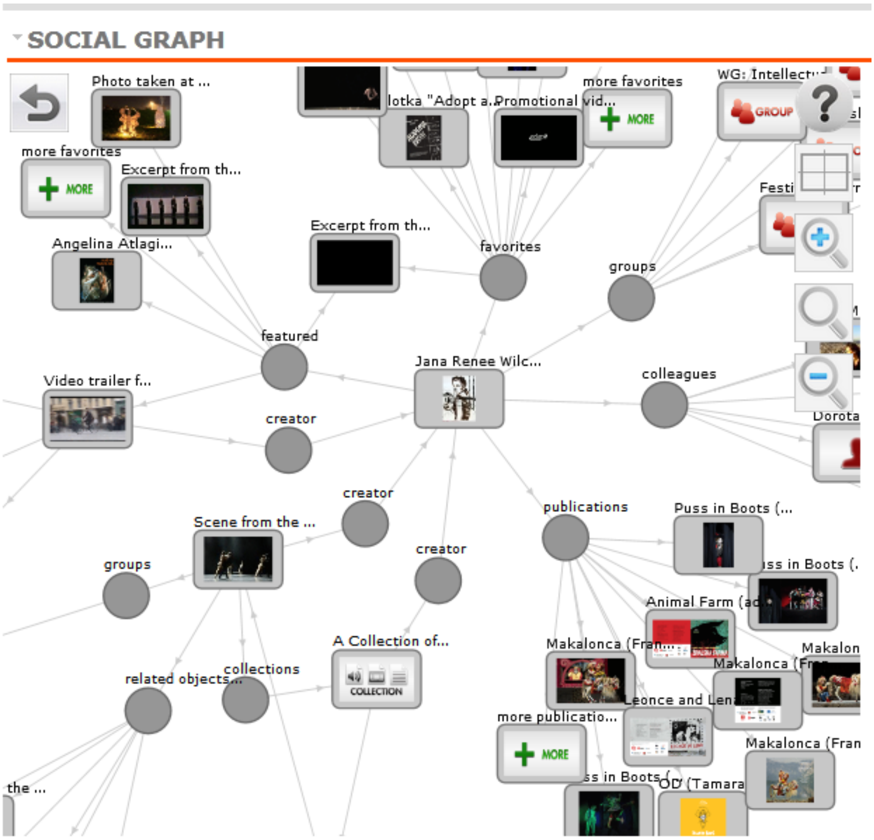

Fig. 4. The ECLAP Social Graph

6 Conclusions

The ECLAP portal is now publishing as linked open the description of more than 110,000 content items, the taxonomy used to classify them, as well as the annotations defined over them. This data is available and it can be used by semantic crawlers to find information about performing arts and other linked data systems can reuse our ontology or taxonomy terms or link to our content. Moreover the relations among the information that is present on the portal can be visualized using the ECLAP social graph that allows to navigate these relations allowing to find new content or some unexpected relation.

However the work is still in progress for linking the dataset to other source of information like DBpedia but also to identify person names that are present in the descriptions to create an authority file of people in the performing arts.

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A New Generation Digital Content Service for Cultural Heritage Institutions

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Abstract. The evolution of semantic technology and related impact on internet services and solutions, such as social media, mobile technologies, etc., have determined a strong evolution in digital content services. Traditional content based online services are leaving the space to a new generation of solutions. In this paper, the experience of one of those new generation digital content service is presented, namely ECLAP (European Collected Library of Artistic Performance, http://www.eclap.eu). It has been partially founded by the European Commission and includes/aggregates more than 35 international institutions. ECLAP provides services and tools for content management and user networking. They are based on a set of newly researched technologies and features in the area of semantic computing technologies capable of mining and establishing relationships among content elements, concepts and users. On this regard, ECLAP is a place in which these new solutions are made available for interested institutions.

Keywords: best practice network, semantic computing, recommendations, automated content management, content aggregation, social media.

1 Introduction

Traditional library services in which the users can access to content by searching and browsing on-line catalogues obtaining lists of references and sporadically digital items (documents, images, etc.) are part of our history. With the introduction of web2.0/3.0, and thus of data mining and semantic computing, including social media and mobile technologies most of the digital libraries and museum services became rapidly obsolete and were constrained to rapidly change. A tremendous push on renovation has been directly driven from the young users that expect to find in accessing and using cultural heritage and educational services (such as, digital libraries, museum, and educational portals and tools) the same mechanisms and dynamisms they are used to find in games and social networks. In fact, it is quite common to see teenagers sharing discussion groups on school aspects on Facebook with their teachers, and/or to get from professors demonstrators about experiments as links to play videos

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from YouTube portal. On the facts, at the present, we are in the phase in which the most famous cultural institutions have already partially adequated their services and offers to exploit the new technologies and opportunities, e.g., getting visibility on the major social networks. For example, on top positions in terms of Facebook likes and/or Twitter followers we have: MoMA, Metropolital Museum, Musée du Louvre, British Library, Guggenheim Museum, Centre Pompidou, British Museum, Getty Museum, Los Angeles, Smithsonian Institution, etc. In most cases, these institutions use social media solutions as promotional channels rather than taking the opportunity of exploiting the semantic computing innovations to provide new services and tools for their customers, for example to increase the user engagement. The last step would imply to dominate a higher level of technology awareness and it is much more complex to be conquered, in terms of both acceptance and investments. Success cases include: museums that have included interactive installations, mobile tools with augmented reality for supporting the visits, interactive content for mobile devices, the exploitation of geolocalized information, etc. Thus addressing different phases in which the user interact with the digital content in virtual and physical scenarios; before, during and after the visits in the museum. A faster and more complex evolution is observed for digital libraries and archives; which are cultural institutions in which the final experience start and finish on internet, rather than physical such as in the museums. Recently, new ways of fruition of cultural heritage digital content on the web have been proposed in which both content and users find their reciprocal relevance, and advances in establishing/creating stable relationships. The attention of professional users is focused on content oriented web sites, and in most of them several forms of content aggregation are offered. Several web portals and social services are growing as portals/engines, for example, collecting content metadata of articles, video, etc., indexing citations; thus, indexing cultural heritage metadata. Those portals and services are facilitators for the content identification, and the real content files/items, the digital essences, are only referred from the metadata; real files are only accessible from the original portal (web site, archive) of the content provider. This happens for many digital libraries, such as Europeana and partially for ACM, PubMed and IEEE and the other portals of publishers.

In most cases, the cultural institutions see their content ingested, promoted, distributed and exploited by final users via online commercial partners (e.g., google, amazon, YouTube), that may take benefits to commercial resell and/or via advertising. Most of these services are extremely general purpose and gradually exploit semantic computing technologies taking into account user profiling and providing suggestions and recommendations, also reselling ads spaces in web pages. In most cases, the benefits obtained by final users in exploiting the social networks services have motivated the users to use largely them, also as early solutions for professional usage: for example for content based service promotion, sharing content with students, distribution and discussion channel, etc.

Recently, professional users are unsatisfied by those general purpose social media solutions since they do not provide satisfactory facilities to perform advanced semantic aggregations and associations, learning management, that are, in effect, needed for educational and professional purposes. This new trend has determined the creation of a number of more specific and tuned services that in the case of digital library for arts can be identified as: Artyčok: http://www.artycok.tv, Digital Theatre: http://www.digitaltheatre.com, Digital Dance Archives: http://www.dance-archives.ac.uk, SP-ARK: http://www.sp-ark.org, etc. The needs of more sophisticated content services is becoming more sophisticated, pretending from the content and user services new social and semantic features with collaborative tools, aggregations tools, linked data, connection with social networks and mobile devices, augmented reality, navigation tools, etc.

In this paper, and overview of ECLAP (European Collected Library of Artistic Performance, http://www.eclap.eu) is presented. ECLAP has been set up as co-funded by the European Union ICT Policy Support Programme as part of the Competitiveness and Innovation Framework Programme, Theme CIP-ICT-PSP.2009.2.2, Grant Agreement N°250481. The main goal of ECLAP is the content aggregation and metadata semantic enrichment for Europeana. Europeana http://www.europeana.org collects cultural heritage metadata coming from several aggregators (as ECLAP), institutions, universities, foundations, museums, schools of art, that represent the European cultural heritage. Europeana foundation and portal do not collect content items files, but only classification information (i.e., metadata), including the original URLs to the content. These URLs refer to the original content owner and/or to the content aggregator. According to this, ECLAP performs cultural enrichment and promotion of European culture, and provides support for relevant improvements in learning and research in the field of performing arts. At the same time, ECLAP is a live lab in which several new technologies and solutions in the area of semantic computing and social media have been developed and put under trial of the final users and institutions. On this regard, ECLAP is open for both content and research results experimentations, and presently comprises more than 35 prestigious international institutions; 18 of them started since ECLAP early set up in the 2010, others joined ECLAP successively as affiliated and networking partners of ECLAP. They are representative of many different cultures and countries of the world such as: University of Florence, Dario Fo & Franca Rame Archive, University of Rome La Sapienza, Liber Liber, Fondazione Fabbrica Europa, Italy; Beeld en Geluid (Sound & Vision), University of Amsterdam, The Netherlands; Escola Superior de Música e das Artes do Espectáculo do Porto, Portugal; Festival International de Films de Femmes de Créteil, France; The Institute of Polish Culture University of Warsaw, Grotowski Institute, Poland; Museu de les Arts Escèniques Institut del Teatre de Barcelona, Universidad de Castilla La Mancha, Spain; La Bellone House of Performing Arts, Belgium; MUZEUM of Ljubljana, Slovenia; Hungarian Theatre Institute, Hungary; Museum of Archaeology & Anthropology, University of Cambridge, University of Glasgow, Coventry University, UK; Spain; Festival Cielos del Infinito, Chili; University of South Africa, South Africa; Department of Information Systems for Arts and Humanities, Russia.

The paper is organized as follows. Section 2 provides an overview of ECLAP. Section 3 presents the ECLAP aggregation tools. Mobiles tools are described in Section 4. In Section 5, the ECLAP services as collaborative and social tools are commented, putting in evidence their added value. Some notes on administrative tools and related data about ECLAP usage are reported in Section 6. Conclusions are drawn in section 7.

2 ECLAP Overview

ECLAP offers a wide support to cultural institutions on performing arts in moving towards the direct exploitation of new technologies for digital content management for different purposes that range from direct: dissemination, promotion towards Europeana, open data, social media, education and training, to the better understanding of new technologies and solutions. To this end, ECLAP is both a Best Practice Network and provider of Content and User Services (see Figure 1).

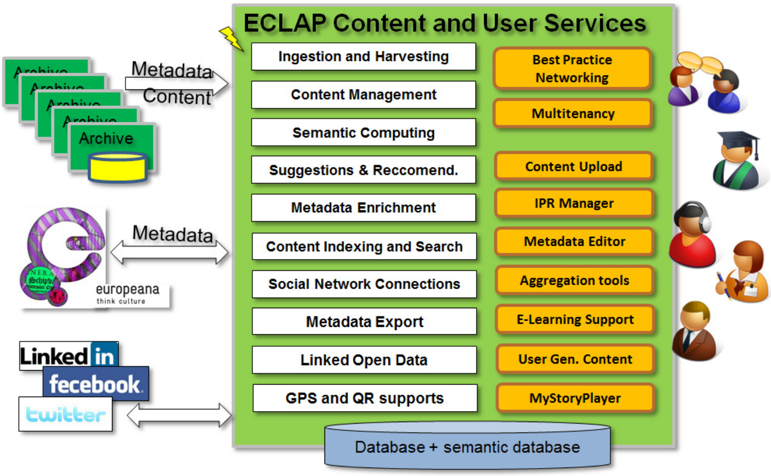

Fig. 1. ECLAP Services: back end and front end

As **Best Practice Network,** ECLAP consists of a number of working groups that analyse the state of the art and identify the best practices for the creation of guidelines to cope with technical and strategic problems of the sector. To this end, three main ECLAP Working Groups (with corresponding blogs and forums) have been set up to cover the areas of: digital libraries and models for performing arts content [1],, intellectual property management and tools [2], and digital content based tools for teaching and learning of performing arts in the new era [3]. Other Working Groups can be activated on ECLAP to cope with other topics. The ECLAP networking activity is grounded on the ECLAP community of experts that work on the working groups and meet each other at ECLAP workshops and conferences, such as ECLAP 2012 in Florence, Italy [4], ECLAP 2013 in Porto, at Europeana meetings, and in other conferences of the sector. For facilitating the networking and discussions, ECLAP is also a repository of technical documents, demonstrators, best practices and standards that can be used to better understand the sector problems and find corresponding guidelines, state of the art solutions as well as future activities and project proposals.

On the **cultural content side**, ECLAP is bringing together hundreds of thousands of the most relevant performing arts content items (often previously inaccessible on Internet), including collections on theatre, dance, music, cinema and film. These consist of performances, master classes, lessons, educational material, festival, costumes, sketches, scenography, lyrics and posters. Managed file formats include video, audio, documents, images, animations, playlists, collections, annotations, 3D, interactive content, Braille music, e-books and cross media interactive content, serious games and tools [5].

The ECLAP **Content and User Service** exploit the use of advanced social media and semantic computing technologies and solutions for the content enrichment, aggregation and distribution of rich multilingual performing art content towards multichannel: PC and mobiles (see Figure 2). Presently, ECLAP distributes more than 110000 distinct objects, up to 13 major metadata languages, towards a community of about 2000 registered users, world-wide distributed, while the largest communities of users and connections come from Italy, UK, USA, France, The Netherlands, Portugal and Slovenia. This means that ECLAP users can search from a unique service both technical documents and performing arts content. This approach may be an advantage since in many cases the distinction from technical documents and performing arts content is not strict. For example, these aspects are mixed and blurred in backstage technical documents, interviews, educational content, comments, and web pages. This also means that, for this purpose, the indexed content on ECLAP is heterogeneous and cross media, ranging from video, audio, documents, images, to blogs, web pages, collections, play lists, annotations and tools [6]. In fact, at each query the ECLAP query service provides an answer in terms of faceted results including different content types and formats. The indexing and search facilities of

Fig. 2. ECLAP Portal

ECLAP provide support for fuzzy correction of typos and for advanced queries, with and/or operators, substrings, perfect matching, etc. [6]. ECLAP offers a wide range of innovative solutions and tools to support cultural institutions in managing, providing access to and disseminating their online digital content collections to users in 21 languages. The ECLAP major content services are reviewed in the following.

Managing Content. ECLAP provides services and tools for automated content ingestion, adaptation, metadata ingestion and editing, semantic information extraction, indexing and distribution by exploiting the most innovative and consolidated technologies [7]. The content ingestion may start taking metadata and content files from any kind of archive and/or database or by providing them via FTP and/or web based utilities. Once the metadata area ingested, an intelligent content processing back office is capable of collecting and automatically repurposing content for distribution via pc and mobiles, coping with more than 500 digital file formats. According to ECLAP workflow, the obtained metadata are sent to Europeana only after that the metadata have been enriched and linked to a reachable digital resource and when the IPR details have been finalized, with needed quality level. The IPR management and the assignment of access restrictions is a way to enable the increment of possible available content on the internet. Permissions as IPR models can be enforced on content by each ECLAP institution (content owner), by using the IPR Wizard tool [5].

ECLAP supports the institutions in all their activities: metadata selection and mapping, content ingestion, to the definition and management of permissions and licenses on contents, and finally managing their users on ECLAP services.

An ECLAP IPR Model can be associated with each single content or collection. The IPR model has been derived from the work performed on MPEG-21 [8]. This means that access rules are imposed to restrict and regulate the content access taking into account: content format (video, audio, document, etc.), actions/rights (play, download, stream, embed, etc.), device (PC, mobile, mobile application), users' type (private, public, educational, etc.), location (nationality, university, ..), resolution (HD, high quality, medium, low, etc.). This model for content distribution with IPR management, is associated with a strong legal model as Terms of Use and privacy policy (see them on the portal). This allowed ECLAP to have in two years of content ingestion and distribution only one IPR resolution to be managed, that have been solved in a couple of emails, despite to the high number of newly published and accessed content items, and content providers involved, coming from different nationalities.

The ECLAP content management performs a wide range of metadata enrichment activities (based on AXCP media grid [7]). The typical **metadata enrichments** performed by ECLAP can be the addition of technical descriptors of source files, the addition of more languages, the geo localization passing from location named into metadata and descriptors to formal GPS position, the production of QR codes for museum inspection and linkage (see it as augmented reality first step), the content aggregation, the addition of comments and tags, the association of taxonomical classification, the establishing of connections with dbPedia open data, the addition of a formal IPR license descriptor, the association of univocal date and time, the association of an UUID (permitting the management of any kind of identifiers that may be available for the single content element such as: ISBN, ISAN, ISMN, private coding IDs, etc.), the production of LOD model, the content aggregations, etc. [9]. As a result, the content is described in terms of metadata based on the so called ECLAP semantic model which is much richer than the ECLAP ingestion model [10].

Therefore, the activity of **content publishing** to **Europeana** and as **Open Data** is very simple for the institutions since the content can be automatically ingested in several different manners, processed and automatically adapted for format, metadata and IPR, to arrive to be published as full content information on ECLAP service portal, while a subset of the metadata are provided to Europeana according to the EDM, Europeana Data Model [11]. The enriched metadata are also made available in different formats (as LOD, OAI-PMH, DC, etc.) for the former institutions (content providers) and for massive diffusion and promotion. Thus, the content published on ECLAP is widely indexed on all major engines and can be accessed from any kind of device, from PC, TV and mobiles. The ECLAP service also allows to update and review the extended metadata, for example to make corrections, add more details and/or additional languages, create links with other sources, etc., and automatically provides the updates towards Europeana, LOD, ECLAP, mobile, etc.

The ECLAP content model on WEB also allows the embedding (Copy HTML) of ECLAP content in third parties portals. The institutions may exploit ECLAP as streaming service for the audio-visual content by integrating in their lighter servers the provided HTML code of the ECLAP players. Moreover, ECLAP also provides infrastructural connection for direct promotion of content towards a large number of social networks, including: Facebook, LinkedIn, Diggs, Twitter, etc. The above described mechanisms can be exploited for promoting content on Internet and among other institutions.

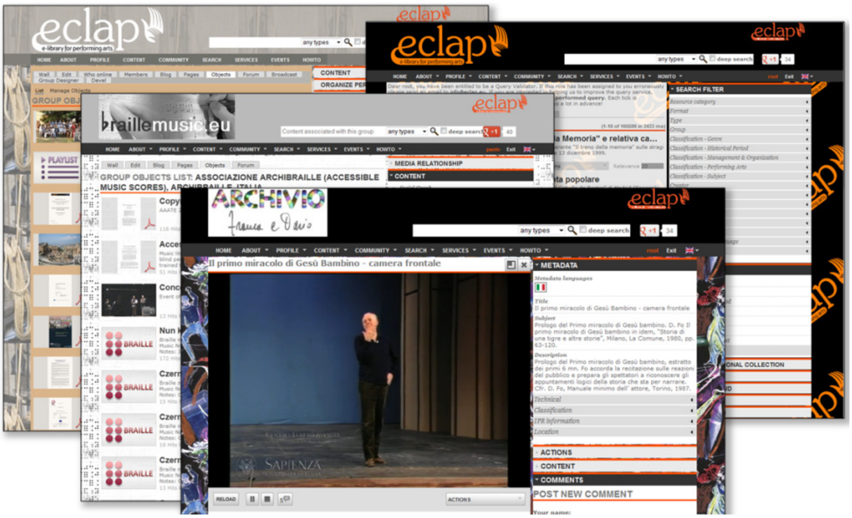

Fig. 3. ECLAP: institutions' groups and channels, e.g., BrailleMusic and CTFR of Franca and Dario Fo

On ECLAP, each content provider may have its own distribution channel/group (including a forum and a blog in addition to the space for their content collections, and the groups can be open, moderated or private) with the possibility of customizing the group user interface according to their logo and colours (see Figure 3). This **multitenant modality** permits at the institutions to see ECLAP as a non-intrusive service, to reinforce their brand and at the same time to exploit and experiment a number of innovative ECLAP tools, to accelerate the promotion exploiting ECLAP social media, LOD and Europeana channels, and ready to access new users for their content. Moreover, the ECLAP solutions is also very interesting for their users, that may get in contact with other colleagues, and may get a wider set of content in response to their search and queries, and may establish connections among different content belonging to different collections and to Europeana.

3 Content Aggregation Tools

Once of the most interesting features of ECLAP consists in the possibility of creating content aggregations. Content aggregations can be: playlists, collections, e-learning courses, annotations, and audiovisual synchronizations [10], [12]. The ECLAP service allows the users to directly create their own content aggregations and share them with other users. On the other hand, the automated production of content aggregations is possible, for example by providing content that reach the ECLAP ingestion service suitably tagged as belonging to the same collection, e.g., using a collection ID.

In ECLAP, the **Collections** are simple aggregations of ECLAP content that may be personally defined for private use by each user and may be published and shared to the others. During the collection publishing, the user has to assign classification and identification metadata. This allows to consider Collection as regular content and to export them as linked open data, as well as to provide them as aggregated content towards Europeana EDM, and thus are part of the ECLAP semantic model.

The ECLAP **Playlists** are used to create specific collections of audiovisual content, e.g., a set of audio tracks, videos and images, to be played in a given order. The playlist execution consists in the sequential play of the single content objects. In ECLAP, the playlist supports the inclusion of images and audiovisual segments of the media. The same media can be included in several playlists and/or any time segment can be used in any playlist. The execution time ordering for each playlist object is user defined. In ECLAP, the user may put in the play list a small segment of video and audio, without the modification of their corresponding files. The access to the video segment is performed in real time by the video player as execution time only. This permits to create e-learning units without the need to slicing audiovisual. The semantic of ECLAP playlist allows to play the audiovisual content according to the identified sequence only once or in a continue loop, from last to the first forever. From the operative point of view, a user can take from the portal any audiovisual segment to compose its own playlist. The operation is performed on a specific audiovisual flash player in which one can select the start/end of the audiovisual segment. In the case of images, a duration time of their permanence on screen can be also set. Once a play list is complete, the user may decide to publish and share it on ECLAP. In this case, metadata and taxonomical information are requested. The published playlist can be aggregated in Collections and into Courses as basic elements. Please note that the association of metadata keeps unchanged the metadata associated with the objects composing the playlists.

On ECLAP, e-learning **Courses** are defined as a set of content objects (audio, video, collection, playlists, web pages, blog, events, etc.) organized in lesson units and glued by descriptive guiding text of the course. A lesson unit may include also links, external resources, questionnaires, soundages, etc. The courses have specific mechanisms to control their access from the students according to the e-learning/distance learning certifications models and legislations. These mechanisms allow controlling the effective access and fruition of the single lesson unit. To this end, a specific back office is provided (for teachers, students, coordinators, tutors, administrators, etc.) to manage the course subscription, monitoring student progresses, etc., as in regular learning management systems, LMS.

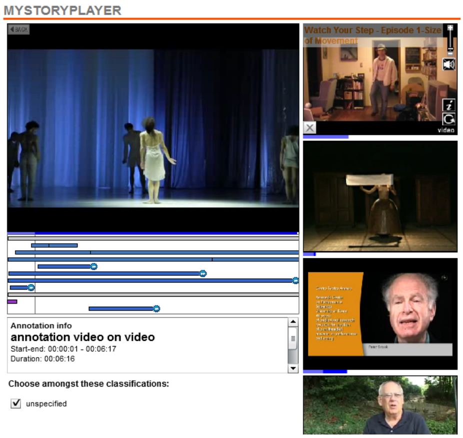

Fig. 4. MyStoryPlayer

A more sophisticated aggregation tools has been derived from MyStoryPlayer tool [12]. With MyStoryPlayer users may define **annotations and/or relationships** among audiovisual content segments (image, video, audio) (see Figure 4). For example, defining sequences of video, synchronized execution of video segments, annotation of an audiovisual segment by using another segment, etc. The associated comments and tags to the relationships can be used to search, filter and describe the annotations. This approach allows creating multiple media executions and comments that can be used for training and explaining didactical situations. By using the MyStoryPlayer, an ECLAP user can perform annotations on any audio, video or image located on the portal by using a simple on-line tool. Then the annotations performed may be played/executed by the MyStoryPlayer tool, where a full interactive player allows navigating on the several relationships established among the audiovisual content elements on ECLAP. The activity performed on the audiovisual executions, including the clicks and jumps from one video segment to another, etc., can be recorded as personal experiences (paths) and shared with the other users, for example for educational purposes. The semantic model in terms of RDF triples allows searching for annotations and it is sent to the MyStoryPlayer according to contextualized SPARQL queries [13]. The semantic relationships are also published in terms of LOD and on Europeana EDM, and thus are part of the ECLAP semantic model. As for the other features like play lists and collections, no alteration is performed on the original file, thus no specific IPR authorization is needed to use them in MyStoryPlayer.

4 Mobile Tools

The content access from mobile devices is presently a facility that is given for granted by many institutions. Most of the present smartphones and tablets are capable to access at complex web pages to play video and open large documents. On the other hand, in order to use these devices for educational and professional usages several other features have to be available. To this end, in ECLAP the Content Organizer mobile application has been developed. The Content Organizer allows at the final users to get access content from multiple cultural heritage portals according to the IPR models, saving the registration and authentication credentials. It is available for iOS, Android and Windows Phone and it allows users to download and organize content in the mobile device. The content download may start from ECLAP portal as well as from QR code. Once the content is downloaded to the mobile, the user can manage on the mobile device, performing search, browse, tags, and get GPS and general information, etc. The Content Organizer may organize and play ePub formats, video, audio, cross media content, images, documents, pdf, collections, etc. The content can be browsed for groups, portals, taxonomy and personal tags. The latter are also used for creating a personal organization. The content is indexed and can be accessed via GPS locations, permit the upload of content from their mobile, etc.

5 ECLAP Added Value Collaborative and Social Tools

One of the challenges of ECLAP has been the setup of a service and environment in which professional activities would be facilitated by the mediation of computer supported collaborative tools. In fact, in most cases content aggregation portals are simple ingestion tools in which the metadata are ingested and then passed to Europeana. In the case of ECLAP, the best practice network and the service portal have the potentials to continue at providing the services for a longer time. In terms of services for the final users, ECLAP is providing a set of added value tools and services that motivate the institutions and final users to continue stay the usage of ECLAP.

Networking and connections with colleagues. ECLAP service allows the user to get registered on groups and channels, on which blogs and discussion forums are available. Moreover, the comments and votes can be associated with each content and web page. This allows creating a collaborative environment in which different kinds of discussions may be hosted. These mechanisms are also supported by the possibility of importing contacts from social networks and by the possibility of sending direct recommendations and messages, and establishing stable connection with other colleagues. **User recommendations** and suggestions. In different contexts, the ECLAP users receive suggestions about content and/or colleagues of their interest. This service is based on estimating similarity of those elements with their static and dynamic profile [14], thus contextualized suggestions on the basis of general interests and recent behaviour on ECLAP. This feature is strongly appreciated by ECLAP users, since the suggested contents are among the most frequently clicked. Suggestions are also provided by means of regular newsletters via mailing. **Content management**, publication and promotion, publication and update on Europeana, publication of LOD, distribution towards mobiles, content and video streaming for third party portals via embedding, IPR management to control content access, multitenant solution for content provider branding of the group, connection with social networks for content promotion (contact importing, social icon and recommendation towards social networks such as: YouTube, Facebook, LinkedIn, Twitter), etc. The automated content ingestion and processing facilities based on AXCP belong to the content management [7]. They are provided for both massive professional and user generated content. **Content aggregation tools**, which can be used for personal purpose and for educational access and content distribution, such as: playlist, collection, MyStoryPlayer, courses, Social Graph. This feature is associated with the several facilities for content enrichment (addition of semantic information, links, comments, annotations, contextualization, tags, votes and the addition of other languages for metadata). **Search facilities** with its indexing, advanced features and faceted results on all the extended metadata (more than 500 metadata fields for each content) is a very interesting and requested feature [15]. Taking into account that ECLAP provides a much better search quality with respect to the similar services accessible for cultural heritage content provided by the former institutions. This is due to the fact that: most of them do not take into account full text multilingual and semantic search. Moreover, only a small part of the ECLAP semantic model metadata are accessible on Europeana. **Social Graph tool** (see Figure 2) that allows seeing, explore, play and browse the relationships among users and content. The Social Graph is directly accessed from the home page of each registered user. The users have the possibility of learning more about the relationships established among content and those among users, thus stimulating them in creating more connections among content and users. A large number of new relationships are going to be added on this semantic tool.

6 Administration and Monitoring Tools

In ECLAP, a relevant effort has been dedicated to provide at the single institutions and group a set of tools for managing and monitoring the development of their content and activity for their groups/channel members, and social network analysis. The content management allows performing single and massive editing and changes on content associated with the group. For example, to change the taxonomical association to all content elements of a collection, the change of the IPR model for a large set of selected content, etc.

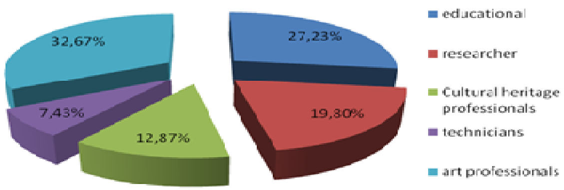

Fig. 4. Distribution of ECLAP users profiles

Regarding the group's users, each group manager can pose specific queries. For example, to understand which are the most active users, the most accessed content, the most active periods, the commonly accepted content types and topics, the most interested devices, the collective intelligence profile of the registered users, etc. In Figure 4, the distribution of the active 1800 ECLAP users is reported, where: educational are teachers and students; cultural heritage professionals are editors and archivists; and art professionals are performers, directors, composers, etc. The ECLAP users remain on the portal for about 5 minutes for each session, and during their permanence spend a large part of their time playing video, reading documents and web pages, 6% of them perform queries, and recently the 10% of them navigate into the social graph. In terms of areas of work, they dedicate their time at the content workflow for the 55%, at content access 20%, networking the 11%, query and search 4%.

In terms of content, the ECLAP users present an equal interest on content and informative web pages. Among the content accessed and downloaded, the most requested are PDF documents with 60%, while online video streaming and documents view provoke similar interest of about 18%, images are seen in the 55% of the cases. These data have also to be weighted with respect of the offered population of the 112000 content elements that present: 65% images, 4.5% of audiovideo, 1% of web pages, 29% of documents.

7 Conclusions

The strong technological evolution in the field of digital media, digital library, social networking and cloud computing have determined a strong push in the renovation of cultural heritage solutions for archival institutions and museums.

ECLAP is presently used by more than 35 institutions mainly from Europe. It may be regarded as a new generation of digital content service tools for cultural heritage institutions that allow them to exploit specific and advanced benefits from semantic and social media technologies: networking and social networking, automated user recommendations, automated content management, advanced and collaborative content aggregation tools, IPR management, advanced indexing and search facilities, social graph and LOD, and mobile applications. These advanced features are also supported by precise and massive administrative and monitoring tools, which include facilities for social network analysis, and statistical data analytics.

ECLAP can be regarded as a vertical service for performing arts institutions, while it could be easily replicated for several other cultural heritage single institutions and/or aggregations of them. Moreover, some of the ECLAP tools (IPR Wizard, MyStoryPlayer, Social Graph, automated back office based on AXCP [7], MINT metadata mapper, etc.) can be also adopted in other services.

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How to Catalogue the Cultural Heritage "Spectacle"

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Abstract. This paper provides first a brief history of digital archiving and cataloguing cultural heritage in Italy and important achievements obtained by Prof. Eugenio Battisti and his team of the University of Rome "Tor Vergata" in the last decades of '900. Then the author presents a comparison between available catalogue schemas provided by public and private institutions and the cataloguing needs of a particular cultural heritage like "spectacle". A new prototype schema is proposed, which has already been used in a real project.

Keywords: component: spectacle, digital catalogue, costumes, dress, cultural heritage, VeAC.

1 A Cultural Heritage in Data Management

In the Second University of Rome "Tor Vergata" an interdisciplinary team of researchers, led by Prof. Eugenio Battisti[1], has started in 1983 at the Engineering Faculty to experiment a new catalogue system based on computer systems.

«With these software, wrote E. Battisti, among which one of the best is considered DbaseIII plus [2], it is possible to divide every handcraft in smaller parts, yet in homogeneous and significant manner, in order to compare it as by details as per whole with others similar or different, to obtain a comparative or enumerative table, shown in a graphic layout, too. [...] With respect to the paper schema, the structure can be always modified during work proceeding and even afterwards [...][3]».

Computer and computer programs should not only be used to archive massive data, but also and mainly to offer the possibility to compare them simultaneously.

The research goal was to find a structure as complex as can be, which was able to answer the request of an expert, in this specific case an art historian.

To work this out not only programming skill needed to be provided, but also expert of art history, theater and other disciplines had to participate in the present research,

«The research strategy was not devoted to inventory, but mainly to historical interest, with large scale comparisons based upon rare and experimental associations[4]».

The catalogue obtained by using DBase III plus started to provide incredible results for that time. Each schema was formed by 128 fields, giving the possibility to create

P. Nesi and R. Santucci (Eds.): ECLAP 2013, LNCS 7990, pp. 39–49, 2013.

128 per 128 cross index data table. On the other hand, these cross indexes can be multiplied by simultaneous opening of 10 data files.

The art or architectural handcraft' s critical analysis possibilities available to an expert increased enormously.

All terms used in this catalog were collected and indexed, in order to obtain a "Dictionary of Terms" which could then be translated in other languages, to enable international experts and users to use this program.

An international project titled Critic Art Data was started in 1987 involving Italy and Spain, according to the E. Battisti' s idea of using database programs for collecting data regarding catalogues of contemporary art exhibitions.

Cristina Gutierrez Cortinez led the Spanish art history expert group. At that time she was Director of cultural events and evening courses in University of Murcia (from 1978 until 1993).

The Italian art history expert group was led by Rossana Buono, researcher at E. Battisti' s cathedra.

First result of this working group was to create a new documental center of contemporary art "Archivio del Contemporaneo" in the Second Rome University "Tor Vergata".

In November 1988 I had the chance to record an interview with E. Battisti[5]. He told the Radio RAI public and me that the main goal of this documental center was to preserve not only exhibition catalogues on papers, but also video records related to contemporary art happenings, which in fact were the unique historical memory of the early '70s art performances, not recordable in any other way.

E. Battisti was very generous, too, by donating to this new center all videos owned by the magazine "Marcatrè" he had founded in Genoa in 1963.

Next, he signed with RAI an agreement allowing the center to get TV and Radio tape records related to art and interviews of contemporary artists from our national company.

E. Battisti understood prior to many others how well new recording media would fit data archiving and preservation needs.

To best meet the actual paper archiving and cataloguing procedure it was important to have a suitable data archiving program which could be able to satisfy all the requirements.

Therefore, E. Battisti started to search and test several of the available archiving program on the market. His aim was to test these software according to cataloguing and archiving requirements.

In order to accomplish this task, he created a school class which would provide knowledge and skill to a group of students in order to perform this testing and researching activity.

By working in this manner E. Battisti has given to his research a general purpose, providing the basis upon which cultural heritage data archiving and preservation would enhance by the use of computer system and programs, as well as to meet a very wide online data accessibility to almost every kind of user.

A new software called "Catalogo dei Cataloghi" was the result of the above research, and all data present in ca. 9000 existing paper catalogues were recorded into this new catalogue archiving program.

During Frankfurt Fair (Germany) in 1988 the new "Catalogo dei Cataloghi" was shown to the public in the Italian section held by "ArteOggi". It was the first Italian public cultural heritage data base program[6].

E. Battisti' s research was not limited to realize a public data base program, and furthermore attempted to approach interactively any possible user of the program. The chance to realize it was during the exposition "In Forma Urbis"[7] held in Rome in the same year.

Still today it is possible to visit the documental center of contemporary art "Archivio del Contemporaneo" in the Second Rome University "Tor Vergata" at the department of " Scienze storiche, filosofico-sociali dei beni culturali e del territorio" , as well as online on internet site of the University.

In charge as Director of "Archivio del Contemporaneo"[8] is Rossana Buono, since 1989, who has also joined other projects and researches led by E. Battisti in the '80s.

2 From Interactive to Hypertext Schema

As a whole, a spectacle is a fleeting and expressive matter of study in respect to past history and usually catalogued per kind (category). It is philologically explained by analytical retracing of memories. The analysis of theatrical performance takes advantage of different methods: historical (historiography), comparative, semiotic, social and anthropological, which have all been imported, adapted and applied to the present matter from other context[9]. Due to short extension of time and nonmaterial nature of a spectacle, the historian attaches great importance to real documentation. It becomes matter of delimited researches, derived from the original nucleus not available anymore.

Subdivision of Academic specialties in different matter of interests gave the opportunity to preserve important memories of spectacle. It has brought to an accurate document analysis finalized in producing a catalogue of them. This work helped very much in preserving and defending past spectacle objects and has given the chance to create digital archives of them, which today are very often visited and navigated by researchers[10].

On the other hand, a sector and specialty analysis ends to isolate a "part" from the "whole" and the spectacle, summary and synthesis of all animated and not animated parts it is composed by, no anymore appears as a complete art work to which costumes, stage sketch or tool, libretto, play script, video and others are strongly related. Cataloguing any one of these real document involves a sector specialist who usually "isolates" investigation object in his study, instead of composing it with the original unity[11].

Art historian, according to an academic point of view, considers stage scene and costumes a craft work, which means a minor piece of art as per value as per importance in respect to a major art, like architecture, painting and sculpture. This approach, not to be underestimated, has brought to many mistakes in theoretical studies as well as in preserving and valuating cultural heritage in respect to recreation and rearrangement of a spectacle. In Italy, just recently scene sketches has become popular to art historian, who studied them with regard to researches of well known artists in order to compound the whole painting and/or sculpture work done by these artists[12].

Character' s sketch and costumes are generally referred into the history of style and fashion. About their study, the first is usually considered an artist invention and therefore belonging to art historian, while the second belongs to costume historian.

In 2010 the Cultural Heritage Ministry in Italy (MiBAC) edited the book *"Vestimenti antichi e contemporanei. Scheda VeAC e Lemmario – Strumenti di catalogazione per la conoscenza e la tutela di un Patrimonio"*, written by G. Butazzi, G. Damiani, E. Giffi, R. Orsi Landini, T. Schoenholzer Nichols, and introducing the new VeAC (Ancient and Contemporary Dresses) schema[13]. In elaborating the digital schema VeAC, guideline proposed by the multidisciplinary expert team (historian, technological, scientific, commercial and others) was to have an easy to use computer program with common tools and uniform behavior suitable to several different areas of public and private archiving institutions resident in our country.

VeAC schema is composed by an eight pages long table, splitted into several sub frames related to technical or administrative data, regarding where it comes from, its usage and how it looks like, its tailoring technique, origin and ownership of ancient and modern dressing. The present schema works with a wide selection of specific terms ("Lemmario") the user has to choose among the appropriate one to fill in descriptions and answers when and where requested by the VeAC schema filling program. In this manner «[…] description of cultural heritage is structured inside a given schema and a descriptive vocabulary is prepared with "normalized" and controlled words»[14].

This "ideal model" provided to catalogue dresses, which public and private institutions should use to input data with a common procedure, came out to be not quite applicable in normal operations. To complete each Data Input Table takes a long time and operators need to be skilled in several disciplines in order to choose the correct answer, which brought to increase cost and time of the archiving procedure.

Nevertheless, the work done to design and to realize the VeAC schema is fundamental because it has taken the MiBAC institution to recognize the historical, artistic and cultural heritage of "dresses and costumes". It has been the first time that "dressing" was defined as "cultural heritage", which means a real part of national property and therefore an object to be preserved and valuated.

In November 2011, in relation to the project work " '900 Fashion archive" the ANAI Institution (Italian National Archives Association) together with the Archive General Management opened the new "Fashion Archive Portal"[15]. The schema used to present online web data related to each dress takes advantage of the previous VeAC schema, even if many general and specific data has been taken out to allow the user to read just in one window the most he might be concerned about each dress. Data are structured as a branch-leaf tree (hierarchy), with a root frame containing the principal data and several links available to navigate through other information in different related archives. Likely, even if made more simplified in content and presentation, are digital data schemas related to ancient and modern costumes available in "Europeana".

A quite similar structure, just to catalogue theatrical costumes data, has been chosen by the research group of DAMS institution in Bologna, managed by Paola Bignami, who promotes since '990 researches on stage costumes and tutors their archives and catalogues. With respect to the present research work, a group of teachers and researchers of the University of Bologna is in contact with MiBAC institution in order to receive documentations and clarifications, as well as giving their feedback from the "field".

In 2010 Bologna' s team has published a new digital schema VAC-S (simplified) dedicated to theatrical costumes and composed by a six pages long table where several fields are available to collect data regarding a dress, as well as data related to manufacturing and to the spectacle the present dress belongs to. Already prepared data are offered to user in order to input a correct essential description of the stage production which the costume has been created for. In the site RADAMES (Melodramma and Stage Show Archive and Document Centre) [16] created by the same group of Bologna it is possible to find a simplified digital catalogue for theatrical costumes. Also in this case a single window frame presents principal data available about a costume, letting user to choose either or to navigate through related sub frames via several links present in the main window frame.

In years 2010-11 at the University of Rome "Tor Vergata" the present author, teacher of "Metodologia e Critica dello Spettacolo", has given a thesis focused on archiving and cataloguing theatrical costumes. The student Sonia La Notte was well prepared in theatrical costume sawing and dressing manufacturing, which allowed her to understand the content of the new VeAC schema in order to use it properly for cataloguing the available dresses and costumes.

The opportunity came out with the private institution "Fondazione Annamode"[17], to whom I was introduced by my collegue Rossana Buono. They gave us the possibility to choose among quite 30.000 costumes owned by them, created for movie stages, as well as opera houses and theaters, and others like those realized on character's sketches designed by stage director Pierluigi Pier'Alli for the work *Il Principe Costante* di Calderon de la Barca, performed in February 2002 at Theater Fabbricone in the town of Prato.

The first problem was to choose the type of schema to use to create the catalogue.

Once the above different schemas (VeAC and VAC-S) were compared, as well as the simplified ones, it came out their peculiarities and innovations still belong to the original archetype, which is strictly related to an ancient art work catalogue point of view.

With a structural dependency to a "single" art work object in the schema concept, like a painting, the schema itself is not able to catalogue and taking care of the many dependencies a theatrical costume belongs to.

Such a complexity is not much related to the dress, as to the fact a costume shall not be considered as a "dress" by itself. Its scope on the stage, dressed by the actor and being part of the theatrical play, implies a coming out of this dress from its everyday use. It turns into a "visual sign" and communicates, gaining much more pregnancy and carries out a meaning immediately captured by the audience. Theatrical costume is not for being dressed, but to be part of the expression the body of the actor wants to perform. It is strictly related to its character' s sketch, which is graphical idea of the actor performance, as well as into the stage scene[18]. Costumes are a relevant part of the spectacle, and the stage itself depends on them and comes from them out.

So, it' s not possible to use such an already prepared schema which delimits a theatrical costume as a simple dress, an art object independent and complete by itself! Doing this way, we would lose its scope and its meaning in relation to the whole. Information provided with the metadata referred to this schema that analyzes the dress by itself will be good for the archivist or the costume historian, but will not be understood by whom is not having the same qualified skill, for example theatrical historian, researchers, students, amateurs etc. Even operators in the theatrical environment, as sawing manufacturers and private institutions, who need to digitalize in a proper catalogue everything they own in relation to this activity, have several times disagreed with the proposed schemas.

So, what shall we do now ?

First step is to accept the basic difference between a dress and a costume and, therefore, the principle of useless in case a costume is archived only as an ancient or modern dress.

From this assumption we started the thesis for the catalogue of *Il Principe Costante*. The author asked the student to collect all documentation already available and eventually to record memories of people, notes and sketches of this spectacle (for example: direction notes, character' s sketches, photos of the stage and actors, newspaper records and interviews) prior to work on the costumes. The idea was to go back to the several steps this spectacle went through in order to be able to study costumes and to design a new schema for them.

The above assumptions carried out very good results: it was the first time that many of the documentation and sketches of *Il Principe Costante* by Pier'Alli, were collected and digitalized, spread around in several theaters, private and public institutions, in several Italian towns. This was the manner to collect either memories or material of the cultural heritage "spectacle", and to start its preservation process, too.

Thanks to the working sawing handbook, to the characters' sketches and to the interview with the stage director it has been possible to document the history of the design and manufacturing of each costume which, in the meanwhile, was recorded by the student in relation of its material, internal structure, general dimensions and single parts, accessories and decorations as well as their actual preservation status.

Following step would be to input data and information in a proper schema setup to hold and catalogue them, but the short period of a thesis could not cover and solve this subject, too.

A new schema was designed taking advantage of the existing ones, and finally the result was a three page long schema with a new metadata "Description", not provided with the others, and according to the knowledge of the author very important to compound for the user all data the costume is related to.

Scheda N.	**11**
CODICE	**11_PRC – 15.05.2012**
Compilatore	Sonia La Notte
Ubicazione	Sartoria Annamode68 Formello (RM)
Inventario	22635
DESCRIZIONE	
Costume completo femminile, abito secentesco composto gonna e corpetto separati di tessuto felpato viola con inserto di una striscia di tulle bianco sul petto. Burlotti imbottiti sui fianchi.	
Oggetto	
Definizione	Completo
Tipologia modello	Storico
Categoria	Costume teatrale
Numero componenti	2 pezzi: corpetto, gonna
Funzione/ occasione	Spettacolo teatrale
Genere ed età	Femminile
Definizione storica	Costume barocco
Soggetto del personaggio	Zara, Rosa
Finalità del costume	Spettacolo teatrale
QUANTITA'	
Numero dei pezzi	*2*
Complementi	0
NOTE OGGETTO	
CRONOLOGIA	
Secolo (e/o frazione)	XXI (primo quarto)
SPECIFICA	
Datazione	6 -24 febbraio 2002
ALLESTIMENTO	*Il Principe Costante*
AUTORE	
Nome	Pierluigi Pier'Alli
Motivazione dell'attribuzione	Documentazione storica
AMBITO SARTORIALE	
Denominazione	Annamode68
Motivazione dell'attribuzione	Conservazione dei costumi in loco
COMMITTENZA	
Nome	Teatro Metastasio di Prato
Data	2001
Circostanza	Allestimento "Il Principe Costante"
Fonte	Documentazione storica
FRUITORE	
Nome	V. Bianchi, I. di Luca
Data	4-26 febbraio 2002 e seguito
Circostanza	Spettacolo "Il Principe Costante"
Fonte	Archivio Teatro Metastasio

Fig. 1. 1st of 3 pages of schema costume digital catalogue *Il Principe Costante*

MATERIALI	
CORPETTO	
Fibra/ materia	Fribra sintetica
Tecnica	Tessuto
Analisi	Tessuto unito
Colore	Viola
Decorazione	Spallette e colletto di raso
Posizione del tessuto	all over
FODERA/ STRUTTURA INTERNA	
Tipologia	fodera
Fibra	lino
Tecnica	ginea
Colore	Panna
Posizione	All over
NOTE MATERIALI	Al centro del corpetto, parte di solo tulle senza fodera.
GONNA	
Fibra/ materia	Tessuto felpato
Tecnica	Tessuto
Analisi	Tessuto unito
Colore	Viola
Decorazione	Fianchetti imbottiti
Posizione del tessuto	
FODERA/ STRUTTURA INTERNA	
Tipologia	Fodera, imbottitura,
Fibra	fibra sintetica, gommapiuma
Tecnica	
Colore	Bianco, fucsia
Posizione	Davanti raso, dietro tulle, imbottitura sui fianchi

MISURE (in cm)	
INGOMBRO	COSTUME
Lunghezza totale massima	172
Larghezza totale massima	268
Profondità max/min	20
BASE	CORPETTO
Lunghezza totale davanti	54
Lunghezza totale dietro	63
Larghezza dorso	45
Circonferenza petto	72
Circonferenza vita	60
Circonferenza fianchi	0
Circonferenza orlo	74
MANICHE	
Lunghezza esterna	60
Larghezza max/min	34/18
BASE	GONNA
Lunghezza totale davanti	106
Lunghezza totale dietro	126

Fig. 2. 2nd of 3 pages of schema costume digital catalogue *Il Principe Costante*

Circonferenza vita	60
Circonferenza fianchi	136
Circonferenza orlo	421

CONSERVAZIONE	
Stato di conservazione	Buono
Indicazioni specifiche	macchie di polvere

ELEMENTI DECORATIVI	
Tipologia elementi decorativi	Fili di raso sulle spallette e sul collo ripresa della stoffa sulle maniche
Materia/ colore elementi decorativi	Viola
Tecnica elementi decorativi	Cuciti
Motivi elementi decorativi	Geometrici
Posizione elementi decorativi	Spalle, collo, fianchi,
ELEMENTI DECORATIVI	
Tipologia elementi decorativi	Inserto di tulle
Materia/ colore elementi decorativi	Bianco
Tecnica elementi decorativi	Cucito
Motivi elementi decorativi	Geometrico, a forma di goccia allungata
Posizione elementi decorativi	Centrale petto

Documentazione	
Tipo	**fotografica**
Autore	Omettere
Ente proprietario	Teatro Metastasio
Data	Febbraio 2002
Codice identificativo	Appendice A. Figura 1,2,3,17
Documentazione	
Genere	**grafica**
Tipo	figurini
Ente proprietario	Sartoria Annomode68
Autore	Pier'Alli
Data	2001
Codice identificativo	Appendice B. Figura 19

COMPILAZIONE	
Data	6 marzo 2012
Nome compilatore	Sonia La Notte
Nome revisore	Donatella Gavrilovich

Fig. 3. 3rd of 3 pages of schema costume digital catalogue *Il Principe Costante*

New metadata were added in the new schema, essential to relate costume to the spectacle and to the actor it was dressed by.

The digital costume catalogue of the *Il Principe Costante* was printed to be part of the thesis [see figure 1,2,3], together with all other documents that were collected being part of the spectacle. The digital costume catalogue was there now, even if not all the aims of the research were reached.

Nevertheless, the question has risen about *"how"* to catalogue a cultural heritage related to "spectacle" as a unity.

Complexity for a catalogue of that kind should be solved, according to the author, by using a "product" and "addition" method instead of a "subtraction" and "division" method.

Fundamental parts which constitute spectacle cultural heritage' s memories shall not be separated.

Archive and catalogue procedures of each object composing a stage work shall be part of a *hypertext* in terms of E. Battisti "A catalogue of the catalogues". It shall collect all different catalogues, which may be complete by themselves, titled as "Scenery", "Costumes", "Music", "Actors", etc. containing metadata to record each stage object. Every catalogue will be able to provide data just about its own scope, giving the chance to get linked data if available, as well as other window frames with related data in the scope.

Scope of this work is giving back to spectacle, which is told to be a "fleeting and expressive cultural heritage" in our current law, its historical consistency by collecting, archiving and preserving all objects that compose it as a complete art work.

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Contemporary Italian Theatre on the Web

A Short History and Some Perspectives

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Abstract. An overview of theatre sites and blogs in Italy.

1. The evolution of theatre information on the web, useful to identify some of the different tasks of a cultural website.
2. A map of Italian theatre blogs and websites, with a possible taxonomy, and the Rete Critica Award.
3. The first online list of theatre productions in Italy.
4. The project of an aggregator of theatre blogs and websites.

1 A Short History of the Web through www.ateatro.it

Since its birth, the web has been evolving, in many ways. To survive in this changing environment, any website has to constantly adapt: new software arises, bandwidth increases, new possibilities and new features emerge, while some old ones are dropped (it happened to the tail in homo sapiens, and to forums in many websites...). Following the history of a small and almost jurassic website (as for XXI Century and 2.0 standards) can help to identify the role of any web presence.

1.1 It's Me!

`www.ateatro.it` is the natural evolution of a personal site, www.olivieropdp.it. It was a kind of ancestor of a blog, online from 1998, with resources on Italian avant-garde theatre (the digitalized version of the book *Il nuovo teatro italiano. 1975-198*, and several essays, and interviews.

1.2 A Community

The blog `www.olivieropdp.it` attracted several professionals, and students. When Mario Martone, the Director of Teatro di Roma, was forced to resign in the Fall of 2000, these readers began writing mails to `info@ateatro.it`, expressing their opinions, and the site began publishing these messages. It was the only public debate on the difficult situation of one of the most important theatres in Italy, and on the complex relationship between culture and politics. Around the blog, a small community was recognizing itself. It was time for a change.

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1.3 A Journal

`www.ateatro.it` went online on January the 14th, 2001, one day before Wikipedia. In its first version, `www.ateatro.it` was a journal, or a bulletin, with a new issue every two-three weeks. Number 0 was written entirely by the editor, but Number 2 (February the 18th, 2001) assembled texts written by other authors, who sent their texts to the webmaster.

1.4 It's Us!

Some authors just sent one piece, but others became regular contributors. An editorial staff emerged, with Anna Maria Monteverdi as co-editor. At the same time, the journal decided to concentrate on some specific issues, that other medias did not cover:

- new theatre in Italy, and abroad;
- the relationship between theatre and new media (Anna Maria Monteverdi);
- the economy and policies of culture (Mimma Gallina).

This kind of "specialization" is also a feature of other sites/blogs. For instance:

- *Playwriting*: Dramma.it (`www.dramma.it`), edited by Marcello Isidori, online since September 2000, with a database of more than 1600 Italian contemporary plays; Drammaturgia.it (`www.drammaturgia.it`), edited by Siro Ferrone, and linked to the Dipartimento di Storia delle Arti e dello Spettacolo at the Università degli Studi di Firenze;
- *Musical and commercial theatre*: Silvia Arosio's Dietro le quinte (`dietrolequinte.blogosfere.it/blogger/SilviaArosio`).
- *Young people's theatre*: Eolo (`www.eolo-ragazzi.it`), edited by Mario Bianchi.
- *Ancient theatre*: Dionysusexmachina (`http://dionysusexmachina.it`).

1.5 Push and Pull

Two other features were added, using other freeware: the possibility to subscribe to a newsletter, and a newsletter with the summary and the editorial of each new issue of the journal.

1.6 One to Many, or Many to Many

To open a discussion space for the community, a Forum was open: it was a free forum, asking no registration, and offering several topics: among others, "theatre of war" (both on the political nature of theatre, and the struggles to renew Italian theatre), Italian plays, job research and offers...

1.7 Back to Reality

The virtual community gathered around the site can become a community in the "real" world too. In 2004 www.ateatro.it launched "Le Buone Pratiche del Teatro" (Best Practices for Theatre), a meeting held every year, and often in a different city (Milan, Naples, Bologna, Turin, Genoa, Florence...), with 300-400 people attending, from MPs to theatre students, from big institutions to small independent groups. (This means, by the way, that a website can also conceive, promote, and manage important cultural projects.)

The "Buone Pratiche" meeting, in a full day of discussion, has two goals. First of all, to examine the Best Practices conceived and practiced by Italian theatres, artists, critics... And to explore and discuss the current situation of Italian theatre, with the help of experts, politicians, civil servants...

1.8 From Static to Dynamic

In the beginning, the site was just a set of static html pages. But the quantity of the material published by www.ateatro.it kept increasing: hundreds of articles, mainly texts, and in Italian, amid an almost totally Anglophone web, in the Jurassic web.... In 2004 a database was added, using (as always) some freeware. This happened of course before the new era of free "do-it-yourself" blogs, like MySpace, Wordpress or Joomla. But this was, and has been, also a choice made by the webmaster: keep it simple, and keep control both of the content, and of the software and interface.

1.9 Flow

The database also gave a new opportunity in releasing the information: from separate blocks of data (the different issues of the magazine/journal) to a continuous flow of information, allowing the site to be constantly up-to-date. This allows the site to work sometime as a news agency, with some scoops, that some mainstream medias did relaunch.

1.10 Information Retrieval

In the beginning, again, it was www.yahoo.com and then www.google.com, of course. The blogsphere was still small, and it was quite easy for an independent site, nested in a small niche, to be indexed in the first pages of Google Research. Then two things happened: the web, and the mechanisms of the Google research/advertising engine, changed; and the quantity of the material in the website kept increasing.
So new features were added:

- a small research engine, fishing in the database;
- an index of the various issues of the journal, mentioning the special issues devoted to a particular subject: for instance, subjects as Myth, Puppetry, Voice, Theatre culture, or great masters like Giovanni Testori, Jerzy Grotowski, or Julian Beck;

- a tagging system, used as an access key for the "ate@tropedia", a small theatre encyclopaedia with more that 200 entries, linking to the single records of the database. Some of these entries make up a kind of eBook. The "ate@tropedia" has been very useful, especially to theatre students, that use its material as an important resource in their studies, and research. The Italian association of theatre university professors (CUT, Consulta Universitaria del Teatro) produced a ranking of theatre journals and magazines, as the texts they publish give credit in academic evaluation processes: `www.ateatro.it`, having no connection with universities, got a B ranking (ranks going from A to C).

This information structure gives several access options to the material in the site. With the rise of social networks, some more access oppurtunities to this database have been added.

1.11 Multimedia and Streaming

As bandwidth increased, it became easier to add images and videos to texts (and to create and broadcast infographics, and other form of innovative teaching material). In a second step, it was also possible to enhance radio- and video-streaming (for the first time at the "Buone Pratiche" meeting from 2011, a whole day of video streaming on `www.studio28.tv`)...

1.12 Becoming Social

Forums began to have bigger, and bigger problems, for several reasons: security issue, with increasing loads of spamming, and hackering (in the case of `www.ateatro.it`, it led to a warning message from Google); and legal problems, with trolls attacking individuals, and institutions, that can trigger legal actions against the site hosting the offensive posts.

Social networks offer a protection from both of these threats (but they privatize the personal relationships of their users, and the contents they publish; and of course they discourage the mask of anonymity). Since 2010, the migration from forums to social networks (such as `www.facebook.com`, and `www.twitter.com`) has been for many webmasters an unavoidable step. On the other hand, social networks can help to strengthen the community, and to spread information.

1.13 What a (Theatre) Website Can Do

A website can be, at the same time, many things. It can be, at the same time:

- a magazine, or a journal;
- a constant flow of information, a newsgency, and online newspaper, radio, tv...;
- a multimedia archive, a database, always researchable, and available;
- a tool for teaching and research;

- a community on the web (through mailing lists, newsgroups, forums, social networks...);
- a project manager, conceiving and organizing events, or publishing books, or magazines, in the "real" world;
- a community in the "real" world;
- a subject active on social networks:
- ...

`www.ateatro.it` has been trying to carry out some of these tasks, of course with the small figures that a niche website can achieve: more that 2200 posts in 12 years, around 400-500 single visitors every day, and more than 3000 "I like" on Facebook; but the site activities also had some significant echo on maistream medias, and has an acknowledged presence in theatre word and in the academic world.

2 Rete Critica: An Award and a Network of Theatre Sites and Blogs

2.1 A Constellaton

On the web, `www.ateatro.it` is not the only resource focused on Italian theatre. The scene is extremely lively, with several interesting experiences. The landscape is very rich and diversified, in the organization, structure, style, and look of the sites, and in the range of their interests and focus.

2.2 A Possible Taxonomy of Theatre Blogs and Websites

As for the structure and organization of these sites and blogs, and also looking at their historical stratification, we can focus on some possible categories, with examples:

- *Independent theatre blogs*, by single bloggers, in the tradition of the web 1.0.
- *Blogs hosted by major newspapers*: for example, Anna Bandettini's Post-Teatro on "la Repubblica" (`bandettini/blogautore/repubblica.it`), or Massimo Marino's Controscene, hosted by "Corriere della Sera" (`controscene/corrieredibologna/corriere.it`); Bandettini and Marino still write for their "paper newspapers", but their blogs are richer in contents and have wider and deeper interests.
- *Blogs hosted by cultural sites*, in a special theatre section: as cultural debate shifts to the web, it is important to note that the editors of these sites feel that a theatre critic is useful, and perhaps necessary. Some examples are Myword (`www.myword.it/teatro`), and Doppiozero (`www.doppiozero.com/category/tag-universali-area-tematica/teatro`).
- *Blogs hosted by sites covering new art & media, and technology*: as the performing arts and the visual arts become closer, and directors and performers use new media and technology, we see a growing interest in the new theatre scene. Some of these "trendy" sites hosting a theatre blog or section are Art Tribune (`www.artribune.`

com/category/rubriche/teatro/), Digicult (www.digicult.it/it), Laura Gemini's Incertezza Creativa (www.incertezzacreativa.wordpress.com), Persinasala (www.teatro.persinsala.it, a site covering also movies, music, and the visual arts).
- *Theatre sites*: they are in fact online theatre magazines, with an editorial staff, and the editorial customs of traditional paper magazines. Some of them are based in one town, others have correspondents around the country, a few of them also have foreign correspondents too. Among the more interesting Italian theatre online magazines, we can mention ateatro (www.ateatro.it), Krapp's Last Post (www.klpteatro.it), Il Tamburo di Kattrin (www.iltamburodikattrin.com, that also publishes every week a selection of links to the best articles posted by other blogs and sites), teatro.org (www.teatro.org), Teatro e Critica (www.teatroecritica.net), teatroteatro (www.teatroteatro.it). Some magazines are the web extension of a paper edition: the online version can be a mirror (or a selection) of the paper magazine (it happens with "Hystrio", www.hystrio.it), but some of them have also additional content.
- *Blogs or sites connected to universities* (or to academic magazines). Some of them are an extension of the paper magazines, often quite authoritative. Others (more and more) are published online, with no paper edition. Among the most interesting, Culture Teatrali (www.cultureteatrali.org), linked to the Bologna DAMS, also in paper; Turin D@ms Review; Stratagemmi (www.stratagemmi.it), also in paper. In the last months, at least two new academic web magazines came to life, Acting Archives (www.actingarchives.it), sponsored by the Università di Napoli "L'Orientale"; and Mimesis Journal (www.ojs.unito.it/index.php/mj), also linked to the Università di Torino.

Overall, these blogs and sites produce hundreds of posts every month. Many of them are indexed in a weekly selection by www.tamburodikattrin.com.

As for their relevance, the blogs hosted by major newspapers make very big numbers, while many others have just a few hundreds single visitors every month.
The quality of the material can also be uneven: form short news (that can sometime be just a kind of cut & paste from press releases) to long essays, from short theatre reviews and interviews to wide range reports on major issues.

2.3 A Network

In 2011, some of these sites (after a call from Massimo Marino, Anna Maria Monteverdi, Oliviero Ponte di Pino, and Andrea Porcheddu) entered in a network, awarding the Premio Rete Critica (Critical Web Award, http://www.ateatro.org/retecritica2012.asp). In October 2012, the final events of the second edition of the award was part of a two day meeting, in the Teatro Olimpico in Vicenza, when many of these bloggers and webmasters discussed the situation and perspectives of theatre criticism and information.

3 The *Patalogo* of Italian Theatre Productions: From Paper to the Web

3.1 A Catalogue of Italian Theatre on Paper

From 1978 to 2010, Franco Quadri and his imprint, Ubulibri, published the Patalogo, a yearbook of Italian theatre. It was an ambitious and non-conventional project, as you can guess from the title, inspired by Alfred Jarry's "pataphisique", the science of imaginary solutions. The first part of the *Patalogo* was of course the list of the Italian theatre productions, with the cast, photographs, and sometimes press clips. This was also a useful tool for the critics who had to vote in the referendum for the Premio Ubu, the more prestigious Italian theatrical award.

3.2 A Catalogue of Italian Theatre on the Web

After the death of Franco Quadri, in 2011, his sons and some friends decided to keep on working on his legacy, as much as possible. The archives of Ubulibri and Franco Quadri (more that 350 linear meters of material) were entrusted to Fondazione Mondadori, to be catalogued (and partially digitalized), and opened to students and researchers. And the Premio Ubu had new editions, in 2011 and 2012. Unfortunately, it was not possible to keep on publishing the *Patalogo*, but the list of the productions of the season was still necessary for the award: so it was decided to publish it online.

For the first time, a list of all the theatre productions of Italian theatre is accessible online, through a database with more than 700 records every year, from the big shows of commercial and State theatre to the small performance of newborn independent group (`www.ateatro.org/mostraubu_titolo2012.asp`).

4 An Online Daily Theatre Newspaper or an Aggregator?

4.1 Some Web Resources on Italian Theatre

We have several resources on the web:

- a number of theatre sites and blogs, publishing every week material on Italian contemporary theatre;
- a survey of these material, by `www.iltamburodikattrin.com`;
- a list of the productions of Italian theatre;
- the embryo of an online theatre encyclopaedia.

We also have several problems:

- the list of the theatrical productions looks quite bare, and is of small use to a general audience;

- almost all of the theatre sites (except the ones hosted by the sites of big newspapers) have very small visibility;
- and of course the economy...

4.2 An Aggregator?

The next step – a project some Italian websites are working on in the first months of 2013 – would be to create an aggregator that can:

- link all the reviews and articles to the record of the single production in the list, and possibly to the artist, theatre, theatre group/company they refer to (and viceversa);
- give better visibility to the single sites/blogs, without changing their nature and peculiarities;
- help to get some more income from ads etc.;
- help sites/blogs to create a network and perhaps try some common ventures.

One of the weaknesses of bloggers is that they focus on the present (what is happening right now), but they do not care as much about the archive and data retrieval. Their posts appear on the homepage for a short period, and then, as new content is posted, they "fall down" from the homepage. As they seldom use effective tagging and indexing systems, it is very difficult to extract meaningful information. This "aggregator project" could help to give more strength to single blogs/sites without changing their identity, and to build an archive, available to theatergoers and students.

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Open Creative Framework for a Smart Cultural City: Bologna Porticoes and the Involvement of Citizens for a UNESCO Candidacy

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Abstract. ICT projects dedicated to Cultural Heritage, in order to both democratise knowledge and act as an additional attraction towards audiences, should not neglect the communicative aspects. This approach can led towards two different perspectives: the creation of emotional and engaging events, and the creation of applications aiming at a more active participation of users in the development of the final product. The candidacy of the porticoes of Bologna as a UNESCO World Heritage Site will exploit the second solution to best involve citizens in the effort, offering, at the same time, training opportunities to students and young professionals.

Keywords: D.2.13 [Reusable Software]: Reuse models—H.3.5 [Online Information Services:]: Data Sharing— I.3 [Computer Graphics]: — J.5 [Arts and Humanities]:Architecture— K.8 [Personal Computing]: Freeware/shareware.

1 Introduction

The centrality of the visitor in museums has been recognized for some time now [1] and, in general, we can say that a communication capable of reaching a diversified audience has become essential also for almost all cultural heritage applications. For the ICT ones, communicativeness can focus on aesthetics, as with the movie dedicated to the reconstruction of the Parthenon frieze [2], [3], narrative [4] or on interactivity [5], [6]. An example of good interaction can be considered the entire design of the Virtual Archaeological Museum of Herculaneum (http://www.museomav.it). Otherwise several communication solutions can be used simultaneously, as with the Etruscanning project [7] or the multi-target project dedicated to Selinunte Metopes [8]. In a country such as Italy, where cultural resources are so valuable, it is no longer possible, then, to neglect communication in order to both democratise knowledge and act as an additional attraction towards audiences [9].

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This approach can lead towards two different perspectives: the creation of emotional and engaging events, and the creation of applications aiming at a more active participation of users in the development of the final product. But, by adopting the second approach, it is necessary to face several more problems in order to attain a reasonably good result; problems that the ICT applications aiming at supporting the candidacy of the porticoes of Bologna as a UNESCO World Heritage Site will have to deal with.

2 Reaching the Audience

A communication based on aesthetics, narrative, interactivity or on a mix of these solutions, that foresees a fruition of the contents by the users in a top-down relation needs, most of all, a good multidisciplinary team, combining content managers, technicians and experts in communication and / or artists. Instead, a project aiming at involving users, besides a good team, has to be able to get this involvement, and is not at all easy. The effort is doubled and results can be disappointing. How to get in touch with citizens? Through which media? How to motivate them in order to obtain, in the end, their active participation?

Here are a couple of examples of ICT projects dedicated to Cultural Heritage that have sought to actively involve the "visitors". These examples are selected among those developed within the project CreativeCH (http://www.creative-heritage.eu/), aiming at exploring the potential of Cultural Heritage as a local development factor. Presented at a workshop held in November 2012, they focus on how citizens and communities can be enabled to actively engage with cultural heritage in a participatory and inclusive way.

The first one, carried out by a consortium of four Portuguese universities, has created a website dedicated to the Portuguese culture and its influences, extended, of course, to all former colonial areas (http://www.hpip.org). Areas which, at present, may be theatre of wars and, therefore, it is difficult to know the current situation and document it. The website, through a specific section, asks users to collaborate, in order to improve its possibility of becoming a collecting point for visual evidences and narrative. Opened on April 2012, the site has received so far about 15 contributions per month, of which 5 have been approved and displayed. A problem may lie in the validation of the contributions, which, in this case, is made by the same editorial board that has edited the volumes published together with the universities consortium. Too often, however, it is not even necessary to get the validation, because images are not of a sufficient quality to be used (they are too low in resolution or with a wrong framing).

In Brighton and Hove (UK), in 2011, the local University held a crowd-sourcing test finalised to the photographic acquisition of 36 monuments scattered trough the city. Citizens were asked to take the photos following some precise guidelines, since the documentation would have been used by the staff for creating 3D reconstructions of the monuments. Only 50% of the photos shot has been useful and just 70% of the selected monuments were recorded at all, enabling the final reconstruction of 18 monuments out of 36 [10]. Despite the effort deployed for involving people through different motivational mechanisms, such as promotional material distributed by press and web based social media sites, presence at local events across the city and prizes from local organisations, the project registered a limited number of participants.

These experiences raise some interesting issues that have to be faced when trying to organise projects relying upon the collaboration of the public:

- get to people and motivate their participation;
- if possible, train the "collaborators";
- have quality contributions;
- validate the contributions.

Besides, usually this kind of projects are, at least, medium-term ones and, therefore, their economic sustainability during time has to be planned in advance.

How to overcome the difficulties? As said in [10]: "[...] motivating users is also time consuming. For instance, it is important to select the type of volunteers most suitable to the objectives of the initiative. Loosely associated individuals might be harder to motivate than people already associated with the organisation. In contrast, associated groups might be easier to contact and motivate". Associated groups can also be selected among those with at least a minimum training level, suitable for the aims of the project. This should enhance the quality level of the contributions that, anyway, have to be selected and validated by a board of some sort.

Hence, the creation of applications aiming at a more active participation of users in the development of the final product is a laborious and time consuming endeavour, but it can be a worth and valuable effort and local and national institutions appreciate the opportunities offered and accept the challenge, as in the still under development EuroMACHs project related to the digital Archive for the Portrait Books of Regensburg (http://angel4heritage.wordpress.com/) or in the recently launched project dedicated to the porticoes of Bologna.

3 An Opportunity: The Candidacy of the Porticoes of Bologna as a UNESCO World Heritage Site

The nearly 40-km-long porticoes make the city of Bologna unique in the world and the Municipality has decided to candidate them as a UNESCO World Heritage Site. To better support the candidacy, a crowd-sourcing ICT project, involving Bologna City Council, CINECA and Department of Architecture of Bologna University, has been devised.

Fig. 1. A GIS layer, in yellow, showing the length of the porticoes

For Bologna, since the middle ages, porticoes are such a widespread and characterizing feature; they provide a common thread along the geography and the history of the city, and will be used as an element of union with the wealth of information that can be provided to the visitors of the city.

The first part of the ICT project is based on the organisation and management of as many useful data about the porticoes as possible. The existing documentation and the one that will be acquired during the preparation of the UNESCO candidacy will be organised according to a valid, clear and readable space-time geo-referenced grid. Data will include philologically and architecturally accurate 3D models realised by students of the Department of Architecture through different techniques, depending on the historical and architectural value of the porticoes.

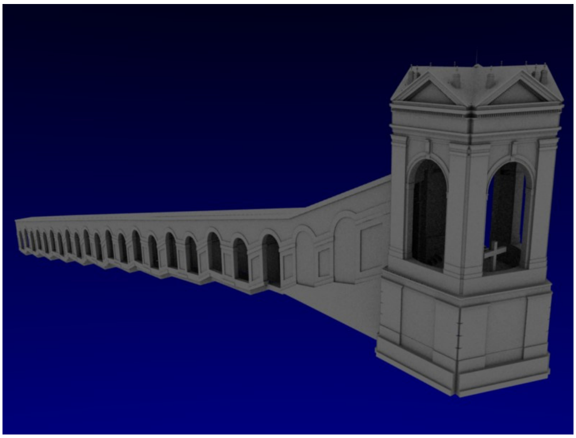

Fig. 2. A segment of St Luke's porticoes realized by the students of the Department of Architecture

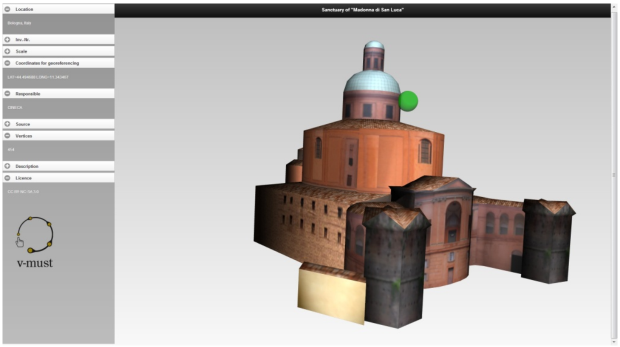

Fig. 3. X3D model with metadata using X3Dom framework. Further information are reachable through the green sphere.

Virtual models would, then, become platforms to get to the network of up to date and up-datable historical and architectonic data. A good wi-fi connection, granted along the network of the Bolognese porticoes, would animate them and enable their transformation into narrative corridors.

This part of the project can be considered as a top-down realisation, with information reaching users and visitors as an already organised set. From this point on, however, citizens would be asked to directly participate in the development of other features. The Municipality has been inspired along this path by Charles Landry's thoughts about creative cities [11]. Landry encourages open-mindedness and imagination when addressing urban problems. An imaginative approach to public, private and community spheres can widen the potential solutions since creative thinking can come from any source and a creative city should identify, nurture, attract and sustain talent. In Bologna, porticoes are not only a sheltered space where to have a stroll, they are part of the communitarian landscape and in some areas suffer from neglect and deterioration. The UNESCO candidacy is considered as a way for both promote this awesome heritage and protect it, trying to raise citizens' awareness while triggering their emotional attachment.

The part of the ICT project aiming at involving people will be devised in several sections and one of them foresees the organisation of a contest for the creation of videogames concepts to be set inside a 3D virtual Bologna. At present, it is still under development and has not jet been decided if to implement it as an on-line competition or as a hackathon.

There will be also a training program, conducted by CINECA, which will provide access to on-line resources through the portal and try to establish a true open source community (on the model of Ubuntu, the Gimp, Blender, etc. communities) and, at the same time, to incorporate the best of the Open Data philosophy and model (http://dati.emilia-romagna.it/) [12].

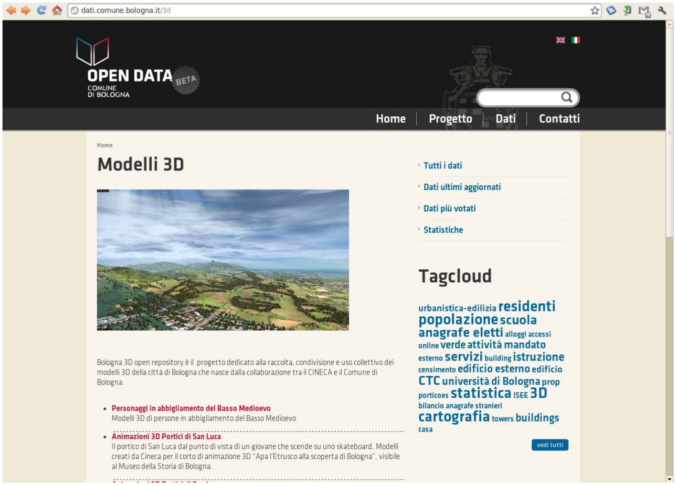

Fig. 4. Bologna City Council OpenData page dedicated to 3D models. Bologna is the first European city to make 3D models available as Open Data.

The portal will both collect and share 3D models and the useful background knowledge to create them. Alongside the on-line resources, a specialized course of advanced education will be held, giving way to some internships during which the models of the porticoes will be used for training and for producing new contents. The advanced school will be part of the V-Must network training opportunities (Virtual Museums European Network of Excellence www.v-must.net), of which Bologna City Council and CINECA are partner.

The social use will be further fostered by a geo-blog with the possibility of linking to the virtual counterpart of the porticoes images, personal thoughts and even report any critical issue.

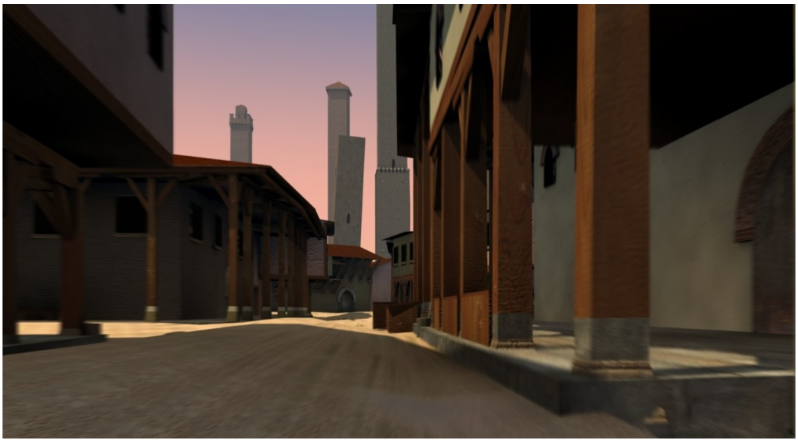

Fig. 5. Medieval porticoes reconstructed by CINECA for the short 3D movie "APA The Etruscan" [13]

4 Conclusions

The proposed approach is intended for the setting of a sort of transparent framework, enabling scholars (historians, art historians, architects, etc.), involved in the Unesco candidacy of the porticoes of Bologna, to share their work and citizens to follow and monitor the experts' activities and to participate with their own realisations.

The framework will also manage questions raised by citizens, trying for example to give answers to some of the administrative issues related to the management of the porticoes, as they are - since the Middle Ages - a private space but ruled by public laws.

Even the WIFI structure is obviously conceived as an enabling resource, foreseen as the backbone to the creation of multimedia corridors, in order to host projects and transmedial experiences designed by artists and students, mixing educational opportunities and creativity contests.

Fig. 6. A possible AR application visualising ancient views of the porticoes by the XVIII century painter and engraver Antonio Basoli

We can imagine georeferenced mp3 audio podcast narrations accompanying tourists strolls, up to augmented reality experiences, such as the one achievable through the fruition of ancient views visible in the exact place where the artists took them, or urban experiences of gamification.

In any case, the framework will try to give a further cultural boost to an already lively city.

v-must.net
Experience the Future of the Past

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Preserving Authenticity Evidence to Assess Provenance and Integrity of Digital Resources*

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Abstract. During their lifecycle, digital resources, notably digital representation of artistic work, may often go through changes of custody, format migrations and other changes of their representation. This may pose a threat to the integrity of their intellectual content and makes it difficult to trace their provenance. The paper addresses the crucial problem of gathering and preserving the evidence that would allow, at a later time, to properly assess the authenticity, the provenance and the integrity of these resources. The solution that we propose is based on the definition of special XML structures to preserve the authenticity evidence, which are compliant with PREMIS Data Dictionary, a widely acknowledged standard in the digital preservation community, and hence guarantees a sound basis for the interoperability among different repositories.

Keywords: authenticity, provenance, integrity, preservation, metadata, interoperability, XML, OPM, PREMIS.

1 Introduction

Conveniently managing the authenticity of preserved Digital Resources (DR for short) is an important issue in the field of cultural heritage and performing arts. This has several motivations. On one hand, it is necessary to preserve all the elements necessary to attribute and support the authorship of artistic work, and to guarantee that the intention of the creator is correctly represented. On the other hand, it is important to be able to assess the provenance and the integrity of the preserved resources, that is to prove that no changes have intervened since their creation, that may have altered their intellectual content [7]. In this paper we will mostly concentrate on the second problem, notably a crucial one in the management of digital libraries and preservation repositories, since very often the preservation of artistic work as electronic records involves a complex lifecycle, and may entail several changes of custody, and possibly format migrations.

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The issue of authenticity in the preservation of digital records has been widely addressed in the literature, especially referring to the record management domain and to the preservation of science data [4-6], where a consistent set of baseline requirements have been identified as a common conceptual framework aimed at supporting and assessing long-term authenticity as part of the chain of custody.

Special attention to this topic has been devoted by InterPARES, an international project aimed at "developing the knowledge essential to the long-term preservation of authentic records" [9], and in the ISO-IEC OAIS Reference Model, the fundamental and universally acknowledged standard in digital preservation [15]. According to OAIS "Authenticity is the degree to which a person (or system) regards an object as what it is purported to be. Authenticity is judged on the basis of evidence." And provenance is "the information that documents the history of the Content Information. This information tells the origin or source of the Content Information, any changes that may have taken place since it was originated, and who has had custody of it since it was originated. The Archive is responsible for creating and preserving Provenance Information from the point of Ingest; however, earlier Provenance Information should be provided by the Producer. Provenance Information adds to the evidence to support Authenticity."

These definitions set up a clean framework for authenticity management, provide the general principles and clearly outline the main issues:

- appropriate evidence needs to be preserved for all transformations that the DR has undergone during its lifecycle and that could have affected its content;
- all changes of custody of the DR need to be documented and this information must be preserved, in order to allow, at any later time, the tracing of the history of the DR and the related responsibilities;
- all this information should be gathered and preserved along the whole DR lifecycle, since its creation, even before ingestion in a preservation repository.

A further substantial contribution in this direction, which fully takes into account the above issues, has been provided within APARSEN, a EU funded Network of Excellence funded by the EU (2011-2014) with the goal of overcoming the fragmentation of the research and of the development in the digital preservation area by bringing together major European players [1]. The APARSEN proposal consists in a DR lifecycle model where the *transformations* that may affect the DR authenticity, and the related authenticity evidence to be gathered are clearly identified and specified. Furthermore, a set of *operational guidelines* is provided to direct the instantiation of the model in specific environments [2],[8]. The model and the guidelines have been successfully put to test on experimental environments provided by the APARSEN project partners [3],[13].

The next step, that is presented in this paper, is to design *interoperable structures* to preserve the authenticity evidence, and implement an *authenticity management service*, to be used by preservation repositories, as well as by other repositories involved in the DR lifecycles, to cooperate and implement their own authenticity management policies. To this purpose the APARSEN team has joined efforts with SCIDIP-ES, another EU funded project, whose specific mission is to upgrade a set of prototypal preservation services into scalable, robust e-infrastructure components to support digital preservation of all types of digital objects [14].

The main results of this cooperation, that we shall discuss in detail in the next sections, can be summarized as follows:

- exploiting the *Open Provenance Model (OPM)* formalism [10] to model the DR lifecycle as a *provenance graph*, and, for this purpose, adapting and extending it to meet our specific requirements;
- defining a set of *standardized XML-based structures*, to represent both the provenance graph and the authenticity evidence gathered and preserved in connection with DR transformations and changes of custody;
- achieving interoperability among different repositories in managing the authenticity evidence, through the definition and the reference to a *common dictionary*, based on *PREMIS Data Dictionary for Preservation Metadata* [12], a widely acknowledged reference in the digital preservation community;
- implementing a prototype version of an *authenticity management service* that provides a set of basic functions for the management of the authenticity evidence according to our model through an API interface.

The paper is organized as follows. In Section 2 we will provide a proper formalization of the DR lifecycle, give precise and unambiguous definitions, and introduce the general principles according to which the authenticity evidence is gathered and preserved. In Section 3 we briefly introduce the OPM formalism and discuss how it can be adapted and extended to conveniently represent the DR lifecycle as a *provenance graph*. In Section 4 we introduce the *Authenticity Evidence Records*, i.e. the standard XML-based structures that we propose to represent the lifecycle transformations and the related information, and we discuss how this information can be conveniently organized in order to embody the lifecycle structure, and can be labeled to guarantee PREMIS compliance, and hence a sound basis for interoperability among different repositories. Next, Section 5 discusses the design and the implementation of a framework to support the authenticity management service, which has been carried out as part of the SCIDIP-ES strategy to provide robust e-infrastructure components to support the digital preservation process. Concluding remarks are given in Section 6.

2 Gathering Authenticity Evidence along the DR Lifecycle

In the previous section our approach to the problem of authenticity management along the DR lifecycle has been informally stated. Before going to a more precise formalization, let us summarize the main principles:

- a DR undergoes several transformations during its lifecycle that may affect its authenticity, as, for example, format migrations and changes of custody;
- in order to be able, at a later time, to assess the authenticity of the DR, one needs to gather and preserve for each transformation the appropriate authenticity evidence;

- since the DR is preserved, at different times, in different repositories (both keeping systems and preservation systems) interoperability in the management of this information must be guaranteed.

In order to proceed further, we need now to introduce precise and unambiguous definitions.

2.1 Basic Definitions

Being especially concerned with interoperability, i.e. with guaranteeing the correct interpretation of the preserved evidence, we have decided to refer to a well acknowledged standard, that could be largely shared and accepted as a common ground. Our choice for a common language has been *PREMIS Data Dictionary for Preservation Metadata* [12], promoted by the *Online Computer Library Center (OCLC)* and *Research Libraries Group (RLG),* with the purpose “to develop a core set of implementable preservation metadata, broadly applicable across a wide range of digital preservation contexts and supported by guidelines and recommendations for creation, management, and use.” We decided therefore that our proposal should be ‘PREMIS compliant’, both in the definition of the main concepts and in the terminology for the labeling of the authenticity evidence. According to this approach we give the following definitions.

- **Intellectual Entity (IE).** Corresponds to what, until now, we have called Digital Resource, and is a “coherent set of content that is described as a unit”, the goal of the preservation process being “to maintain usable versions of intellectual entities over time”. As the lifecycle evolves, different *versions* of the IE are produced and preserved.
- **Representation**. Is a set of digital objects required to display, play, or otherwise make useable to a human a given version of an IE.
- **Transformation**. Is a change that intervenes in conjunction with an *event* in the IE lifecycle, and produces a *new representation* of the IE, thus potentially affecting its authenticity. In Section 2.2 we will discuss a relevant set of such transformations.
- **Agent.** Is the actor (human, machine, or software) associated with a given transformation of an IE, and who bears the responsibility of it.
- **Authenticity Evidence Record (AER)**. Is the information that is gathered and preserved in conjunction with a transformation, to allow to assess, at a later time, the impact of that transformation on the IE authenticity, provenance and integrity.
- **Authenticity Evidence Item (AEI)**. Is an individual element of the AER. Typical AEI are specification of time, tools, etc., reference to involved digital objects and record of actions and controls performed by the agent during the transformation.
- **Authenticity Evidence History (AEH)**. Is the set of the AERs for all the transformations an IE has undergone since its creation.

When assessing the authenticity of a given IE representation, the AEH allows to trace back the transformations, step by step. More precisely, how we will discuss in detail in Section 4, the structure we propose for AERs is specifically meant to allow retracing the lifecycle and providing all the necessary authenticity evidence. Finally, referring to the OAIS terminology [15], when forming the *Information Package* (SIP or AIP), the AEH provides the content of the *Preservation Description Information (PDI).*

2.2 Lifecycle Transformations

As far as authenticity management is concerned, the most relevant kind of transformations we should look at are *format migrations* and *changes of custody*, since, on one hand, any format migration is a potential threat to the integrity of the representation, and, on the other hand, a crucial part of any authenticity assessment is being able to retrace the chain of custody. However, several other kind of transformations must be considered. For a thorough discussion of the issue, one may directly refer to [2],[13]. Here, due to space limitations, we restrict to mentioning the most important transformations (and by far the most frequent ones), in order to give the reader a quite complete idea of the potential complexity and articulation of the IE lifecycle.

- **CAPTURE**. At the end of the creation process, the author delivers to a repository the original representation of the IE.
- **MIGRATION**. Within the repository that holds it, the current representation of the IE is converted to a different format, with the intention to preserve its intellectual content.
- **CHANGE OF CUSTODY**. The custody of an IE is transferred to a new repository, by handing to it the representation held by the current custodian.
- **AGGREGATION**. The representation of two or more IEs are aggregated to form a new IE.
- **EXTRACTION**. A component of an IE is extracted from its current representation to form the representation of a new IE.
- **INGESTION**. The custody of an IE is transferred to a preservation repository. A new representation of the IE is generated, as an *Archival Information Package (AIP)*, conforming with the prescription of the OAIS Reference Model [15].

By considering the above transformations, it is quite evident that each transformation generates a new representation of the IE (or the representation of a new intellectual entity in the case of AGGREGATION and EXTRACTION), by operating on the representation of a single IE, with the exception of AGGREGATION, that operates on the representations of multiple IEs. Therefore we may expect the structure of the lifecycle (and of the AEH), that may be represented by what we shall call the *augmented provenance graph*, to be a sequence of transformations with possible backwards branching.

3 Augmented Provenance Graphs

To model the provenance graph we had as a primary reference the Open Provenance Model (OPM) [10], which has been designed with the main purpose to allow provenance information to be exchanged between systems, by means of a compatibility layer based on a shared provenance model [11]. OPM has been adopted by W3C (World Wide Web Consortium) Provenance working group, and has been used by several authors, mostly to model complex creation processes of intellectual entities [16-17]. We aim instead at using this formalism for a somewhat different purpose, i.e. to model the transformations that an IE undergoes after its creation process has been concluded, during the preservation part of its lifecycle. We had therefore to adapt and extend the model, as we shall discuss in this section.

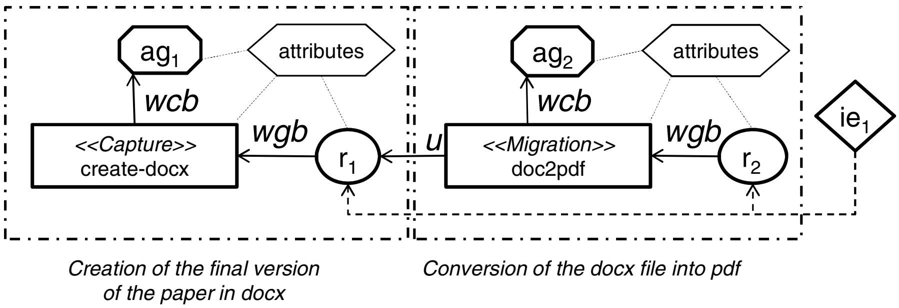

Fig. 1. Provenance graph: CREATION and MIGRATION of a conference paper

OPM assumes that any change that has happened in an IE or in its representation can be described through causality relationships, and consequently can be represented by means of a directed acyclic graph. According to this idea a provenance graph consists of two types of elements:

- **Nodes.** Represent the entities involved in the changes. An entity can be an *artifact*, a *process* or an *agent*. An *artifact* is the representation of an IE. A *process* is a set of actions that generate a new *artifact*. An *agent* is the actor (i.e. person, organization or software) controlling the *process*. According to the definitions we have given in Section 2.1, *artifact* corresponds to *representation*, *process* to *transformation*, and the two definitions of *agent* just coincide.
- **Edges.** Represent relationships among entities. OPM defines five types of edges, of which we only use three:
  - *used (u)*: indicates the *artifact* used by a *process*; in our terminology this becomes the *representation* on which a *transformation* operates;
  - *wasControlledBy (wcb)*: indicates the *agent* who controls a *process*; this becomes in our terminology the *agent* who controls the *transformation*;
  - *wasGeneratedBy (wgb)*: indicates the *artifact* generated by a *process*; this becomes in our terminology the *representation* generated by the *transformation*. For our purposes we adopt the OPM graph structure, but we use different names for the nodes, to be consistent with our terminology (*representation*, *transformation*, *agent*).

Figure 1 shows a fragment of an *augmented provenance graph*, representing two transformations on a specific IE (actually this conference paper). The first transformation represents the CAPTURE, i.e. the archiving of the final version of the paper, as created by the authors, in docx format, and the second one a MIGRATION, i.e. a conversion from docx to pdf format. As the picture makes evident, the graph can be naturally segmented in elementary *provenance subgraphs*, each corresponding to a single transformation. More precisely, it can be shown, under quite general assumptions, that each subgraph includes a single transformation node, a single agent node and a single representation node, moreover the subgraph only includes edges of type wasControlledBy (wcb) and wasGeneratedBy (wgb), as internal edges. This modular structure is especially interesting, since it substantially replicates the modular structure of the Authenticity Evidence History (AEH), that we have discussed in Section 2.1., with a provenance subgraph corresponding to an Authenticity Evidence Record (AER), as we will see in more detail in Section 4.

Table 1. Attributes of augmented provenance graph nodes

ENTITY	ATTRIBUTE	DESCRIPTION
AGENT	Identification	Personal identification and authentication data
	Role	Role within the repository and in the transformation
REPRESENTATION	Reference	Identifier within the repository
	Type/Structure	Internal structure of the representation, files composing it
	Format	File formats, version
	Fixity	Hash method, and hash file values
TRANSFORMATION	Type	Transformation type: creation, migration, transfer, etc.
	Timestamp	Day and time the transformation was performed
	Tools	Software application
	Controls	Report of controls performed by the agent

Moreover we extend the definition of the graph, with respect to OPM, to embed the authenticity evidence information. To this purpose we introduce the notion of *attribute*, that represents the information associated to the nodes of the graph, i.e. to the entities, and that will contribute to the AER. A general set of attributes is shown in Table 1.

4 Interoperable Authenticity Evidence Management

As discussed in the previous section, each provenance subgraph corresponds to a transformation. In this section we describe the XML, PREMIS compliant, structure that we propose for the Authenticity Evidence Record. This XML document actually contains two kinds of information:

- the topological structure of the subgraph, to which the AER corresponds, and the external connections to other subgraphs;
- the authenticity evidence related to the transformation, i.e. the Authenticity Evidence Items (AEI).

The high-level structure of the XML document is outlined in Table 2. There are three main sections: i) HEADER, ii) ENTITIES and iii) DESCRIPTION. The HEADER section contains an identifier of the AER, which is unique with regard to the IE, the reference to the IE, and specifies the representation(s) on which the transformation operates. The ENTITIES section describes the three main entities involved in the transformation: the agent, the transformation and the (generated) representation. The elements for all three entities have the same basic structure, with the same inner elements and attributes: *identifier*, *type* and *annotation*. The DESCRIPTION section, which is structured on several elements, that largely depend on the type of transformation, contains a report produced by the agent, which gives the details of the transformation, the fixity information, as well as the list of the controls that have been performed by the agent and their outcome. All the elements in the document may include annotations to give further details and improve readability.

Table 2. Structure of the Authenticity Evidence Record

SECTION	ELEMENTS	DESCRIPTION
HEADER	IntellectualEntity	Reference to the Intellectual Entity
	Sources	External AERs referenced in this AER
ENTITIES	Agent	Agent responsible for controlling the transformation
	Transformation	Transformation described in this AER
	Representation	Representation generated by the transformation
DESCRIPTION	Report	Additional evidence including report on controls

To give some more details, let us refer to the provenance graph in Fig. 1, that represents the creation and the format conversion of a conference paper (this paper), and, more specifically, let us concentrate on the last transformation, i.e. the conversion from the docx to the pdf format, which is represented by the subgraph on the right. The corresponding XML document that represents the AER is shown in Fig. 2. The IE is referenced by an identifier, which has been assigned in the repository where the CAPTURE took place (Università "La Sapienza"). The only source to the transformation is the representation of the paper in docx format, which is referenced through its AER (AER-001). The agent is one of the authors, and he is identified through his Fiscal Code (which is unique in Italy). The representation generated by the transformation (the pdf file) is identified by a URI which addresses the file in the archive of the University. Inner elements of the transformation are the identifier, which is a serial number locally assigned, and the specification of the software application; the annotation gives further details about the options selected for the conversion. The report element contains most of the authenticity evidence items, as the timestamp, the fixity information, and the assessment by the agent on the outcome of the transformation: a general statement and some specific ones about controls that he has performed. In particular two significant properties [5-6] have been checked, to ensure that the appearance of the paper had not been improperly changed by the conversion process: the evidence certifies that the number of pages in the two versions is the same, and the all page breaks occur in the same place, which may be considered reasonable criteria to assess the quality of the conversion.

```xml
<evidence-record label="AER-002">
    <intellectual-entity label="ie1">
        <identifier type="UniSapienza" value="UniSap-Salza-2013-021-ECLAP"/>
        <annotation value="Preserving authenticity ECLAP2013"/>
    </intellectual-entity>
    <sources>
        <source value="AER-001"/>
    </sources>
    <agent label="ag2">
        <identifier type="Italian Fiscal Code" value="SLZSLV48C05H501O"/>
        <type value="Person"/>
        <annotation value="Agent name: SILVIO SALZA"/>
    </agent>
    <representation label="r2">
        <identifier type="URI" value="https://archive.uniroma1.it/docs/SalzaECLAP13"/>
        <type value="file"/>
        <format value="pdf " version="7.1"/>
        <annotation value="PDF version of final draft"/>
    </representation>
    <transformation label="doc2pdf">
        <identifier type="DisEventId" value="E-2013-02-19-000119"/>
        <type value="Migration"/>
        <software  swtype="application" swname="Adobe Acrobat Pro" swversion ="9" />
        <annotation value="convert docx file into pdf; include fonts"/>
    </transformation>
    <report>
        <datetime value="2013 February 21 18:00:12"/>
        <used value="AER-001:r1" />
        <fixity type="MD5" value="0f218e0e483cc7937bd81d354b520e7"/>
        <significant-properties>
            <significant-property type="page count" value="12 "  outcome="true"/>
            <significant-property type="page breaks correspond " value= "11" outcome="true"/>
        </significant-properties>
        <agent-assessment value="true"/>
        <annotation value="All fonts have been compared in the two versions and correspond"/>
    </report>
</evidence-record>
```


Fig. 2. AER XML document for a MIGRATION (right subgraph in Fig. 1)

5 The Authenticity Toolkit

SCIDIP-ES (SCIence Data Infrastructure for Preservation Earth Science) [14] is an EU funded project, that aims at providing a modular architectural framework for the implementation of *Long Term Data Preservation (LTDP)* repositories, The framework is based on a set of *Services* and *Toolkits*. According to SCIDIP-ES terminology, a *Service* provides its functionalities through a remotely-accessible interface. Examples of services are *the Orchestration Service*, a message broker, and the *Persistent Identifier Service*. On the other hand, a *Toolkit* is a module that implements a set of homogeneous functionalities. For instance, the *Packaging Toolkit* provides methods to assemble *Information Packages* (notably AIPs) under the specifications of the OAIS Reference Model [15], and the *Authenticity Toolkit* provides methods to manage authenticity evidence. Based on this framework, a preservation repository can be

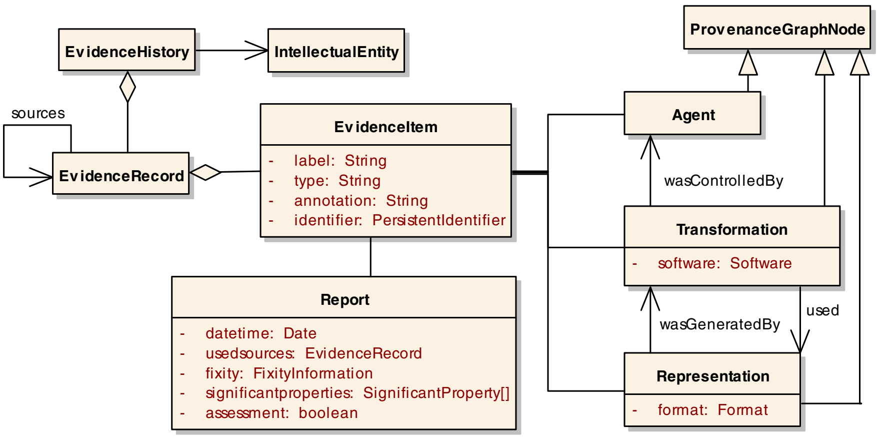

Fig. 3. Authenticity Toolkit UML domain model

effectively implemented by exploiting the services and by incorporating the toolkits as part of a more complex architecture.

As part of the APARSEN-SCIDIP-ES cooperation, the Authenticity Toolkit has been designed in order to implement the authenticity model that we have presented in the previous sections, according to the specifications of the UML domain model in Fig. 3. The implementation is based on REST principles and Java technology.

Table 3. The EVIDENCEMANAGER interface of Authenticity Toolkit

METHOD	DESCRIPTION
EvidenceRecord getEvidenceRecord	Get an AER from the AEH of an IE
boolean addEvidenceRecord	Add an AER to the AEH of an IE
void checkEvidenceRecord	Check an AER based on given criteria
void assessEvidenceRecord	Makes an assessment of an AER
void importEvidenceHistory	Import AEH from a set of XML files
list<document> exportEvidenceHistory	Export AEH to a set of XML files

The toolkit methods, which can be accessed through the EVIDENCEMANAGER interface, are listed in Table 3. This simple set of methods provides all the basic functions necessary to manage, according to our model, the AEH of an IE. For instance the method addEvidenceRecord allows to incrementally update the AEH when a new transformation occurs.

Moreover the two methods importEvidenceHistory and exportEvidenceHistory support the exchange of authenticity evidence between different repositories in a change of custody. In order to perform the transfer, the AEH is first extracted by the repository which transfers the custody by means of the exportEvidenceHistory method, which produces a set of XML files, complying with the standard structure discussed in Section 4, that is packed together with the current representation of the IE.

On the receiving end, the AEH is ingested by means of the method importEvidenceHistory, that transforms the XML documents into the internal representation managed by the toolkit.

The Authenticity Toolkit functionalities have been designed according quite general criteria, in order to be used, not only by LTDP repositories, but in general by any kind of repository that may be involved in the IE lifecycle. However, interoperability in exchanging authenticity evidence is not limited to repositories that have been implemented by incorporating the toolkit. The toolkit just makes the implementation easier, since it provides all the necessary functionalities, but any repository that complies with the PREMIS compliant XML structure that we propose for the AERs, may interoperate with just any other.

6 Conclusions

The paper addresses the issue of managing the authenticity of preserved digital resources, to allow the assessment of their provenance and integrity at a later time. This is indeed a crucial problem in many environments, notably in the field of cultural heritage and performing arts, where very often preserved digital resources undergo several changes of custody and format conversions during their lifecycle. Each of these transformations generates a new representation, and hence it is necessary to collect and preserve appropriate evidence to document any change that may have affected the intellectual content.

As different repositories are typically involved in the preservation process, this evidence must be organized and preserved in a way to guarantee, under quite general assumptions, the interoperability in the exchange of this information. To this purpose, we have exploited the Open Provenance Model (OPM) to represent the DR lifecycle as a provenance graph, by adapting and extending this formalism to meet our specific requirements. Moreover, we have defined a standardized XML-based structure, which is devised to represent both the provenance graph and the authenticity evidence gathered and preserved in connection with the lifecycle transformations and changes of custody.

The model that we propose has been developed within a cooperation between APARSEN and SCIDIP-ES, two EU funded FP7 research projects. More specifically, as we have discussed in the previous section, SCIDIP-ES, whose main goal is to provide a series of preservation services to science data repositories, is implementing the model as part of the Authenticity Toolkit, part of an architecture framework meant to provide a set of preservation services to support the capture and management of authenticity evidence.

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Applicability of Digital Library Descriptive Metadata to the Contemporary Artworks

The Sapienza Digital Library Case Study

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Abstract. The metadata framework which supports preservation, management and dissemination of the Sapienza Digital Library (SDL) resources, was built on the most spread digital libraries standards' combination, endorsed by the Library of Congress. This article explores the applicability of the SDL metadata framework to the contemporary art field. It addresses the mapping of the SDL metadata semantics toward museums metadata standards, and analyses the information model's differences, locating complexities in the specific field and technical difficulties in translation. The applicability study is useful to improve the SDL interoperability in the management of the differences in information granularity, and to fulfill the lack or to avoid the waste of information. It is also, the theoretical basement for the implementation of export functions toward resources' aggregators like Europeana, focused also on cultural objects.

Keywords: Digital library, Digital curation, OAIS, METS, MODS, PREMIS, LIDO, GAMA, Europeana, Digitising Contemporary Art, libraries metadata, museums metadata, contemporary artworks description.

1 Introduction

The Sapienza Università di Roma (Sapienza) counts on 20 museums for preserving artifacts, produced by different knowledge domains that mainly represent the variety of interests for a large and multidisciplinary community.

Among Sapienza museums, the Museo Laboratorio di Arte Contemporanea (MLAC)[1], founded in 1986 as Research Center, has undertaken activities for scientific research, high education and cultural exhibitions. The MLAC has a collection of artworks, donated during its almost thirty years of activity, and a media collection of around 2000 titles. The cultural interest around such collection can be improved by the actual digital technology that can provide more visibility of the artworks and trigger connections with other digital resources and documentation. In addition, the

[1] http://www.luxflux.net/mlac/

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availability of documentation materials in digital form can allow a deeper exploitation of the collection itself, and can support the curatorial activities in the creation of new cultural events, as well as in the collection's management. Furthermore, the reference community can exploit digital resources, reusing documentation materials for focused educational materials, for new publications, for easing the production of documentation about new exhibitions and, last but not least, for creating new artworks, considering the peculiarities of the contemporary artifacts (i.e. in some Conceptual Art example, the documentation is the artwork; some digital art reuses digital materials for artistic purpose).

This article shows how the Sapienza Digital Library (SDL) is the means for reaching this objectives for MLAC collection, and exposes the case study for the applicability of the SDL descriptive metadata framework, to the contemporary art domain, and the feasibility of the interoperable exchange of digital resources with the relevant European aggregators.

2 The Sapienza Digital Library Project

The Sapienza Digital Library[2] (SDL) is a research project undertaken by Sapienza Università di Roma (Sapienza), the largest Europe's campus (140,000 students, more than 9000 faculty/employees), and the Italian supercomputer center Cineca[3], the 9th in the Top500[4], which is a no profit consortium, made up of 54 Universities, 2 Research Institutions and Ministry of Education, University and Research.

The SDL project aims to build an infrastructure supporting preservation, management and dissemination of the past, present and future digital resources, containing the overall intellectual production of the Sapienza University[1].

The target of the project is the digital intellectual material of the different organizational units for learning and scientific investigations, that represent the Sapienza University. Those organizational units cover almost all disciplines of knowledge, and are divided into 11 colleges and 68 departments, in addition the memory organizations are represented by 59 libraries, 20 museums and 2 main archives, current and historical.

Collecting and managing the Sapienza intellectual materials (present, past, future) coming from that large organizational scenario, has required a cost-effective solution, which has leveraged on standardization of digital resources, which allows an effective management and exploitation in the long term.

Nevertheless, the standardization process of resources mustn't flattening the specificity of the intellectual material, wasting knowledge domain information about contents.

[2] Sapienza Digital Library, `http://sapienzadigitallibrary.uniroma1.it` (expected on May 2013).

[3] Cineca consortium, `http://www.cineca.it`

The general approach of the project is to gather the provided information about intellectual materials and to translate that information, in a common language, useful to the management of the resources in their digital life-cycle, defined in the Open Archival Information System (OAIS)[2]. The information, semantically lost in translation, is preserved as original raw data, and provided on request for more specific application contexts. In this way the project will make available centralized services, useful for all communities and for interdisciplinary studies and investigations.

2.1 General Objectives

Consequently, the main objective of the project is to provide Sapienza University with a digital library, which contains all intellectual materials produced by, held by, with ownership of, or granted to Sapienza, in the past, present and future.

The objectives to be matched by the users point of view are:

- Offering to the Sapienza's designated communities the opportunity to exploit a broad variety of born-digital and digitized materials, which is collected, archived, preserved and make available across both, centralized services and object focused services;
- Managing, organizing, grouping, and indexing information, supporting their browsing and searching on different dimensional views, and their reuse in different contexts;
- Optimizing, improving, and enhancing the value of digital materials, through the web semantic technologies and the social tools;
- Allowing the interoperable conversation with other kinds of information management systems (libraries/archives/museums/universities, open access repositories…) and interconnected with the most important Italian, European, and International digital resources aggregators.

2.2 Organizational and Technical Requirements

The requirements taken into account for designing of the information system conditioned by the global digital libraries, and digital curation scenario, were defined as:

- Managing digital materials coming from former digitization projects, making retrospective conversions of existing materials;
- Achieving a satisfying level of information not only for user needs, but also for enabling advanced services for preservation and dissemination;
- Enriching general information and preserving specific information making it reusable and connectable with other application contexts;
- Adhering to the OAIS[2] functional model and developing compliant services supporting the Long Term Digital Preservation (LTDP);
- Adopting the most spread digital libraries and digital preservation metadata standards, in order to maintain and to guarantee the interoperability of the SDL system with other systems, supporting the worldwide dissemination of digital resources;
- Adopting platforms and tools based on open source solutions.

2.3 Activities Short Report and Outcomes

The project has started in January 2011 and it was divided into two work phases.

The objective of the first phase, was to release a prototype for digital resources consumption as SDL engine, which had implemented all the functions defined by the OAIS: ingesting, archiving and access. Consequently, the outcome of the first phase was prototyping the SDL metadata framework, the Sapienza pre-ingestion workflow, the Sapienza SIP building, the SDL Digital Library Management System.

The second phase started in January 2012. The objectives were: 1) developing a SDL website portal which frames the SDL resources' exploitation engine, 2) enriching and harmonizing information about the resources, in order to optimize the common services of searching and browsing, and enriching information supporting the

Table 1. Collections ingested and accessible on the SDL portal

Tot Digital Objects	Objects' Types	Tot Gbytes	Metadata records	Collection's Title	Working status
1954	jpeg	0.155	1954	Theatrical icons	Ingested
192	tiff, jpeg	13	96	Carlo's Severati eye on Brasilian architecture	Ingested
3	jpeg	0.003	281	Origins museum	Ingested
666	jpeg	0.024	666	Museum of Chemistry	Ingested
927	mp4	291	4647	Video bank for performing arts	Ingested
22	tiff, jpeg	10	3	Ancient cartography of Architecture	ingested
995	pdf	47	362	PHD dissertations on Physics, astronomy and Materials Science	Ingested
17557	tiff, jpeg	402	34	Ancient books of Mathematics	Ingested
12031	tiff, jpeg	331	27	Ancient books of Engineering	Ingested
40714	tiff, jpeg	301	22	Classical books of Political Economy	Ingested
20352	tiff, jpeg	342	49	Ancient books of Environmental Biology	Ingested
17207	tiff, jpeg	195	109	Italian population historical census	Ingested
0		0	2543	Investigations products of Department of Arts history and Performance	Ingested from Sapienza Research Catalog
112620		**2.114**	**10793**		

digital preservation strategies, 3) developing a cataloging tool focused on the digital resources, and implementing community focused controlled vocabularies.

Table 1 summarizes the contents actually ingested by the SDL.

At this moment, the SDL project is working to the increment of the collections. It is expected that new collections will be ingested by the beginning of May, and moreover the first Sapienza 3000 books, coming from the Google books digitization project[5], will be ingested as well.

The SDL portal will be publicly opened in May 2013.

3 The SDL Metadata a Framework Modeling Specificity of Intellectual Materials

The SDL metadata framework is a superset of structured information which supports the functions required by the OAIS model[2]. Specifically, at the Submission stage of the digital resources' management, the Submission Information Package (SIP) is already provided of all necessary metadata information for unleashing specific services and for supporting the DL repository system functions of Archiving and Dissemination. In other words, every single resource is built with descriptive, administrative, structural, rights management, preservation[3], technical, and use[4] information. All made up information is differently used in diverse application contexts during the digital life cycle of the resources.

The different formats of digital objects, as well as the interdisciplinary target of the SDL, has required the design of different information models, in relation to the reference metadata standard.

In order to code internal SDL metadata framework, toward open metadata standards, it was adopted the most usual metadata standards‘ combination. The Metadata Object Description Schema (MODS)[5], the Metadata Encoding & Transmission Standard (METS)[6], and PREservation Metadata Implementation Strategies (PREMIS)[7].

Nevertheless, as explained above, it is possible to get other descriptions expressed in other standards but they are mapped to MODS for exploiting SDL user interface (one of the dissemination service) but the bitstream of the original description coming from information providers are encapsulated in METS structure leveraging on the flexibility of METS and consequently preserved together with other bitstreams.

The produced SIP, must be identified by a code connected to the organizational provenance which is assigned at the born of the digital resource. Based on the provenance, a set of enriching information frames and classifies the resources. The digital curators responsible for the original resources enrich data at collection level, specifying agents, responsibility, rights, and the reference knowledge domain. The relevant information from the collection are inherited by the collection's resources.

By the technical point of view, the resources' types (i.e. image, video, map), and the system's services were coherently modeled for ingesting, managing, and

[5] Google books project, `http://books.google.com/`

accessing the content. For example, even though maps and photographs are both images, the fruition services, provided by the system, are differentiated in regard to the image's dimension.

3.1 The MODS Profile for Core Descriptive Metadata Set

The SDL descriptive metadata is based on MODS semantics, and specific content model were defined in order to represent the different contents, coming from different knowledge provider, in a suited way. The general adopted approach was to represent as much as possible information, about the specificity of the content. The MODS metadata description is the "core" on which the SDL services for searching and browsing are built. Different MODS profile were defined for different content model, in order to cover different information need.

The modeling of the content descriptive metadata has respected and followed the Digital Library Federation/Aquifer Implementation Guidelines for Shareable MODS records[8]. The elements required by the DLF/Aquifer requirement level, has been adopted as SDL policy for the basic requirement level in resource's description. Furthermore, for special collections it has been taking into account the Master Data Element List of Library of Congress Metadata for Digital Content[9].

The MODS has been used for describing materials, not only at the single item level, but also at the collection level. Every item or resource (here meant as a discrete unit, conceptually equivalent to the OAIS Information Package (IP), existing in SDL, must belong to an identifiable collection, that indeed is described by MODS elements.

The MODS was considered more suitable for the SDL metadata framework, because is the richest standard for bibliographic records in digital library.Nevertheless, for increasing the level of interoperability, the MODS record is automatically dumbed down to Dublin Core[6]. Anyway, mappings toward other standards that are well suited for non bibliographic materials are available to the community[10].

3.2 The METS and PREMIS Structure

For packaging all metadata together into the defined SIP, the SDL metadata framework devised, has exploited the flexibility of METS for connecting different metadata standards together (MODS/DC/original description). The pre-ingestion activities has enriched the metadata framework with the embedding of other technical standard, like for example MIX[7], and the preservation standard PREMIS.

The SDL metadata framework was designed to guarantee the minimum conformance with the PREMIS standard both on semantic unit and data dictionary level, following requirements and constraints, and by collecting all the metadata defined as mandatory by the PREMIS Data Dictionary[11].

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[6] The Dublin Core Metadata Initiative, `http://dublincore.org/`

[7] NISO Technical Metadata for Digital Still Images Standard, `http://www.loc.gov/standards/mix/`

4 SDL Content Model Definition for Contemporary Art Materials

In SDL were ingested two collections coming from Sapienza's museums. From the descriptive metadata of the Chemistry and Origins museums, provided in a local database, was done a mapping of semantics toward MODS and an enrichment of collections with the SDL framework vocabularies and elements. In this way, both collections were quickly visible in the prototype of the SDL system. At that time, no specific model for museums artifacts were considered, because the main objective was to provide immediate web visibility to the museum's item through SDL prototype, and to test the retrospective conversion workflow.

Considering that the most important European projects[8] have based their ingestion model on Lightweight Information Describing Objects (LIDO)[12], the SDL needs of a mapping model for exporting museum's items, toward the relevant European repositories. In particular, this article is aimed to describe the case study of the applicability of the SDL metadata framework to the MLAC collection of contemporary artworks, and to define a new specific content model, that will allow the export toward the relevant Europeana projects. Furthermore, it can be the reference content model for other types of SDL cultural objects.

4.1 The Convergence Scenario of Libraries and Museums Standards

In 2003 the International Committee for Documentation(CIDOC) of the International Council of Museums (ICOM)[9] and the International Federation of Library Associations and Institutions(IFLA)[10] have created the International Working Group on the Functional Requirements for Bibliographic Records(FRBR)/CIDOC Conceptual Reference Model (CRM) harmonization. The initiative suggests the real need of facilitating the integration, mediation, and interchange of bibliographic and museum information. In May 2009, the version 1.0 of FRBRoo[11], the object-oriented version of FRBR, harmonized with CIDOC CRM, was published by the Working Group. The main goal was to reach a common view of cultural heritage information with respect to modeling, standards, recommendations, and practices. Indeed, the boundary between libraries and museums is often blurred: libraries can hold museum objects and museums can hold library objects. Often similarities overlap characteristics of the cultural heritage objects, preserved in both types of institutions. This can be particularly true for contemporary artworks, where the documentation can be the artwork itself.

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[8] *Use of LIDO,* `http://network.icom.museum/cidoc/working-groups/data-harvesting-and-interchange/lido-community/use-of-lido/`

[9] *CIDOC ICOM's International Committee for Documentation,* `http://network.icom.museum/cidoc/`

[10] *International Federation of Library Associations and Institutions,* `http://www.ifla.org/`

[11] FRBR object-oriented definition and mapping to FRBRer (version 1.0), `http://www.cidoc-crm.org/docs/frbr_oo/frbr_docs/FRBRoo_V1.0_2009_june_.pdf`

Consequently, the need of building a common conceptualization of the two memory's institutions underlies the FRBRoo formal ontology, for representing the semantics of bibliographic information, with the integration of museum semantics.

4.2 MODS and LIDO, the FRBR Joining Link

The evaluation of the SDL descriptive metadata framework, has started with the analysis of the existing metadata standards about museums and the initiatives around digital materials pertaining to the contemporary art field. In particular, the MODS description was evaluated in order to understand, how this standard can be potentially interoperable with museum standards.

Going through the existing mappings of MODS with other standards, two specific crosswalks are interesting. The first example is the Getty Metadata Standard Crosswalk [10] and the second is the mapping of cataloging rules Resource Description and Access (RDA)[12]. Even though there is waste of information in both mappings, it is important to underline the fact that, the first example mapping expresses the communities' need of matching between libraries and museum semantics, and the second expresses the need of linking MODS semantics to the FRBR conceptual model.

In addition, despite its museum provenance, the LIDO conceptual framework has more FRBR similarities than MODS. The LIDO Object (FRBR Work) contains Descriptive Metadata which describes the Object itself. The LIDO Administrative Metadata Wrap contains specific information about Object's Rights and Record Information, and contains metadata about physical/digital Representations (FRBR Item) of the Object.

LIDO is a metadata model for harvesting metadata about museum objects, and is a wrapper like METS for library objects. LIDO was adopted by many Europeana projects for ingestion.

4.3 The Target Framework

In order to cover the objective of this article, the first thing to consider is to analyze the metadata framework adopted by the Europeana project, relevant to the contemporary art materials.

The project Digitising Contemporary Art (DCA)[13] was taken into account for analyzing the exhaustiveness of the artworks' descriptions and for checking if the SDL existing semantics can cover the information need of the contemporary art.

The DCA is a cooperative project made of 25 partners from 12 countries, and the objectives that are interesting for the aim of this are:

- Identifying best practices for metadata attribution for different situations and contexts
- Aggregating the digitized reproductions for ingestion into Europeana

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[12] RDA to MODS 3.4, `http://www.loc.gov/standards/mods/rdaMODSmapping.xls`

[13] Digitising Contemporary Art, `http://www.digitisingcontemporaryart.eu/`

- Determining long-term preservation strategies (both SDL and DCA have adopted PREMIS)

The DCA general implementation guidelines[13] define the application profile filtered from LIDO and suitable for the metadata exchange of contemporary art.

Similarly to the Linked Heritage project[14], that is defining an application profile of LIDO targeted to fine arts, DCA is defining an application profile of LIDO targeted to contemporary artworks. The focus of LIDO covers the exchange with both, horizontal aggregator like Europeana[15] and vertical like the Gateway to Archive of Media Art (GAMA)[16], and the DCA application profile was filtered by a combination of the LIDO and GAMA models.

GAMA is an European harvester targeted specifically towards media art, which is a part of contemporary artworks.

In order to improve the information retrieval in Europeana for contemporary artworks, the DCA application profile encompasses the best terms from GAMA for integrating the concision of LIDO description.

4.4 The SDL-DCA Metadata Framework Mapping

Considering that, the specificity of the contemporary artworks requires a certain complexity in description, a comparison between the DCA application profile and the SDL descriptive metadata framework was done, in order to test the comprehensiveness of the metadata framework, as well as the availability of the corresponding metadata. Even if the metadata framework is expressed in different semantics and the data models are based on different assumptions, the comparison of the information units is necessary to verify the consistency of the logical structure of the metadata framework in the SDL pre-ingestion system, and to detect lack and/or waste of information in the crosswalk.

The comparative analysis has taken a sample of the SDL content model related to a digitized photograph, where the technical metadata standard for still image (MIX)[17] has to be mapped. The Figure 1 shows a graphic of the metadata mapping, where a selection of the relevant SDL metadata elements, coded in the adopted standards semantics (MODS/METS/MIX/PREMIS), were driven toward the relevant properties pertaining to the DCA application profile's entities.

It is noteworthy to describe some relevant aspects that have came out during the mapping theorizing, and that are important to take into account in the real implementation.

The first thing to consider is that the specification of the original analog and surrogate in the MODS application is distinguished by the assumption that, the MODS description is always applied to the original work. The specification about the

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[14] Linked Heritage, `http://www.linkedheritage.eu/`

[15] Europeana portal, `http://www.europeana.eu/portal/`

[16] Gateway to Archive of Media Art, `http://www.gama-gateway.eu`

[17] NISO Technical Metadata for Digital Still Images Standards, `http://www.loc.gov/standards/mix/`

surrogates is given by the metadata physicalDescription/digitalOrigin, where the value "reformatted digital" clearly defines that, the resource was created by digitization of the original which was in a non-digital form. Moreover other specifications can be applied, when necessary, about born-digital or digitization of other analog not original. Considering the conceptual base of the MODS description, the mapping toward DCA model can be applied in a consistent way driving corresponding elements toward the Artwork or Surrogate properties.

The SDL semantic elements are mapped to the relevant DCA entities metadata, by means of different types of connections, graphically characterized in the Figure 1.

The red "M" at the end of DCA boxes says that the property is Mandatory, the dark red "R" says that the property is Recommended, and the absence of letters means that it is an additional property.

The DCA entities (Artwork, Surrogate, Event, and Actor) are interlinked by the curved blue arrows.

The black arrows show the elements that can be mapped in a direct manner. The continuous red arrows highlight that more SDL metadata elements can be mapped to the same DCA entities' properties, because of the replication of the same information value, expressed in different standards semantics (mods:internetMediaType, mets:file/@MIMETYPE).

The red dashed arrows highlight that refinement and specification about the relevant information has to be done. Rights taken from mods:accessCondition can be of different types, as well as the premis:rights can have rights statement which impacts on the artwork (i.e. in case of born-digital artwork). Similarly, in case of surrogate's dates, it should be differentiated what is the relevant date, if the creation date or the image processing date or how to properly distinguish them.

Regarding to the unmapped information, like Type and Subject, it is interesting to note that it requires controlled values from different vocabularies (the MODS type of resource is not the same type of Artwork or Event).

Consequently, specific integration of DCA vocabularies has to be done in the SDL framework.

Furthermore, reminding the MODS description's assumption, the Surrogate's Language and Description are not connected because they should be the same of the Artwork, and more specific cases should be analyzed.

In the end, the other information not mapped is the description of the event. Even though the event is not considered mandatory by the DCA, it is important to note that both GAMA and DCA application profile can describe an event as an artwork. The straight purple arrows highlight properties that are shared by Artwork and Event. The MODS description doesn't provide any element regarding to the event information, except for the mods:name/@type="conference"/namePart, as reported in the RDA/MODS mapping.

Definitely, making exception for the specificity of the properties, that contain controlled values, the obligation requirements of the DCA is covered by the availability of the relevant SDL metadata elements.

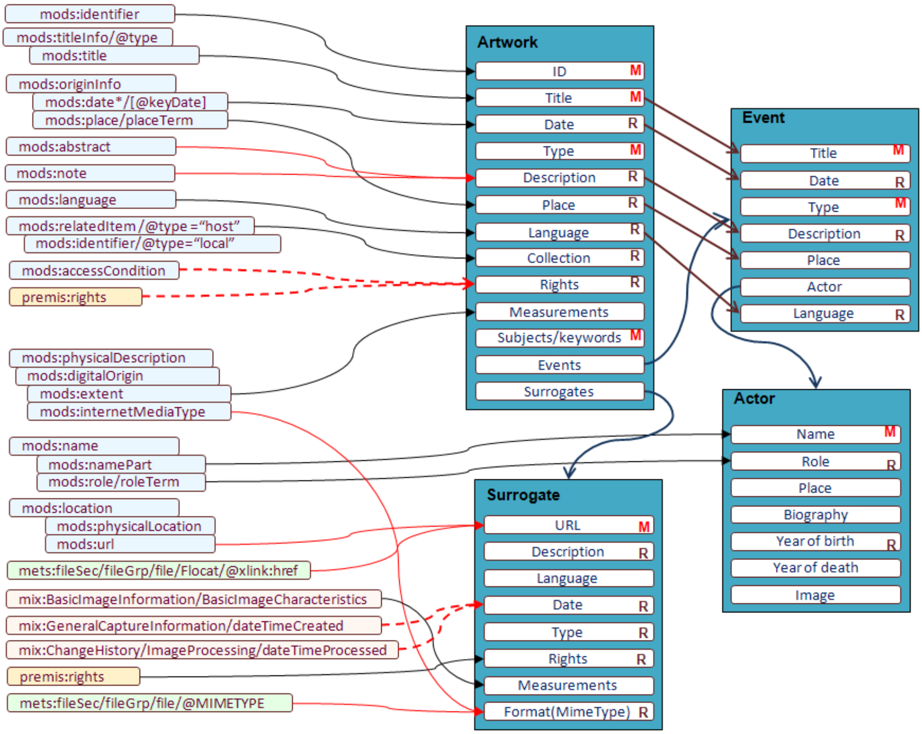

Fig. 1. Mapping from MODS/METS/PREMIS toward DCA application profile(LIDO/GAMA)

5 Conclusions

The comparative analysis can be useful to the forthcoming implementation of the export function toward Europeana repositories, in the SDL system.

In the real implementation, the underlined aspects in the mapping theorizing must be taken in consideration, in order to respect the semantic correspondence of information from one model to another.

Some questions remain open about the description of an event as SDL resource, because it is not yet clear, how to qualify properly the event with the available MODS metadata elements.

On the other side in the DCA application profile is not clear how to link the names with Artwork, if the Event property is not mandatory.

An implementation test of the enrichment of the SDL metadata framework with the missing information will be done, in order to improve the interoperability of the SDL framework toward museum metadata standards.

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Metadata Quality Assessment Tool for Open Access Cultural Heritage Institutional Repositories

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Abstract. Currently, the Metadata Quality in Cultural Heritage Institutional Repositories (IR) is an open issue. In fact, sometimes the value of the metadata fields contains typos, are out of standards, or are totally missing affecting the possibility of searching, discovering and obtaining the digital resource described. Goal of this work is to support institutions to assess the quality of their repository defining a Quality Profile for their metadata schema (e.g. Dublin core) and identifying the Completeness, Accuracy and Consistency as High level metrics. These metrics are translated in a number of computable Low level metrics (formulas) and measurement criteria. The quality measurement process has been implemented exploiting the Grid based AXMEDIS infrastructure to rise up the OAI-PMH harvesting and metadata processing performance. The quality profile metrics and the prototype have been tested on three Open Access Institution Repositories of Italian universities and the evaluation results are presented.

1 Introduction

The Metadata Quality (MQ) issue is still relatively unexplored, while there is a growing awareness of the essential role of MQ to exploit contents in the Cultural Heritage (CH) repositories. In fact, the creation of metadata automatically or by authors who are not familiar with commonly accepted cataloguing rules, indexing, or vocabulary control can create quality problems. Mandatory elements may be missed or used incorrectly. Metadata content terminology may be inconsistent, making difficult to locate relevant information. While there is a wide consensus on the need to have high MQ, there are fewer consensuses on what high MQ means and much less in how it should be measured. Following the Fitness for purpose point of view, the [1] work considers high quality metadata if support the functional requirements of the system it is designed to support. In [1], internal and external functional requirements of metadata are defined in relation to the archive's web user interface such as search, browse, filter by, etc. These functional requirements are used to decide whose metadata are needed according to the aims of the archive, the designed community, the type of objects you are going to manage. In [2], the quality definition is related to the meeting or exceeding customer expectations or satisfying the users' needs and preferences.

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Moreover, as stated in [3], the metadata relevance of a resource, and consequently their quality, has to be determined taking into account the context of use. For instance, a metadata record of absolute correctness and full completeness may not be of low quality because of the values of metadata fields do not comply with the context of use (domain standards and guidelines, e.g., wrong coding of language). Enforcing quality assurance during metadata creation [4] is one of the main concepts of the MQ. Thus, the semantic and descriptive elements associated with each resource in an institutional repository (IR), affect the quality of the service provided to the IR users. Similar to these approaches, that identifies the metadata requirements in relation to the final user expectations, are those presented in [5] and [6]. In [6], how the MQ affects the bibliographic function of research, use, dissemination, authenticity and management is described. The article defines that the main scopes of the metadata are related to retrieve, identify, select and deliver resources that are the main functions of online catalogues and digital libraries. In the Open Archive Information System (OAIS) standard [5], the Generate Descriptive Information (G-DI) function extracts Descriptive Information (DI) from the Archive Information Packages (AIPs) and collects DI from other sources to coordinate updates, and ultimately Data Management (DM). This approach includes metadata to support search and retrieval of Archive Information Packages (AIPs) (e.g., who, what, when, where, why). From the Library point of view, the QM reflects the degree to which the metadata performs the core FRBR functions of find, identify, select and obtain a digital resource [8].

In literature, the above mentioned functionalities, quality dimensions and metrics definitions are in general presented in a comprehensive Quality Features (QF). The QFs define several dimensions that the assessed information should comply in order to be considered of high quality. In [13], these QFs vary widely in their scope and goals. Some have been inspired by the Total Quality Management (TQM) paradigm, such as [14]; others are from the field of text document evaluation, especially of Web documents such as [15], others are linked to degree of usefulness or “fitness for use” [16] in a particular typified task/context. The NISO Framework of Guidance for Building Good Digital Collections presents six principles of what is termed “good” metadata [17]. These criteria and principles are defined by NISO to provide a framework of guidance for building robust digital collections, while they do not provide a clear number of well defined quality dimensions leaving the implementers free to address the issues in different ways. There are other metadata QFs that are formally defined and can be computed. They differ in granularity/detail, name of dimension, complexity and operational and there are many overlaps among them. In [18], three types of approaches to study information quality: 1) intuitive, 2) theoretical, and 3) an empirical approaches have been identified. The intuitive approach is identified when the researcher selects information quality attributes and dimensions using intuition and experience. In theoretical approach, quality features are a part of a larger theory of information/data relationship and dynamics, and, finally the empirical approach uses the information user data to determinate which dimension/feature the user applies for assessing information quality. In [19], 23 quality parameters are identified and some of them (e.g., ease of use, ease of creation, protocols, etc.) are more focused on the metadata schema standard or metadata generation tools. Stvilia in [20] uses most of them (excluding those not related with metadata quality), adds several more, and groups them in three dimensions of Information Quality (IQ): Intrinsic IQ, Relational/Contextual IQ and Reputational IQ. The Stvilia's framework parameters includes accuracy, naturalness, precision, etc. Some of these parameters are grouped and included in comprehensive dimensions (completeness, accuracy, provenance, conformance to expectations, logical consistency and coherence, timeliness, and accessibility) by of Bruce & Hillman framework [21]. Another interesting initiative is the Metadata Coverage Index (MCI)[31]. This index evaluates the completeness dimension of a metadata set as a percentage. MCI is the number of fields in a record for which information is provided, as a percentage of the total fields available. Anyhow, MCI is not based on a quality profile (weights) and does not take into account other dimensions. Thus MCI alone cannot be considered guarantee of quality.

1.1 OA Fragmented Landscape

Several studies over the use of the metadata schema in Open Access repositories, such as those reported in [9], [10], [11], and [18], confirm the fragmentary landscape in terms of the interpretation of these schema, the policies adopted, the frequency of use of a certain field, and so forth. In [9], some criteria such as "Use of Metadata set" shown that the distribution of metadata set is quite spread and 153 different metadata schemas have been identified, over only 853 repositories; thus a high percentage. In general, there are several metadata standards promoted by different communities or even promoted and adopted by a single one. The most commonly spread are: Dublin Core[1](generally supported by default), METS[2], MPEG21 DIDL[3] (as a wrapper of other metadata models), MARCXML[4], etc. Unfortunately, there is a number of other sets such as Context_ob, Xepicur, junii, Uketd_dc that have been adopted by less than the 8% of the assessed archives. There exist a 15% of institutions using metadata sets which have been based on ad-hoc model (single instances in the distribution) or which do not have a significant number of institutions adopting them. The adoption of a non-standard metadata set and schema affects the effectiveness of archive visibility and distribution.

1.2 Issues in the Schema Implementations

When searching and browsing across archives, users expect to have typical search capacities also provided by single archive environment. The user will want to look for metadata records on documents that meet certain criteria, e.g., that belong to a certain author, or that date from a certain period of time. The language of the document might be relevant, or the user might be interested in documents that contain certain keywords in the title or abstract. In order to look for documents whose publication date might fall within a certain time period, the user should be able to formulate queries containing a comparison ("date before 2001-01-01 and date after 1999-12-31"). That implies that the dates contained in the metadata must be well formed, computable and

[1] http://www.openarchives.org/OAI/2.0/oai_dc.xsd
[2] http://www.loc.gov/standards/mets/mets.xsd
[3] http://standards.iso.org/ittf/PubliclyAvailableStandards/MPEG-21_schema_files/did/didl.xsd
[4] http://www.loc.gov/standards/marcxml/schema/MARC21slim.xsd

comparable, there must be a uniform date format and an ordering on that format. In [9] some problems regarding the interpretation and use of the single metadata fields have been detected. Moreover, it is well know that the use of simple Dublin Core foresees a high level of flexibility for filling in the metadata field. In fact analysis as [9], has shown that a very few number of institutions adopted a qualified DC model, as defined by standard recommended best practice with a controlled vocabulary such as RFC 4646 or ISO639-1. For example, when the user is looking for an author, he is not interested in other information, thus, if the author field contains address and affiliation the system should distinguish between the author name and the rest of the information [12].

Moreover, the metadata multi-language system is managed in two modalities: using different instances of DC fields for each language or expressing different languages in the same field with a separator. The analysis has outlined that this separator can be arbitrary as: ‘ ,’ ‘ ;’, ‘ – ‘, ‘/’. The instance had value like en, eng, English, en_GB, en-GB, for English or es, spa, Espanol, Spanish; , spa; sp for Spanish and so forth.

Regarding the DC:format field, in [9] different filling modalities have been found with the presence of the file format definitions, physical medium descriptions, the dimensions of the resource and as described by standard definition while the recommended best practice refers to use a controlled vocabulary such as the list of Internet Media Types.

The goal of this work is to support institutions to obtain higher level of MQ for their repository trough a continue or sporadic quality assessment. Thanks to the low effort required for the assessment (automatic) and the scalability of the technology infrastructure adopted, the proposed solution is particularly suited for the institutions with low resources to manage and review the related metadata. Therefore, the main goal of this work is to assess the MQ to support cultural heritage institutions in obtaining and maintaining an appropriate quality level of their IR in a very simples and economical way, defining: (a) a MQ Profile and related dimension able to be assessed through automatic processes, (b) s set of metrics to be used for assessing and monitoring MQ, (c) a technological tool to asses the metrics defined based on a scalable infrastructure, thus estimating reference values from the global state of the quality.

The article is divided in the following sections: in section 2, the MQ Framework with the definition of quality profile, and metric dimensions, formulas and the assessment results on three IR of Italian universities are provided; in section 3, the prototype and its features are described; conclusions are reported in section 4.

2 Metadata Quality Framework

In order to address that transparency and objectivity required for a quality assessment, the adoption of a standard methodology for design metrics and manage the entire workflow is crucial. Although Goal Question Metric originated as a measurement methodology for software development, the basic concepts of GQM can be used anywhere than effective metrics are needed to assess satisfaction of goals [22]. The literature typically describes GQM in terms of a six-step process while in [22] these 6 steps are compressed in the following four phases that this work has adopted as a basis of the entire research workflow:

a) Planning Phase: This phase is represented by the Metadata Quality Profile definitions. (MQP) As stated, the MQP is based on the goal or purpose of metadata records into the OA domain and drives the metrics definition.
b) Definition phase: The definition phase consists in defining the High Level Metrics (HLM) according to the MQP and through the GQM top-down approach, the Low Level Metrics (LLM).
c) Data collection phase: Once metrics are identified, one can determine what data items are needed to support those metrics, and how those items will be collected. A Measurement Plan is defined according to [27] and includes: the definitions of direct measurements with all possible outcomes (values), the medium (tools) that should be used for collecting the measurement, and the definition of derived measurement.
d) Interpretation phase: The last step of GQM process is about looking at the measurement results in a post-mortem fashion. According to the ISO/IEC 15939 this phase foresees the check against thresholds and targets values to define the quality index of the repository.

2.1 Metadata Quality Profile

As we stated before, every quality assessment requires a definition of a clear and stable baseline quality of reference in a given context, called **Quality Profile (QP)**. A QP allows of taking into account the user perspective in the definition of the baseline quality of reference. The QP has to reflect also the notion of the quality of the OA user community and it is worth to notice that a QP must be agreed among all stakeholders involved in the quality assessment. Thus, in order to address this requirement, we submitted a specific questionnaire to the Open Access community with the aim of gathering their points of view about relevance of each DC field in a DC records quality assessment.

Data Filtering

In order to get more confident results from the analysis, we filtered out the answers with the following criteria: Critical target (we have focused Researchers 20,6%, Professors 12,7%, ICT experts15,9%, Archivists15,9%, Librarians 25,4% avoiding not relevant data provided by user with not suitable profiles that may introduce “noise” in the statistics analysis), level of knowledge (the 17% of the responders stated their knowledge of the DC schema is less then 5 in a range from 1 to 10), never worked with metadata (the work 6,3% of the responders does not include the definition and use of metadata), and never dealt with metadata quality (the 11,1% of the responders has never dealt with the quality of metadata). Then we calculated the Average, Variance and the level of confidence from the answers for each DC field before and after the data filtering. The results has shown a reduction of the Variance for each field after the data filtering as a confirmation of the correctness of our assumption.

Field selection

In order to define the quality profile, weaimed to determinate which are the fields to be taken in more consideration. In fact, each field has a different level of relevance in a record. The relevance has been estimated asking to the Open Access community experts to assign a relevance to each DC field from: 1 (the field can be omitted without affect the use of the record) to 10 (absolutely mandatory, the lack of the field makes the record totally unusable). Thus we defined the following criteria to exclude those fields that are not considered relevant by the OA community, from the quality assessment:

- The quality assessment on the field *f* can be avoided if the Average weight is 5,5 or less;
- The quality assessment on the field *f* can be avoided if the difference between the Average weights and ½ of the level of confidence is 5,5 or less.

According to the field selection criteria defined, the results show that Coverage, Publisher, Relation and Source have not passed the threshold of 5.5. In fact, the Average of the Source field score is under the threshold (5.119) yet, while for the other fields the differences between the Average and the relative level of confidence are Coverage: 5.334, Publisher: 5.325, Source:4.923 respectively. This assessment allowed us to identify relevant fields to be taken into account in the evaluation of the quality assessment. The relevance weights assigned to each field are the normalized Averages of the weights assigned by the AO experts (see Table 1).

Table 1. MQ Profile, relevance weights

Fields	Weights
Contributor	0,68
Creator	0,95
Date	0,86
Description	0,78
Format	0,66
Identifier	0,80
Language	0,66
Rights	0,70
Subject	0,73
Title	0,95
Type	0,72

2.2 High Level Metrics Definition

The MQ dimensions provided can be assessed at three levels: metadata field, metadata record, and repository level. In particular, the metadata field level foresees metrics that are able to evaluate the Completeness, Accuracy and Completeness for each metadata field defined by the schema. The derived measures give quality indexes on the fields' implementation into the repository. The metadata record level foresees metrics that, compounding the field metrics properly, are able to evaluate the quality dimensions at record level. The derived measures give quality indexes for the total amount of the Metadata records managed by a repository. The third level foresees a clustering of the quality results obtained from the first and/or the second level to provide an overview of the repository metadata quality. To this end, Consistency evaluation can be performed only if the Accuracy evaluation is passed. The Accuracy can be assessed in the Completeness evaluation is successfully passed.

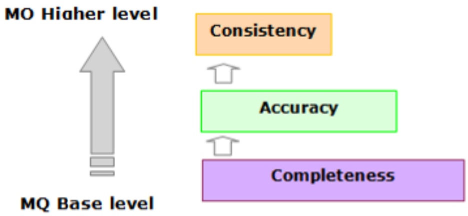

Fig. 1. Multi level MQ assessment

Hence, the Base level of Metadata Quality is assured by the full completeness of the metadata fields in the IR. Built upon this result, the Accuracy assessment can be performed. The Accuracy box is smaller the Completeness one because the number of field analyzed in this process is less than the number of fields assessed during the Completeness evaluation, where all metadata fields are taken into account. The same consideration is for Consistency box respect to the Accuracy one. This is due to the fact that for some fields is really difficult to evaluate accuracy or consistency dimension with an automatic process.

2.2.1 Completeness

Commonly the concept of Completeness is related to the presence of uncompleted fields in a record, and can be generically defined as the degree to which values are available with respect to the required [24]. In [21] instead, the Completeness does not mean that all the metadata elements are used in a given metadata schema because of two main reasons: "*First, the element set used should describe the target objects as completely as economically feasible.[…] Second, the element set should be applied to the target object population as completely as possible.*" It is clear that, there are different ways of considering complete a metadata record by a user or by a community.

Unfortunately, this approach does not seem to be feasible for a certification purpose because of its variability and uncertainty along the time. In fact, if some fields are usually not filled, it does not mean that they are not required or needed. There are several reasons that can determinate an empty value in a field. In [1], analyzing the quality of metadata in an eprint archive, the authors have identified in the publication workflow and eprint software customization the main issues. In summary, the Completeness dimension is function of the relevance weights assigned to the field by the Designed Community[5] according to recognized standards and guidelines.

2.2.2 Accuracy

In the Bruce and Hillman framework [21], the metadata should be accurate in the sense of high quality editing, thus we consider accurate a record when:

- there are not typographical errors in the free text fields,
- the values in the fields are in the format expected.

[5] Designated Community: An identified group of potential Consumers who should be able to understand a particular set of information. The Designated Community may be composed of multiple user communities – IS0:14721:2003 OAIS Reference Model.

The same point of view is adopted by Stvilia [18], when defines Accuracy/Validity dimension of the Intrinsic IQ as: "*the extent to which the content information is legitimated or valid according to some stable reference source such as a dictionary, standard schema and/or set of domain constraints and norms*". As an example, the Accuracy evaluation can be performed taking into account recommendations such as the use of ISO639-1 standard for the DC:language. Again, in the CRUI Metadata Working Group report, it is specified that the DC:subject has to assume the MIUR disciplinary sector values, while the DC:type field value has to be compliant with the MIME[25] definition, where an URI[6] is expected (DC:identifier), thus, a syntax correctness check is required. In summary, there is an Accuracy issue when a metadata record includes values not defined in the standards. Indeed, the Accuracy (correctness) could be a binary value, either "right" or "wrong", for objective information like file type, language, typos, and so with respect to the values expected by the standard.

2.2.3 Consistency

Some synonyms of Consistency referred to the metadata can be: compliance, non-contradictory, and data reliability. From our research perspective, the Consistency dimension has to address the logical error. In a metadata record, the results of a missed consistency control can affect several fields. Examples are:

- a resource results "published" before to be "created" (data fields), the MIME type declared is different respect to the real bitstream associated,
- the language of the Title is different respect to the object description, and
- the link to the digital objects is broken.

Some of the Consistency cases are difficult to be detected automatically or required notable computing efforts. For instance, the assessment of the MIME type can be performed only if the resource is downloaded and processed and a strong scalable infrastructure is required. The consistency issue affects another crucial field in a metadata schema like the fields used to obtain the resource, for example via URL. In this case, the consistency issue is related to the actual access to the resource. In general, this issue occurs when the URL to the resource is for instance, a broken link. This can happen for different reasons such as the digital object is moved to another server and the link has not been updated or the URL is written in a wrong way, and so forth. In this sense, the consistency assessment on those fields is based on the check of the effective access to the content file. In summary, the consistency issues emerge when the value in the field is formally compliance to the standard but is logically wrong.

2.3 Metric Implementation

The overall approach and aim of this work reflect the measurement objectives proposed in [26]. In order to avoid the risk of getting overwhelmed with data, as outlined

[6] Uniform Resource Identifiers IEFT RFC 3986.

in [27] and [28] one factor of defining successful measurement frameworks is to start with the most important measurements and grow slowly as the organization matures, especially if measurements are being tried for the first time. Thus, the basic measures of the three dimensions are applied on each single field and are represented by the following functions:

Completeness of a field is defined by $f(x) = \begin{cases} 0, \text{if the field is empty} \\ 1, \text{otherwise} \end{cases}$

Accuracy of the field is defined by $g(x) = \begin{cases} 0, \text{if an accuracy issue was detected} \\ 1, \text{no problem founded} \end{cases}$

Consistency of the field is defined by $h(x) = \begin{cases} 0, \text{if a consistency issue was detected} \\ 1, \text{no problem founded} \end{cases}$

Completeness of a Record y ComR(y)= $\frac{\sum_{i=1}^{nField(y)} f(x_i(y)) * w_i}{\sum_{j=1}^{nField_{Com}(y)} w_j}$ value ranged from 0 to 1.

Accuracy of a Record y AccR(y)= $\frac{\sum_{i=1}^{nField_{Acc}(y)} g(x_i(y)) * w_i}{\sum_{j=1}^{nField_{Acc}(y)} w_j}$ value ranged from 0 to 1.

Consistency of a Record y ConR(y)= $\frac{\sum_{i=1}^{nField_{Con}(y)} h(x_i(y)) * w_i}{\sum_{j=1}^{nField_{Con}(y)} w_j}$ value ranged from 0 to 1.

The derived measures for the quality are:
the average (Av)of the quality score for each dimension

AvComR= $\frac{\sum_{i=1}^{n\mathrm{Re}cords(y)} ComR(y)}{n\mathrm{Re}cords}$; AvAccR= $\frac{\sum_{i=1}^{n\mathrm{Re}cords(y)} AccR(y)}{n\mathrm{Re}cords}$; AvConR= $\frac{\sum_{i=1}^{n\mathrm{Re}cords(y)} ConR(y)}{n\mathrm{Re}cords}$;

Mean Quality of Repository r QR(***r***)= $\frac{MComR(y)/\sigma_{Com}^2 + MAccR(y)/\sigma_{Acc}^2 + MConR(y)/\sigma_{Con}^2}{1/\sigma_{Com}^2 + 1/\sigma_{Acc}^2 + 1/\sigma_{Con}^2}$ value ranged from 0 to 1.

where:

x is the i-th field in the schema; y is the y-th record; $nField_{Com}$: the total amount of fields in the metadata schema selected for the completeness evaluation, $nField_{Acc}$ the total amount of metadata fields selected for the accuracy evaluation, $nField_{Con}$ the total amount of metadata fields selected for the consistency inspection, and *nRecord*(r)is the number of records in the IR, r.

The table below reports the main measurement criteria to assess the quality dimensions for each DC field. In particular, for the accuracy and consistency dimensions 3rd party tools are used for language recognition, spelling check and MIME type extraction.

Table 2. Measurement criteria

DC field	Completeness	Accuracy	Consistency
dc.title	Javscript Rule (at least one instance) - Result: 0/1	Pear Language detect + Aspell Spelling check - Result: 0/1 + list of wrong word	NA
dc.subject	Javscript Rule (at least one instance) - Result: 0/1	Javascript Rule Comparison with the MIUR subjects list - Result: 0/1	NA
dc.date	Javacript Rule - Result: 0/1	Isdate() - Yyyy ; - Yyyy-mm-dd - dd-mm.yyyy - Result: 0/1	NA
dc:identifier	Javscript Rule (at least one instance) - Result: 0/1	Javascript rule for HTTP validator - Result: 0/1	Javascript rule HTTP broken link check - Result: 0/1
dc.language	Javscript Rule - Result: 0/1	Javascript Rule for ISO 639-2/ ISO 639-1 Check - Result: 0/1	NA
dc:type	Javscript Rule - Result: 0/1	Javascript Rule Comparison with CRUI-DRIVER-MIUR object type definition - Result: 0/1	NA
dc:format	Javscript Rule (at least one instance) - Result: 0/1	Javascript rule For MIME value check - Result: 0/1	Comparison between the MIME type (Jhove) extracted from digital object and the value of the DC:field - Result: 0/1
Dc:righs	Javscript Rule (at least one instance) - Result: 0/1	NA	NA
Cd:contributor	Javscript Rule - Result: 0/1	NA	NA
Cd:creator	Javscript Rule (at least one instance) - Result: 0/1	NA	NA

2.4 Assessment Results

The table 3 shows the results of a quality assessment conducted on 3 Open Access Institutional Repositories of Italian universities. It is worth to notice that the completeness and consistency indicators thand to obtain an high value whiale Accuracy tends to be less of 0.5, thus a low quality. The free text fields like description or language tends to be critical because of the presence of typos or not standard compliant values

Table 3. Assessment results

Repository	Records	AvComR	AvAccR	AvConsR	MQR
University of Pisa http://eprints.adm.unipi.it/cgi/oai2	465	0,765	0,450	1	0,739
University of Roma 3 http://dspace-roma3.caspur.it/dspace-oai-roma3/request	559	0,79	0,39	0,86	0,712
University of Turin http://dspace-unito.cilea.it/dspace-oai/request	497	0,81	0,37	0,86	0,64

3 System Architecture

The MQ assessment tool implements a number of GRID rules that identify the steps of the quality assessment:

Step 1: The process starts form the OAI-PMH [29] harvesting form the Open Access repository. The OAI-PMH [29] harvester is implemented through an AXCP GRID rule. This process collects the metadata records and stores them in the database.
Step 2: The second step is performed by the metadata processing rule. This rule extracts each single field form the metadata table and populate a table with rdf-like tripe and each row represents a field.
Step 3: Then the rules for completeness assessment can be lunched.
Step 4: The accuracy can be assessed for each field through a proper evaluation rules.exploiting open source 3rd part applications like JHOVE[7] for file format evaluation and ASPELL[8] for spelling check.
Step 5: This step addresses the consistency estimation. It can be lunched only on the field that have passed positively the completeness and the accuracy evaluation.
Step 6: The metric assessment, calculates MQ for the repository.

This MQ service is based on AXMEDIS AXCP tool framework, an open source infrastructure that allows trhough parallel executions of processes (called rules) allocated on one or more computers/nodes, massive harvesting, metadata processing and evaluation, automatic periodic quality monitoring, and so forth [7].

The rules are managed by a central scheduler and are formalized in extended JavaScript [30]. The AXCP Scheduler performs the rule firing, node discovering, error report and management, fail over, etc. The scheduler may puts rules in execution

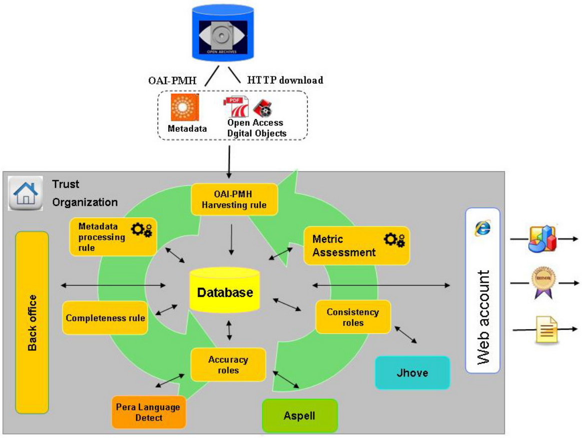

Fig. 2. System Architecture

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7 JHOVE - JSTOR/Harvard Object Validation Environment `http://hul.harvard.edu/jhove/`
8 GNU ASPELL - `http://aspell.net/`

(with parameters) periodically or when some other application request. It provides reporting information (e.g., notifications, exceptions, logs, etc…) to external workflow and tools by means of WEB services. The control and activation of rules can be performed via a Web Service through the Rule Scheduler, by any program and web applications, for example workflow tools (systems such as Open Flow and BizTalk), PHP, CGI, JSP, etc. The single node could invoke the execution of other rules by sending a request to the scheduler, so as to divide a complex rule into sub-rules running in parallel and use the computational resources accessible on the grid. An AXCP rule may perform activities of content and metadata ingestion, query and retrieval, storage, semantic computing, content formatting and adaptation, extraction of descriptors, transcoding, synchronisation, estimation of fingerprint, watermarking, indexing, summarization, metadata manipulation and mapping, packaging, protection and licensing, publication and distribution. AXCP nodes have plug-ins or may invoke external tools to expand capability with customized/external algorithms and tools.

3.1 GRID Based Metadata Harvesting and Processing

The solution approach is based on OAI-PMH protocol, a REST-based full Web Service that exploits the HTTP protocol to communicate among computers, using either the GET or the POST methods for sending requests. According to OAI-PMH protocol, Guidelines for Harvesting Implements [29] and OA implementation tutorial, a client may put a request to OAI server to ask for the stored content descriptors. Answers are related to the accessible records, and adopted formats. The OAI-PMH protocol provides a list of discrete entities (metadata records) by XML stream. As it occurs with a web crawler, the harvester contacts and inspects the OA data providers automatically and it extracts metadata sets associated with digital objects via OAI-PMH protocol. Because of the computational weight of these processes, the harvester has been implemented by using the grid based parallel processing on DISIT cloud computing infrastructure. The grid solution has been realized by using AXMEDIS Content Processing (AXCP GRID). The computational solution has been implemented by realizing a parallel processing algorithm written in AXCP Extended JavaScript [30]. The algorithm has been allocated as a set of periodic processes replicated on a number of grid nodes, typically from 1 to 15 max. The process is managed by the AXCP Scheduler. It is possible to put in execution a number of rules that are distributed to the available grid nodes. Each rule is a 'harvester' executor of an OAI-PMH request to obtain the metadata records, parsing the XML response and storing information in our local database. This solution reduces the computational time up to a factor equal to the number of nodes used for completing the harvesting of repositories. In effect, the parallel solution is not only an advantage for the speed up, but also for the reduction of the time needed to get a new global version of the metadata collected in the OI repositories.

The metadata harvesting is the first step to collect data and per se it is not sufficient to evaluate the quality of metadata implementation thus an additional grid rule got the XML of each non processed record stored in the database and it extracted the single fields. Therefore, each field of each specific record has been stored with its value, type, and additional information in the database. This poses the basis to perform a deeper analysis, as described in the following. This process led to a sort of an extended RDF model and thus to a metadata normalization allowing queries on the single fields. This table turned out to be very huge (for each field of each metadata record a detailed field record is generated. For instance 15 new records are generated from a single DC based metadata record). The resulting table of single fields has been mainly used as a metadata assessment for the purpose of this work.

4 Conclusions

The MQ issue can be addressed though automatic tools if it is possible to identify a number of criteria that can be computable and comparable against a baseline of quality. Sometimes this MQ of reference defined by user community is not strictly aligned with the official standards and guidelines, thus a specific quality profile should be identified to be more effective in the MQ assessment. This work, following the GQM approach has defined a) a MQ profile for CH repositories, b) identified three High Level Metric and their related formulas taking in to account their computability, c) implemented a measurement strategies exploiting 3rd parties and original software roles d) integrated all these components in an online cost-effective service to support Cultural heritage institution in maintaining high MQ in their repositories.

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Validating the Digital Documentation of Cultural Objects

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Abstract. The paper deals with the problem of validating digital documentation of cultural heritage. The trustworthiness of digital replicas of cultural objects relies on the presence of paradata, i.e. data concerning the provenance of the digital document. Several cases are considered, suggesting solutions to support the digital documentation, either born digital through automatic data acquisition or resulting from post-processing of captured data. Also interpretive digital models are considered and a tool for annotating digital objects is presented.

1 Introduction

Since the introduction of photography at the beginning of the 20th century, the documentation of cultural heritage has relied in an increasing way on machines, used to acquire data or to process them. As in many other fields, such process has nowadays become completely digital, producing digital-born documentation generated by equipment or on software processing.

With such increased use of digital equipment to document cultural heritage, the issue of validating the trustworthiness of the documentation produced by such devices, either as sources of the documentation or used to transform raw data through computer processing, has become a primary concern. The use of digital devices and software introduces a "black box", which weakens the relationship between the real cultural object and its documentation. Therefore it is necessary to document information on the machine and the data generating process together with the output – the data generated by that process using that machine.

Since the digital technology has so far mainly affected visual documentation, such questions involve e.g. photographs and 3D scans, directly acquired with cameras or 3D scanners; graphical documentation such as CAD-generated 2D and 3D models; interpretive visual models created to analyse and/or display the results of investigations in a synthetic and communicative way; the digital outcomes of scientific processes used e.g. for analysing the chemical or physical nature of artefacts, or for dating them; and more. Besides, there is always a human behind the machine, so also information about the authors and their documentation purpose concur to support and validate the actual documentation.

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The knowledge about the machine-based process that generated the documentation, or part of it, is called *data provenance* or *digital provenance* [1]. The term is sometimes misleading for heritage professionals, who use the same word to indicate from where an artefact comes. So, to avoid any misunderstanding, we state that henceforth in this paper we will use the term *provenance* only meaning data provenance. We will also follow the use of calling *paradata* the data necessary to support provenance [2].

Previous work on provenance has mainly concerned 3D replicas of cultural objects, i.e. models created with direct data acquisition of the object shape in 3D with 3D scanners or similar devices. CRM_{dig}, created by Martin Doerr and his colleagues of the CIDOC-CRM team at FORTH [1], [3], provides a robust solution to document the provenance of such data, as shown in the 3D-COFORM project [4].

From a rather different perspective, the London Charter [5] provides general guidance for the computer-based visualisation of Cultural Heritage. These guidelines state what kind of background information should be provided to support trustworthy visual documentation, either automatically generated using digital devices or visualizing interpretive results. So far, no full practical implementation of the Charter (besides the already mentioned CRM_{dig}) has been proposed, and there is yet no standard for paradata.

In this paper we will outline preliminary indications for generating paradata in some frequent cases. We will also describe an annotation tool to add paradata when they are missing, developed in the 3D-COFORM project. We hope this will foster the adoption of validation standards for cultural documentation based on complete provenance information.

2 The CRM_{dig} Model

CRM_{dig} [3] is an extension of the CIDOC-CRM ontology implemented to capture all the requirements regarding the provenance of digital objects, and to describe their meaning, the information concerning their creation and their scientific observation.

In particular CRM_{dig} was designed to create metadata records containing information about the digitization of moveable and immovable objects and the further processing which leads to their generation.

Being an extension of the CIDOC-CRM, the model is based on events and is also able to relate physical and digital objects, actors, time and so on. It is also suitable for integrating the knowledge of the digital provenance with the documentation concerning the physical objects that have been digitised, and to describe and to track the history of the devices used in the measurement and digitization processes.

The CRM_{dig} model of provenance metadata is structured to answer the classic five main questions about:

- Who (actors participating in the acquisition/measurement events)
- Where (the place were the event was done)
- When (the timespan in which the acquisition/measurement event occurred)

- What (the objects involved in the event) but also, and specially
- How (the set of techniques and procedures used to perform the event but also the way multiple events are related).

CRM_{dig} takes advantage of all the CIDOC-CRM classes to describe physical and digital objects, actors and places. In addition, it comprises classes and properties specifically designed for the representation of the events leading to the creation of provenance data.

The main class provided by the model is the Data Acquisition Event for describing the main data acquisition process. Any Data Acquisition Event can be further specified by using types (e.g. “Photogrammetry”, “Laser Scanner” and so on) coming from one or more domain specific controlled vocabularies.

The Data Acquisition Event has many subclasses to provide further specification, such as the Capturing Event, to describe the capturing unit using a specific capturing device, the Calibration Event, to encode the device calibration data, the Digital Documentation Event, to represent specific information on the physical objects themselves.

Additionally, each class has its own set of properties according to the class it belongs to, and also complies with the class hierarchy concepts inheriting properties from its super-classes.

The CRM_{dig} model is released as RDFS and uses the RDF syntax to express provenance entities and relationships, a standard format flexible enough to encode both the machine-generated and the human-created provenance information, to share it within various scenarios and to make it easy to be queried in a semantic way.

We will show an example of CRM_{dig} paradata, referring to Doerr’s original papers for a general description [3].

The example concerns the digital replica of a museum artefact. The original object is a cinerary urn from the Villanovian necropolis of Poggio alla Guardia, Vetulonia near Grosseto in Sothern Tuscany, Italy, dating from the ninth century BC. The urn is now at the Archaeological and Art Museum of Grosseto.

Fig. 1. 3D scanning of the Vetulonia urn at the Grosseto museum (left) and a snapshot of the 3D model of the Vetulonia urn (right)

The digital replica was created using a low-cost scanner, NextEngine, shown in Fig. 1. Then the raw data were processed with MeshLab. We present here the documentation of the scanning process.

In the following, E and P denote respectively classes and properties of the CIDOC CRM, while D and L denote classes and properties of the CRM_{dig} extension. For the sake of clarity, the document is presented in chunks, each related to a different part of the documentation; text in parentheses is a comment.

```
Person: http://viaf.org/viaf/258811              (E21 Person URI)
  L4F.has_preferred_label: "Niccolucci, Franco"      (E62 String)
    P131 is identified by: D21 Person Name
     L51 has first name: "Niccolucci"                (E62 String)
     L52 has last name: "Franco"                     (E62 String)
     P107B.1 is current or former researcher of:
       http://www.poloprato.unifi.it/            (E40 Legal Body)
Legal Body1: http://www.poloprato.unifi.it/     (E40 Legal Body)
  L4 has preferred label: "PIN, Prato Italy"         (E62 String)
  P74 has current or former residence:
      http://www.geonames.org/3169921/            (E53 Place URI)
  L4 has preferred label:  "Prato"                   (E62 String)
  P3 has note: "Italy"                               (E62 String)
Legal Body2:
      http://www.museidimaremma.it/it/grosseto (E40 Legal Body)
   L4 has preferred label: "Museo Archeologico
      e d'Arte della Maremma, Grosseto, Italy"       (E62 String)
   P74 has current or former residence:
        http://www.geonames.org/3175786/          (E53 Place URI)
   L4 has preferred label:  "Grosseto"               (E62 String)
   P3 has note: "Italy"                              (E62 String)
Data Acquisition Event: uuid:3c91e0-b3fa-11de-
         98c6-0002a5d5c30a             (D2 Digitization Process)
   L4 has preferred label: "Laser scanning of
         Vetulonia urn 123456 in the Archaeolo
         gical and Art Museum of Maremma"            (E62 String)
   P2 has type: http://www.3d-coform.eu/EventType/
         laser_scanning                                (E55 Type)
   P3 has note: "Scanning of the Vetulonia urn"      (E62 String)
   P9 forms part of: uuid:07f05f40-b415-11de-
         9d48-0002a5d5c30c                         (E7 Activity)
   L31 has starting date-time:
         2013-02-20T08:00:00Z              (E61 Time Primitive)
   L32 has ending date-time:
         2013-02-20T12:00:00Z              (E61 Time Primitive)
```

```
   P7 took place at: http://www.poloprato.unifi.it/
         #Place/MuseumGrossetoScan                    (E53 Place)
   L29 has responsible organisation:
         http:// www.poloprato.unifi.it/       (E40 Legal Body)
   L30 has operator: http://viaf.org/viaf/258811    (E21 Person,
                                             i.e. Franco Niccolucci)
  L12 happened on device: http://www.nextengine
          .com/.../E4035623490              (D8 Digital Device)
      L59 has serial number: E403562349             (E62 String)
      L4 has preferred label: "Next Engine Desktop
          3D scanner"                      (E62 tring)(=Model)
      P2 has type: http://www.3d-coform.eu/
          DeviceType/laser_scanner                    (E55 Type)
      L33 has maker: http://www.nextengine.com       (E39 Actor)
      P3 has note: "Next Engine Desktop 3D
           scanner, Multi stripe laser"             (E62 String)
      P3 has note: "Setting: HiRes"                 (E62 String)
      L23 used software or firmware: http://www.
          nextengine.com/.../Scan_Studio         (D14 Software)
    P16 used specific object: http://www.manfrotto.
          it/treppiedi/055CX3             (E22 Man Made Object)
Object Acquisition Event: uuid:354c91e0-b3fa-
          11de-98c6-0002a5d5c30a      (D2 Digitization Process)
   L1 digitized: uuid:e4761f00-0ce7-11e0-
          81e0-0800200c9a66               (E22 Man-made Object)
   P1 is identified by: http://www.museidimaremma.
          it/it/grosseto/12345                 (E42 Identifier)
   L4 has preferred label: "Vetulonia, urn,
          123456"                                   (E62 String)
      L53 is not uniquely identified by:
           "Vetulonia urn                           (E62 String)
   L55 has inventory no: "123456"                   (E62 String)
  P2 has type: http://www.getty.edu/research/tools/
           vocabularies/aat/300124808                 (E55 Type,
                                                     cinerary urn)
P50 has current keeper: uuid:6f2972e6-ad9e-
           4a72-930d-263f01e75d8c              (E40 Legal Body,
                       Archaeological and Art Museum of Maremma)
```

Note the use of URI to identify: persons, using VIAF [6]; types, via Getty's AAT [7]; equipment, by 3D-COFORM [4] and vendors; places, using Geonames [8]. Other instances are identified via a UUID. The object is identified using a Museum inventory number (the one used here is fictitious). Incidentally, we note that this approach enables Open Linked Data.

3 Documenting Post-processing and 3D Modelling

It is unlikely that visual documentation is stored “as is”, i.e. as it is acquired. It usually undergoes cleaning and filtering in order to produce acceptable images or 3D models. Such post-processing changes the raw data and should be documented to guarantee the provenance of the resulting documentation. Unfortunately, actions performed during post-processing are usually not recorded by the software, with some notable exceptions. Below there are a few examples of how to get the provenance information using software functions that usually were included in the software to automate post-processing or to undo commands.

In general, a post-processing action on the file file1.obj resulting in a new file file2.obj may be modelled in CIDOC-CRM as an event, or more precisely as with the following schema:

```
Post-process event: uuid:c88b2da2-9afd-
        4ab5-a3bf-25d4ef14a1aa           (D3 Formal Derivation)
   L4 has preferred label: 2012-12-01
        Processing of the 3D model of XXX          (E62 String)
   P2 has type: http://www.3d-coform.eu/
        EventType/process_event                      (E55 Type)
   P2 has type: http://www.3d-coform.eu/
        ProcessType/modeling                         (E55 Type)
   L53 is not uniquely identified by: XXX
        processing                                 (E62 String)
   P9 forms part of:uuid:f349af39-969b-465c-
        8b69-d79498ed30d7           (E7 Activity, i.e. Project)
   L29 has responsible organization:
        "http://www.poloprato.unifi.it/"       (E40 Legal Body)
   L30 has operator: http://viaf.org/viaf/258811    (E21 Person)
   L61 was ongoing at: 2012-05-01T00:00:00Z (E61 Time Primitive)
   L2 used as source: uuid:1d95d196-2b0b-
        4737-868f-f7463edcabd5                   (D14 Software)
  L21 used as derivation source: "http://
        documentation.org/file1.obj          (D1 Digital Object)
   P94 has created "http://documentation.org/
        file2.obj"                           (D1 Digital Object)
   P70 is documented in "http://documentation.
        org/log1.txt"                        (D1 Digital Object)
```

where the log file `log1.txt` contains – in a standardized format – a description of the actions performed by the software. No further detail is required at this level on the log file, because the minimal provenance condition is that it exists and it is available for inspection. As regards its format, we may limit to prescribe a plain text XML forma, compliant with some predefined schema typical of the software used for the transformation.

To start with 2D, *Photoshop* [9] enables recording actions and storing them in an action `.atn` file. The file is actually plain text, but it is not XML compliant; it is instead a macro written using the Photoshop scripting language. However, the file could be easily parsed into an XML-compliant format and added as provenance documentation of a processed image. This would add data to the EXIF file, generated by the camera during the acquisition stage, i.e. when taking the original shot. Most cameras store in this header all the relevant information about the capture action, like camera model, lens, shutter and so on. Some include also the camera position using a GPS. In conclusion, a very simple automatic conversion on already available data might generate suitable paradata.

Meshlab [10], the 3D mesh processing software developed at ISTI-CNR with the support of the 3D-COFORM project, has some functions that enable documenting the transformations performed on a digital 3D object. It may be assumed that this recording option was added not only to perform repetitive tasks, but also to comply with provenance requirements, as this was a pillar of the 3D-COFORM project approach.

The software description claims: “The history of the all performed cleaning/editing actions can be re-played on different meshes or saved for archival purposes.” Actually, there is a menu option enabling to visualize and save the filters applied on the object in an XML file with a .mlx extension. Each filter action is saved with the relevant parameters: for example applying the Ageing filter with the default parameter values would be recorded as follows:

```
  <filter name="Mesh aging and chipping simulation">
    <Param type="RichBool" value="true"
name="ComputeCurvature"/>
    <Param type="RichBool" value="false" name="SmoothQuality"/>
    <Param type="RichAbsPerc" value="0" min="0"
name="QualityThreshold" max="0"/>
    <Param type="RichAbsPerc" value="68.452" min="0"
name="EdgeLenThreshold" max="1711.3"/>
    <Param type="RichAbsPerc" value="171.13" min="0"
name="ChipDepth" max="3422.61"/>
    <Param type="RichInt" value="3" name="Octaves"/>
    <Param type="RichAbsPerc" value="342.261" min="0"
name="NoiseFreqScale" max="3422.61"/>
    <Param type="RichFloat" value="0.5" name="NoiseClamp"/>
    <Param type="RichFloat" value="10"
name="DisplacementSteps"/>
    <Param type="RichBool" value="false" name="Selected"/>
    <Param type="RichBool" value="false"
name="StoreDisplacement"/>
  </filter>
```

The script file is saved on demand, but it would be straightforward to save it every time the model is saved, perhaps adding a preference option for saving the .mlx file together with the model, with the same name and the reserved .mlx extension. This would automatize the provenance documentation procedure.

Blender [11], the well-known 3D modelling package, keeps in memory by default the results of the last performed transformations in what is called Undo History. The number of such models is set by the user, but just the results – and not the actions – are kept, as necessary for undoing actions. However, there is an add-on to Blender called Macro Recorder that enables recording the commands given by the user in a text block that may be saved separately. The format in which the command sequence is saved can then be converted to a pre-determined XML format.

On this regard, Blender is superior to *Autocad* [12], where actions may be recorded and saved, but the trick of using the saved file for documentation does not work because it is stored in a proprietary format that can be read only from AutoCAD itself.

For *GIMP* [13], the open source image editor: to record the activities it is necessary to use a plug-in that writes Python code – not exactly a readable documentation. A similar situation happens in *3D Studio Max* [14], where a plugin called also MacroRecorder captures user's actions and generates a script file in MAXscript, the programming language of 3D Studio Max.

In conclusion, until software developers become aware of the documentation needs of cultural heritage, the files created to save "macros" are a good substitute for a log file, as long as they are readable and may be converted to some XML format. If they generate code, in general they will need more complicated processing to be used for paradata generation, and the general feasibility of this conversion is not guaranteed. No solution is finally available when they do not exist, or they cannot be read, as in Autocad.

4 The 3D-COFORM Annotation Tool

The 3D-COFORM project has released a set of tools specifically designed to attach layers of metadata and paradata on 3D object and text documents. The Annotation Framework presents several user interfaces based on a well defined annotation paradigm. Each one of them supports a different annotation scenario, even if for all of them the main goal is to provide semantic information along the different steps of documents existence and of 3D objects' lifecycle, from their acquisition and modeling (e.g. to capture the provenance information) to their publication and presentation (e.g. to realte the 3D models with the real world objects by attaching on them relevant annotations and documentation information).

The 3D-COFORM project proposes a uniform annotation model based on the notion of area. It recommends to define areas on objects by using the METS standard, and also to use some extensions of METS to support information encoded in COLLADA and W3C HTML ranges [15].

The crucial definition of "Area" is also provided by the project. An Area, in the 3D-COFORM view, is a location of any shape or size, considered "of interest" in a given object. The object on which an area is declared can be a text, an image, a video, a 3D object and others. All areas of an object are defined in the object's AreaTable, an XML file encoded using an extension of the METS standard and coming together with the digital resource [16].

The annotation model proposed by the 3D-COFORM project has been defined as an extension of CIDOC-CRM. It relies on the well-accepted and standard procedure known as "Named Graphs", a technique used to define an annotation as a bunch of RDF triples containing the various entities and the relationships with the METS code representing the related areas. Both the RDF information concerning the annotations and the METS data describing the areas can be stored in a semantic repository for integration and reuse.

The annotation model builds on top of two basic entities: the Annotation Event, a subclass of the CIDOC-CRM Creation event, and the Annotation Object, a subclass of the CRM_{dig} Digital Object. The Annotation Event creates the Annotation Objects. Other entities, like the Knowledge Extraction event and the related Knowledge Object, can be used to describe specific associations (see Fig. 2).

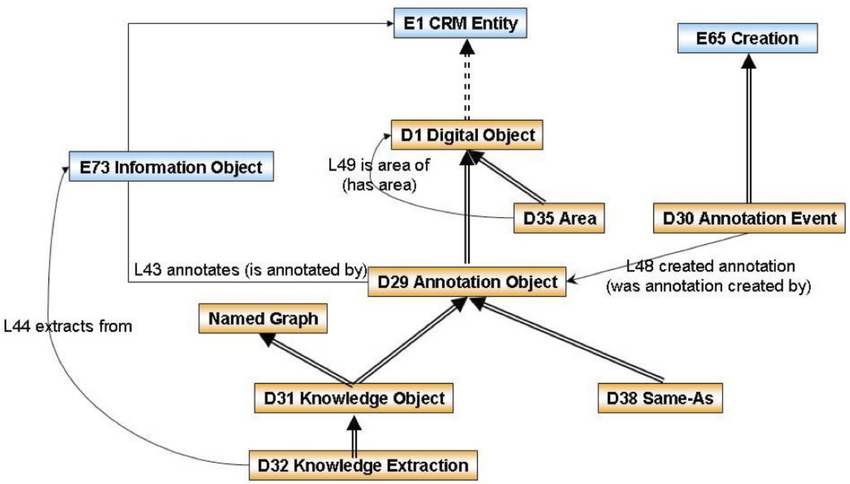

Fig. 2. The Annotation Event and the related classes and properties

Following these assumptions, the project has developed technologies for implementing a complete Annotations Framework and an Ingestion Tool able to store and retrieve objects in a given repository, together with all the metadata/paradata created along the objects' lifecycle.

4.1 The Annotation Framework

The purpose of this toolset is to provide an intuitive semantic annotation and tagging framework that will allow users to manually establish relationships between 3D artifacts and textual information, and to specify the meaning of segmented parts as efficiently as possible. This allows the user to create new or extend existing annotations. The framework interfaces are able to guide the user during the various operation , allowing him to comment texts and 3D models using the CIDOC-CRM entities and relationships, and to perform complex operations of annotation and knowledge extraction. Interfaces for thesauri are also provided for the standardization of the various terms used during the various processes [17].

4.2 3D Models Annotation

The 3D Model annotation facilities allows user to create a comment or a relation on a 3D model by selecting an area of interest. On the selected area it is possible to define a label and to type a comment concerning that specific section of the digital object. Selected (and commented) areas, can be also saved or stored into the repository to be used in other annotation operations. To create a relation, the user can browse the existing entities/annotation previously defined and drag drop them on the selected area. Then it is possible to specify the type for the newly created relation and save the whole into the repository [18].

4.3 Text Annotation

The text annotation facilities allow the semantic enrichment of printed or type-written texts by using annotation and knowledge extraction techniques, and the possibility to create and store the information into semantic archives of annotations. Through the Text Annotation interfaces is also possible to create and edit new documents, i.e. the digital copy of the paper version of the original document, thanks to the provided mini editor [19].

The creation of new annotations (which means, in the case of texts, the association between a conceptual layer and an area of text) can be performed at any time on the current document, either during or after the editing session. The operation itself consists in relating a piece of semantic information with a selected area of text. The semantic information assigned can be used to “comment” the area or the whole document, or to provide a meaningful link between the selected text and whatever other annotation or area (e.g. another 3D or text area or another annotation concerning a 3D object or document) available within the system, either locally (e.g. on the same document) or stored remotely, into the semantic repository. To do this, the tool also gives the possibility to load existing annotations from the server, in order to reuse them and to implement a process of semantic enrichment.

Features for visualising comments and annotations are also provided. In order to display the annotation information associated with an area of a 3D object or text, the area can be selected and a preview of the attached annotations is presented in the 3D scene or within the document. The full information is displayed on the viewing frame, a separate window of the annotation interface.

4.4 Ingestion Tool

Another 3D-COFORM tool able to produce additional information concerning digital objects, is the Ingestion Tool, which offers a complete set of features to provide 3D models with valid CRM_{dig} digital provenance metadata before the ingestion into the a digital repository.

The tool guides the user during the ingest process to manually provide sufficient and consistent information on 3D model devoid of creation and processing metadata. It also gives the possibility to create a "process pipeline" in order to support the envisaged reasoning functions for data management and scientific interpretation. In this sense, the main challenge of the tool is to ensure a referential integrity and a semantic coherence of the newly created information.

In particular, all the necessary functions to describe (and encode) the CRM_{dig} Acquisition and Process Event(s) and to state relations with the digital objects acquired, are provided. Establishing relations with the Actors involved in the processes and with the Places where the processes took place, are provided through various forms, which can be also used to create information concerning the devices used for the acquisition and the setup and calibrations of the hardware used alongside the process [20].

5 Interpretive Models

After a long debate on the use of virtual reconstructions and in general of visual interpretive aids in archaeology (the history of this discussion is summarized in [21]), a group of researchers proposed the London Charter for the computer-based visualisation of Cultural Heritage [5]. The Charter dictates very general principles and provides no guidance for implementation.

A recent book [22] has collected a number of essays on the subject. Among others, [22] defines paradata and discusses them extensively. However, his definition is focused on visualization, while here we are using the concepts more extensively. A few papers deal with the practical implementation of the Charter in some applications, and present some non-systematic attempts to collect the background information prescribed by the London Charter.

A full application of the London Charter has been so far attempted also in two research papers. In the first one [23], the authors report about a Dublin Core-based information system where all the relevant information concerning the Abbey of Lorsch, a World Heritage Site in Germany, has been virtually reconstructed. The sources were stored in a database, while no proper system was devised for the inferences based on them. Reconstructions were also loosely linked to sources and inferences. Finally, all the information was arranged and linked to a timeline.

In the second paper [25], the authors describe the procedure for virtually reconstructing the Hellenistic-Roman theatre in Pathos, Cyprus. They stored all the relevant background information in a database, which helped them in developing the reconstruction, considering also alternate hypotheses. Due to shortage of space in the paper, very few details are given, and reference is made to a web site that unfortunately seems to be no more active.

In conclusion, although both papers acknowledge the importance of the London Charter, neither gives hints on a way – even partial – to implement it.

It must be acknowledged that the subject is indeed complex and difficult to manage for the diversity of sources and interpretations, the subjectivity of inferences and the difficulty of explaining a reasoning which is often intuitive. We will not give here an ultimate solution, but will propose an approach.

Firstly, we agree with [23] that all relevant sources should be stored in a repository. We however suggest that the repository should be organized semantically, as it is rather difficult if not impossible to set such diverse materials for example in a relational database. The organization of the repository depends on the nature of the documents, which can be texts, images, 3D models and so on. The repository may be created for the reconstruction or perhaps one may avail – in toto or in part – of an existing repository which is accessible on-line. Linked Open Data would give a great support to this approach. The repository may be annotated using the 3D-COFORM annotation tool to evidence which parts are relevant to the reconstruction and how.

Secondly, the 3D models representing the reconstruction and any explanatory text might be annotated with the same tools explaining the reconstruction choices and linking parts of the model and chunks of explanatory text to the source.

This approach would overcome, at least in part, the difficulty pointed out by [23] of documenting the inference process, which would be described in the annotations with links to supporting sources and/or to alternate solutions

6 Conclusions and Further Work

There is some resistance among software developers to include in their packages ways of documenting the processing steps in a way which complies with requirements described in the present paper. Similarly, hardware producers do not document enough what goes on in their equipment and software during the initial post-processing of captured 2D or 3D models using pre-set commands (e.g. “Clean”; “Fix holes”; etc.). Also the teams carrying out data capture sometimes complain about the additional work required to collect paradata. At least in the latter case, the complaint is not justified. Such teams use a small number of instruments and settings, which can be documented once for all, and referred directly by URIs, for example using an internal inventory number to describe the instrument, and a named profile to describe the setting. In this way there would be only a small number of URI, defined locally or even globally if the hardware/software producer accepts this convention.

We have shown here some simple ways to produce paradata. There is still much work to be done to cover the remaining cases, especially to document post-processing and transformation in a seamless way, and above all to agree on a structured documentation implementing the London Charter criteria. The latter is paramount if digital documentation of interpretation must become a tool for research. As the background work supporting interpretation is complex and extensive, agreement on a standardized way of documenting is not within easy reach. A possible path in our opinion consists in taking into account examples such as those presented before and structure the information provided. Through generalization it will be then possible to produce solutions to classes of similar problems and eventually, perhaps, to provide a global solution.

Tools like the annotation tool described above will allow intervening and complementing already existing documentation, for example adding missing information as an annotation. This activity will increase the reliability of the documents and improve the general quality of datasets.

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A Workflow Model and Architecture for Content and Metadata Management Based on Grid Computing

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Abstract. Large scale multimedia services such as social networks, content delivery networks, online service archives provide access to huge amount of content with several hundreds of descriptors fields associated with and file versions, thus really complex content management systems. They have a great need of and orchestrated workflow system and automated process management system that allow managing content and metadata, in order to automate as much as possible the activities (thus reducing the costs) and increasing the quality and accessibility. Grid computing technology may aid at integrating and improving existing content management and workflow systems in order to efficiently organize and manage large amount of data and processes to cope with them. In this context, the workflow model and architecture base on grid computing adopted by ECLAP network is presented.

Keywords: workflow, metadata enrichment, metadata validation, grid computing, semantic computing, IPR management.

1 Introduction

Large scale multimedia services such as social networks, content delivery networks, online archives, e-commerce portals, and other service networks, are typically managed by large companies and institutions, thus allowing widespread, simultaneous access to huge amount of content items. Content accessibility is not only the digital resource distribution and fruition by several devices and different kind of users but also the quality of information associated with content, better known as metadata and in general descriptors. Metadata and descriptors have a key role in allowing such systems to be set up, become efficient and automate relevant processes. Therefore, metadata must be created and maintained according a formally well-defined set of procedures. The aim of metadata is to provide adequate and correct information to their users so as to obtain a true description of the content, for access and retrieval. Metadata serve as the "mirror" of the resource, therefore their quality expresses the true representation of the resource and the absence of any distortion of its picture [1].

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Multimedia services need to be supported by content, metadata and workflow management systems to efficiently manage content items and metadata production. Workflow is concerned with the automation of procedures whereby files and data are passed between participants according to a defined set of rules to achieve an overall goal [2]. A workflow management system defines, manages and executes workflows on computing resources [3]. A workflow has to be described in terms of movement of contents or tasks through a sequence of processing steps during which work is performed on the content. It also has to define where and who performs them, and in what order, where and when. The synchronization of tasks might be controlled with auxiliary information flowing to support the activity. A workflow system allows tracking all the above mentioned activities and roles over time. To cope with large amount of data and with the problem of reducing costs and time, multimedia services have great need of automated procedures that allow working on content and metadata in massive way. With the usage of computational grid paradigm, complex solutions have been possible to manage and process large data sets, and execute massive processing on distributed systems. A computational semantic grid allows (i) reducing costs for content and metadata production and management by applying techniques for content processing, transcoding, adaptation, representation (format), metadata translation and quality assessment; (ii) reducing distribution and aggregation costs in order to increase accessibility; (iii) integrating existing content management systems and workflows; (iv) integrating methods and tools for Intellectual Property Right (IPR) or/and Digital Rights Management (DRM) [5]. Grid-based workflow management system aids users by enabling their applications to be orchestrated in the workflow and then executed on the Grid at a higher level of abstraction.

In this paper the workflow model and architecture adopted by ECLAP (European Collected Library of Artistic Performance, [8]) is presented. ECLAP, http://www.eclap.eu, is a European Commission project CIP-ICT-PSP.2009.2.2, Grant Agreement N°250481. ECLAP provides many precious materials as film, video, audio, images, books, posters, etc., and it is an aggregator of Europeana, Http://www.europeana.eu. ECLAP ingests the metadata and digital content provided by more than 35 different prestigious cultural international institutions. The paper is organized as follows. In section 2, the ECLAP overview is presented. Section 3, provides the ECLAP workflow requirements. In section 4, ECLAP workflow tools are proposed, while workflow models are shown in Section 5. Conclusions are drawn in section 6.

2 ECLAP Overview

ECLAP provides cultural institutions and archives, opera houses, theatres, cultural foundations, festivals, research and education institutions and also simple users with special services. This kind of content ranges over several fields: theatre, dance, music, cinema and movie and such content items deal with variety show, performances, costumes, sketches, stage designing, texts or posters, lessons, master classes, music scores, didactical materials. This content is available as: audio and video files, documents, images, animations, annotations, 3D, interactive content items, e-book, multimedia content. ECLAP has a considerable online archive for all the performing arts in Europe providing solutions and tools to help performing arts institutions to enter the digital Europe by building a network of important European performing arts institutions and archives and publishing content collections on Europeana, the European Digital Library [8], [7]. One of main activities of ECLAP is the metadata enrichment, and is achieved in various ways. In ECLAP, Content and metadata processing, ingestion and semantification has been addressed by adopting the AXMEDIS AXCP Content Processing Grid platform ([4] [5]) plus additional open source tools for back-office automation. It is on the back-side of the ECLAP Portal and manages all the "dirty" activities in an automated manner. AXCP uses semantic processing tools and exposes a number of APIs for external applications that may exploit the back office capability of AXCP and cope with massive parallel and distributed requests. The AXCP solution has been set up on a set of computers organised in a grid on which several parallel activities are automatically allocated to perform: content ingestion and integration, database management, content processing (formatting, adaptation, transcoding, etc.), content and users similarity analysis and clustering for users and content recommendations, content aggregation and integration (packing, packaging) for educational and entertainment productions, multilingual processing, text processing, semantic processing, metadata harvesting, crawling and processing by direct mapping and semantic reasoning.

3 Workflow Requirements for Cultural Heritage Services

The main requirements related to the content and metadata management and workflow in ECLAP, as well as in many cultural heritage communities playing the role of content aggregator and content provider service, are reported in the following.

Content and Metadata Ingestion. Users provide professional and/or user generated content as digital resources and metadata. They could manually upload them (one or many of them once) via a web page providing content files together with metadata or when digital resources are too big to get via Internet, they have to be provided by using physical device. Thus an automated procedure for content and metadata collection and ingestion is needed. It has to be possible to start the metadata ingestion without content, and joining later when the digital resource is available. The content would be available until all elements are available and processed. An automated solution involves the access and retrieval from any database and storage area network, as well as the access and processing of XML files and schemas. Moreover, metadata access also implies reaching them via communication channels and harvesting via archive protocols such as OAI PMH or Z39.50.

Content life-cycle: Not all contents when ingested are ready to be public. This depends from kind of user that provides the content and content itself. A professional user providing professional content is considered a *trusted* user and his content could be immediately accepted and published. Common users have to be considered as *un-trusted* and their content has to be moderated by Content Supervisor. In this scenario, content coming from un-trusted user, should be stored in a specific repository (i.e. administrative database) waiting for approval. Moreover, content coming from untrusted users are not entitled to be published to Digital Libraries, whereas professional users could be let free to decide to provide the content also to other Digital Libraries as Europeana. In these terms, we have to consider different workflow types and then coping with different quality requirement for content and metadata.

Content Adaptation and Repurposing. Content processing capability could be required for text, audio, video, image, and multimedia might include adaptation and transcoding (converting from different formats WMV to MPEG, resizing, rescaling, resampling); formatting of presentation layer models (HTML/CSS, SMIL, MPEG-4); cross-media format conversions (MXF, MPEG-21, NewsML, SMIL, HTML/CSS, ePub); and fingerprinting and watermarking estimation, recognition, and extraction.

Metadata Enrichment. Metadata fields of a metadata schema could be expanded and enhanced, for instance by mapping the various metadata models and vocabularies used by content providers to each other, and by semantically enriching metadata, by adding more metadata to digital objects than the metadata already available or correcting existing one. The enrichment can be performed manually by one or more users/experts involved by editing metadata for each record field by field or automatically for generating technical metadata (format, type, size of content) and relationships with other contents (for example via similarity metrics, thus suggestions).

Multilingual Metadata Translation. It may be necessary to have a multilingual version of metadata and to cope with the accessibility of content and for the indexing. Metadata translation is an enrichment activity and it can be performed manually by one or more skilled users or automatically by using external tools or web translation services. In this latter case, the obtained metadata have to be revised and validated before publication or at least marked as obtained by automated translation.

Content IPR Management. Intellectual Property Rights (IPR) modelling, also called licensing is often required to regulate the possible uses/accesses to the digital content (e.g., use on a specific device, use for a specific time period, use on a specific territory, use for educational purposes, etc.). To this end, specific rules have to be defined by experts for each object to formalize the contract. For example, for limiting download, access from location, access to high resolution, etc.

Metadata Assessment and Validation. Since metadata allow successfully discovering the appropriate resources, the assessment of metadata quality has to ensure validity and completeness. Each metadata set has to be evaluated syntactically and semantically [1]. The metadata assessment process may involve one or more experts that manually review and validate metadata or in automatic manner by using logical and NLP rules adding also a check for the availability of the minimum set of metadata (e.g., the metadata set required by Europeana).

Content Assessment and Validation for publication. This is the task of ensuring that the digital content is correct and complete. The analysis takes into account the content by checking if it is complete and uncorrupted, the number of validated metadata, semantic information and IPR formalization and consistency. In order to achieve an automated validation service that is functional in large scale digital content, validation could be proceed with minimal manual intervention. It is not economically feasible to check manually every piece of content placed in a repository. The ultimate reference against which to judge the abilities of any computer based validation process is a person who inspects each piece of content manually. Such person could be a publisher that makes content under approval/assessment accessible or rejects it to apply further improvements.

User and Automated processing. Users and automated processing could concurrently interact with the content under processing, analysis or editing. If this is not controlled and managed, the integrity of changes could be lost. In these circumstances, it is necessary to guarantee a safe access by means of an unlock-lock mechanism that give to user/automated process who takes the content as first the priority to work on content.

User roles. As stated, many activities can be performed on content and different kinds of users with specific skills are needed. We could have common users that upload content, experts on contents that could enrich and validate the information; publishers to evaluate quality of content and metadata, automated tools that can implement some automated assessment that are passed to those relevant and highly qualified users, making their work possible and more valuable.

Logging and keeping trace of metadata versioning. All activities performed on content and metadata have to be tracked in order to keep trace of the work done and changes performed (who did what, when and how). The information recorded in the journal/log should be analyzed to calculate throughput as a measurable value of the workflow efficiency and may be detecting/predicting problems and solution.

4 ECLAP Architecture and Tools

The ECLAP architecture (see Figure 1) and consists of three main areas: Metadata Ingestion Server, ACXP back office services and ECLAP Portal. The Metadata Ingestion Server collects massive metadata provided by digital archives and libraries (using external metadata mapping tools as MINT [9]). Metadata coming in different schema are mapped according to the ECLAP metadata schema and are made available through the OAI-PMH protocol. ACXP back office services provide automated procedures for content and metadata processing (harvesting, ingestion, analysis, production, adaptation, etc…). The ECLAP portal is the front end and provides front-office tools to work on content and metadata, IPR and content management.

4.1 ECLAP Back-Office Services

The ECLAP back-office tools consist of a set of grid processes that run automated workflow processes both on a single and on multiple contents.

Automated ingestion – It ingests metadata and content coming from ECLAP partners and Digital Archives and from the external metadata mapping tool MINT. The process allows ingesting both massively and singularly metadata and digital resources. When resources are big file, they are provided by using physical device. In this case, ECLAP just starts with metadata ingestion and when the digital resources are available, the joining is performed.

Content production and adaptation - This process works with the digital resource and metadata uploaded via web or ingested. Metadata and digital resource are retrieved from the CMS or the storage area or downloaded from the provided URL. Incoming metadata (Dublin Core, Taxonomy, Groups, Performing Arts metadata, workflow type, user) are enriched with technical metadata built by analyzing the digital resource: (i) content format (document, audio, video, image, crossmedia), (ii) content type (file format), (iii) structural information (size, duration, number of pages). The produced enriched metadata and digital resource are aggregated and published in the publication database. Metadata are indexed to make the content ready for access on the portal. The production process works also when the digital resource has to be replaced with a new one (Update). To make the incoming digital resource accessible by different devices Content Adaptation processes are exploited: (i) Content adaptation to different resolutions produces content accessible by different devices (iPhone, iPad, Android, Windows Phone, etc. and on the ECLAP portal, any browser.); (ii) Video adaptation produces the Low, Medium and High Definition versions of a video; (iii) Metadata Translation translates Dublin Core metadata and missing metadata in different languages by using tool or web service for text translation.

Content management - During the life-cycle of content, massive actions on content could be needed: changes in the workflow status, changes in the metadata, addition of details in the metadata sets, etc. Specific actions are also needed to maintain and manage the content and work both on single content and multiple such as: delete content, update metadata, and publish content uploaded by common users.

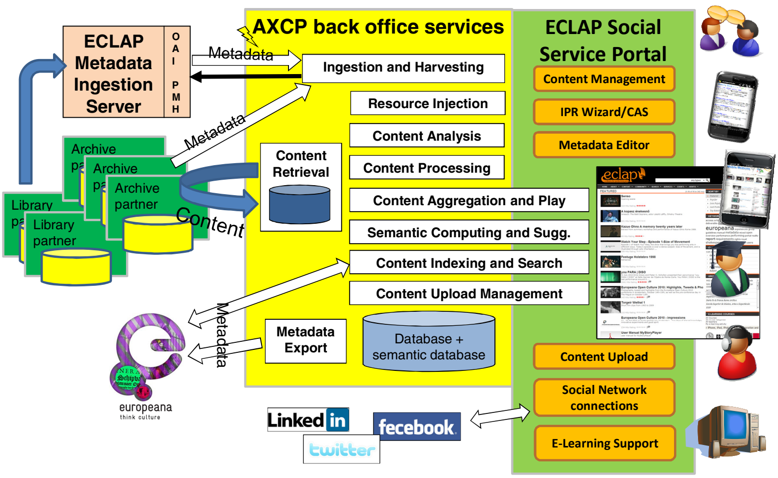

Fig. 1. ECLAP Back Office and Portal architecture

4.2 ECLAP Front Office Tools (ECLAP Social Service Portal)

The following front office web tools of ECLAP allow users covering the whole content life-cycle: content upload, enrichment, validation, IPR modelling and editing, content and metadata assessment and management, publication, etc...

WEB based content upload allows users uploading content on the portal through the Upload web page. The page shows a form where users input: DCMI metadata consisting of a set of Dublin Core fields; Taxonomy consisting of a multiple classification terms selection; Groups assignment (ECLAP Groups); Resource data by selecting one or multiple files from user's HD device or a valid URL (via http or ftp); Workflow type associated with the life-cycle of content.

Metadata Editor is the tool for enriching and validating metadata. Since enrichment and validation activities are governed by ECLAP Workflow, the Metadata Editor is a workflow-drive tool. According to the user role, the editor works in Enrichment mode for enricher users and in Validation mode for validator user. Users without a workflow role access anyway to the editor only in read-only mode. Metadata editor allows editing different types of metadata organized in specific panels to work on: DCMI Metadata, Taxonomy, Groups, Properties and Performing Arts Metadata. All changes made on metadata are tracked to maintain the history of changes and who made it and when.

IPR wizard allows creating IPR Model that takes into account all the issues related to publishing content online in the ECLAP context. The IPR Logic Model implemented takes decisions for the IPR Managers according to the relationships: among user roles and among permissions. The IPR manager has just to select one or more permissions for a user role that he/she wants to associate to an IPR Model (and therefore to a set of contents) and the wizard automatically selects also the permissions implied by those chosen (e.g. download imply play). In case not all permissions to all users are allowed: the Creative Commons Licenses cannot be associated with this IPR Model, so the user can choose the license from one of the restricted licenses allowed by Europeana ("Unknown copyright status" or "Right Reserved – Restricted access").

5 ECLAP Workflow Model

Front-office tools allow working on metadata in different ways. In order to avoid the production of mistakes and problems specific accesses and roles can be granted only to skilled people and any action has to be tracked to trace and assess quality about the performed activities. To this end, specific roles have been defined:

- **WFIPR (CP):** responsible for the definition and validation of IPR models, and IPR assignment to the content; by using the IPR Wizard and during the Upload for the IPR Model Assignment.
- **WFENRICHER (CP, {languages}):** responsible for the metadata enrichment and changes in the specified languages (add, edit metadata) by using the **Metadata Editor** in Enrichment mode.

- **WFVALIDATOR (CP, {languages}):** to validate the metadata for the identified language. The metadata fields can be singularly validated until the object may pass the whole approval phase. Validation and invalidation by using the **Metadata Editor** in Validation modality.
- **WFPUBLISHER (CP):** to take the final decision for publishing on ECLAP and on Europeana. The publishing of single or groups of content can be performed by using the **Content Management Tool and AXCP,** together with much other functionalities, plus eventual new actions to be programmed on the same tools.

Please note that, back-office services are not associated with specific user role since they are performed by rules on AXCP computing grid background automated processes on content and metadata.

5.1 ECLAP Workflow Model and Diagram

ECLAP back-office services and front-office tools work on content and metadata. However, such processes have to work in concurrency: back-office content processing are accessing and processing content in parallel to the user activities on the front-end. Activities of translation, enrichment, validation, IPR definition and assessment cannot be performed by more than one process at time on the same content. On the other hand, sequential processing is too expensive and time consuming to sustain the content workflow and ingestion. In ECLAP, several thousands of new content per days have to be processed. To this end, a workflow state diagram has been modelled, formalized and implemented. Therefore, to manage the concurrency and to guarantee a safety access to the content a mechanism of unlock-lock access has been defined. The general workflow state diagram is coded as described in Figure 2. According to the state diagram, the status and transitions are:

- PROPOSED: The object has been proposed and uploaded on ECLAP by a common user (Moderated Upload). This status is assigned to the content by the ingestion process or the web upload tool.
- UPLOADED: Proposed contents are periodically analysed by the administrator to accept them. Contents that pass this phase go on the status of UPLOADED and published on the ECLAP front end. Experts and professional users have the right to publishing and seen their content passing directly to the UPLOADED state. From UPLOADED the status can pass to the following states:
    - UNDER-IPR is assigned to the content, every time a user with right WFIPR opens the content by means of the IPR Wizard. At the end of IPR session the status returns back to UPLOADED.
    - UNDER-ENRICHMENT is assigned to the content, every time a user with WFENRICHEMENT opens the content with the Metadata Editor. At the end of enrichment session the status return back to UPLOADED.
    - UNDER-VALIDATION is assigned to the content, every time a user with WFVALIDATOR opens the content with the Metadata Editor. At the end of enrichment session the status return back to UPLOADED.

- o UNDER-AXCP is assigned to the content every time a back-office rule takes into account a content processing activities on a given objects that is in the status of UPLOADED. The typical activities are those for producing automated translations of metadata, metadata analysis and validation, content update, content adaptation, etc. At the end of processing session the status return back to UPLOADED.
- o UNDER-APPROVAL is assigned by a back-office activity that periodically analyses the oldest objects in the status of UPLOADED in order to verify if they can pass the minimum level of validation status, including the presence of a consistent IPR assignment. The assessing rule takes a decision, and in the positive case, passes the control to a WFPUBLISHER user that is authorized to pass in publication the content. The submission of the request of publication is performed by sending an email notification. In the case of negative decision, the status return back to UPLOADED and a request for solving the pending problems discovered during the assessment is performed by sending an email notification.

- PUBLISHED: The content in the UNDER-APPROVAL status has been published by an authorized user or by a periodic back office process. When content is PUBLISHED is made accessible for Europeana of EDL, via OAI-PMH, and on ECLAP. When the workflow is limited to ECLAP, the content is accessible only there. Only the top ADMINISTRATIVE user may remove content from the status of PUBLISHED, by forcing it to return back to the UPLOADED state.

The transition from UPLOADED to UNDER-XX status allows managing the concurrency and making a workflow lock request before to start a workflow session. If the transition is not performed, the current activity is stopped or managed safety (front-office tools could allow browsing data without editing). When a workflow session is

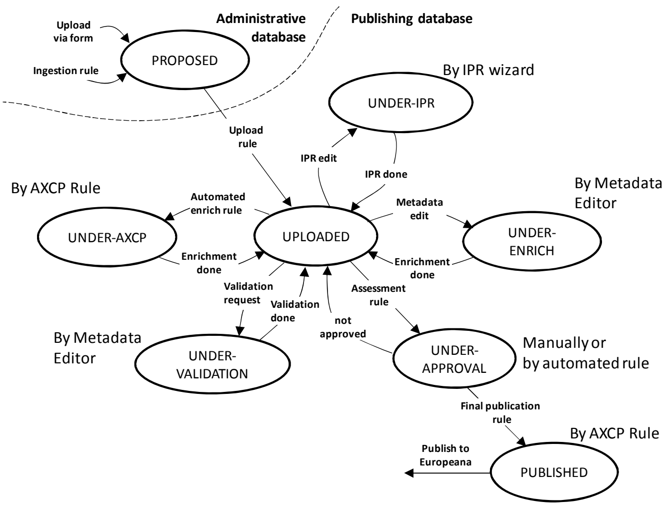

Fig. 2. ECLAP Workflow diagram

ended an unlock request is done by asking for a status transition from the UNDER-XX to the UPLOADED status. The ECLAP workflow provides a workflow engine that allows tracing all workflow transitions and sessions and manages a workflow journal log to track the activities performed on metadata, descriptors and content.

6 Conclusions

Orchestrated workflow system and automated process management system based on Grid technology aid large scale multimedia services to manage huge amount of content and metadata and to increase the content quality and accessibility. A workflow model and architecture adopted by ECLAP network has been presented to show the integration between the ECLAP workflow and automated back-office based on Grid. The proposed solution allows users and automated workflow processes to interoperate securely and to increase the quality and accessibility of content and metadata. This service is currently in use by 31 institutions; it handled at current date 662,534 workflow transactions for 114,579 content items with an average of 5.8 transactions per content and a maximum of 85 transactions for one content. These transactions were performed in 653 days with an average of 1,014 transactions per day and a maximum of 13,162 transactions in one day. The transactions related with manual enrichment were 539 and with IPR setup were 981.

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A Unified Test Procedure Designed for Monitoring the Experimental Settings Ensuring Quality Assurance in 3D and Stereoscopic Productions

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Abstract. In the context of an EU co-funded project, the authors have developed a semantically-enabled solution for 3D and stereoscopic film productions process monitoring. This paper describes the method selected to design and deliver a unified procedure to consistently set-up and test the acquisition prototype developed. The underlying idea is that at each development step it will be necessary to verify the improvement (or defects) introduced. Therefore, after the calibration steps, the repetition of a well codified testing procedure based on standard cinematographic practices and comprising most of the usual possible shooting issues was used to achieve comparable results thus improving quality control.

Keywords: test procedure, quality assurance, process monitoring, experimental settings, 3D and stereoscopic film production.

1 Introduction

The EU co-funded project "2020 3D Media Spatial Sound and Vision" [1] has explored and developed novel technologies to support the acquisition, coding, editing, networked distribution, and display of 3D, stereoscopic and immersive audio-visual content. The target community of users for the technologies developed encompasses media industry professionals across the current film, TV and *"new media"* sectors. Technology developments have occurred incrementally and therefore a reliable testing procedure was needed just like the calibration step to ensure quality control.

The authors have carried out an extensive survey of the present state-of-the-art [37-42,53-57] and literature [2-33,34-36,43,48] related to the field and performed a thorough analysis of stakeholders' requirements [43,49-52]. To provide specific support for quality assurance in the experimental testing of developed acquisition technologies was defined a unified test procedure for monitoring the experimental settings and grant a comparable level of quality assurance across shooting sessions by providing the possibility to compare achieved results.

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2 Experimental Setting for System Tuning

In the project, the partners have been working on auto-stereoscopic, 3D, 2D+Depth content production. Several mechanisms for determining depth maps have been used, from standard computer vision based one to time of flight.

Each progress in the acquisition technology has been validated via a specific data acquisition session. Equipment setup and calibration procedures have been defined and progressively adapted to the equipment evolution taking into account the findings of the previous acquisition sessions.

Trials have been conducted using different combinations of the various technologies and progressive adjustments were introduced to enhance the quality of achieved results. This approach has been applied both to systems calibration and to shooting. In particular it has been apparent that the shooting activities were difficult to compare due to the lack of repetitive or comparable information to use for the assessment. This led to the idea to sketch a procedure that would ensure two major outcomes: 1) be easy to repeat thus providing results that could be compared and 2) would not require specialised personnel to be performed. Additionally, the designed procedure needed be able applicable to shooting activities in either 3D/Stereoscopic, or 2D+Depth, or Immersive development context irrespectively.

To this extent, the authors have defined a concise experimental script that covers most of the typical challenges of audio/visual productions. The script refers to a short sequence (about 30 seconds of finished sequence), which in turn would correspond to approximately 3-5 minutes of shooting time. To this time it would be necessary to add the preparation time for scene/stage, camera, light, equipment etc. Therefore, altogether, the whole time required for setting-up and complete the shooting testing procedure could be estimated as being about 30-45 minutes. The post production time needed to trim each of the sub-sequences, mount them, prepare the sound-track, mix it, finalise the sequence and finally project it could take 45-90 minutes for a total time of about 2 hour work.

2.1 Experimental Settings

The specific purpose of this setting procedure was to provide the technical team involved in the project an industry-significant and measurable example that could be used in every test-bed situation to address the setup, verify that equipment is properly installed and procedures adequately followed, or in other words perform a quality control function. The fact that the same sequence was repeated each time a test-bed was mounted provided comparable results, and therefore, improvements or issues were more easily spotted.

The procedure has been developed following the same approach that would apply to a real production. This aspect is particularly important as the specific purpose for the procedure was to substantially support quality assurance and the monitoring of progresses and actions performed in a real shooting context with experimental equipment.

Once terminated the project, the procedure has been further elaborated in order to derive an enriched version that could be used for teaching purposes in the Arts and Media Department of Universities providing film-making-related training.

The operation settings are very simple as it has been assumed that equipment testing may occur in many places including, but not limited to, the actual shooting stage or location. The procedure does not require a full crew including grip, gaffer, etc. but only personnel with the necessary technical skills to carry out the acquisition trial and check the outcomes using the experimental equipment. It is expected that the team will have at hand the lighting equipment (at least the basic), the selected camera combination (and related camera rig), the calibration tools (charts or light projection utilities), the basic audio equipment (optional) and a basic post processing facility (i.e. a powerful enough laptop or desktop to be used for the verification of the shoot sequence), this latter piece of equipment will have to be connected to a suitable rendering device (which may vary on the basis of the kind of shooting to be performed).

As in most cases the experimentation of techniques will be performed in laboratory or studio facilities, it is expected that the shooting team may have easy access to some simple pieces of furniture (chair, table, glass/mug/jug, bottle/carafe) or at least to some boxes (the equipment shipping boxes or similar).

The actual set-up of the shooting scene will be therefore completed in accordance with the reference script that was purposely designed to cover a number of specific issues so as to challenge the technique being used and at the same time provide outcomes that can be easily compared in terms of quality across test-beds.

It is worth mentioning that colour grading and other aspects of the shooting process were not of concern for this procedure which on the contrary focuses on the respect of the basic filming rules and the implications they may have for the chosen equipment. This aspect has been retained unchanged also in the evolution of the procedure.

2.2 The Reference Script

The reference script refers to a single short sequence and the related storyboard (and shooting plan) was then derived (see fig. 3 for details). The shooting could be carried out using any selected technical combination (3D, stereoscopic, 2D+Depth, omnidirectional, etc.) potentially resulting in a fairly complex equipment setup that should be clearly reported in the continuity log and used at later stage (i.e. when comparing results) to understand pros and cons of the setting in relation to the achieved quality for the shot sequence.

For the sake of clarity, the actual shooting will be described with reference to a traditional 2D shooting, while implied changes or specificity related to 3D / 2D+Depth / Immersive shooting will be detailed afterwards in table 1.

In detail we now examine the script and its implications. A very simple set (representing a rather bare internal location (see fig. 1), two characters are involved in a brief dialogue and a very limited set of actions: *Character-A* sits on an (arm)chair at the back of a small table located in the foreground. On the table there is a glass. In the background, there is a cupboard, on which a glass carafe full of water is placed; *Character-B* is standing nearby.

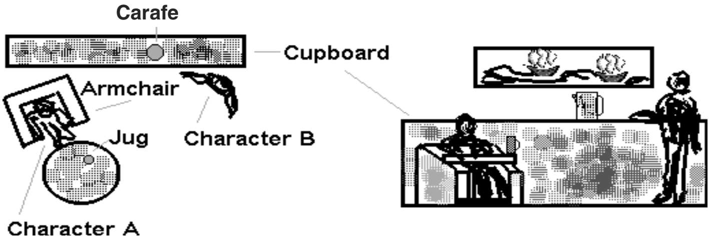


Fig. 1. Experimental scene layout (left) and frontal view (right)

The action to take place is as follows: *Character-A* is drinking from his glass while *Character-B* is standing beside the cupboard on top of which there is a carafe. *Character-A* asks *Character-B*, *"Could you please pour me some more water?"* *Character-B* replies *"Certainly, here you are!"* and pours some water from the carafe into the glass.

In the movie industry, what just reported would be called a *"concept"* and would then be refined into a more detailed into a *"storyboard"* [7,8,11,14] that would look somehow like what illustrated in fig. 3 and the typical setup for the sequence just described will be as reported in fig. 2 and could imply several cameras or a change in lenses. This in turns would be detailed in the shooting plan and will correspond potentially to several sequences for which multiple takes could occur.

It is worth recalling that some of the standard 2D visual tricks used for the visual narrative cannot be used in 3D production [12]. In 3D, the point of view represents also a location in space. In other words, the spectator is located at the camera position; therefore, any change in shot perspective used in 2D to emphasise the narration has, in 3D, the effect of a physical displacement which at times can be rather disturbing [12].

In 2D a wide shot is used to give breadth to the narration, whereas in 3D, it has the effect of moving the viewer away from the scene. All this advocates for a different approach to the narrative approach to be followed via the sequence of shooting. For example, what can be achieved in 2D with a change in shot (i.e. counter field, long to close shot, etc.), requires a different approach in 3D, e.g. a camera dolly movement

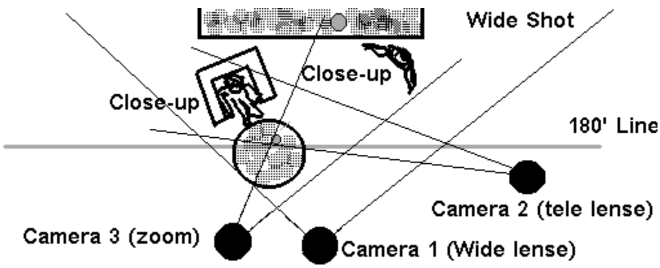


Fig. 2. Typical 2D settings for the shooting of the test sequence

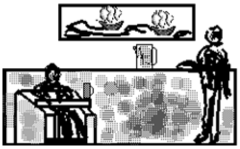
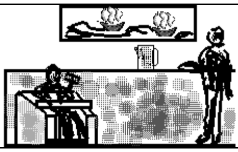
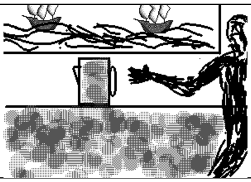
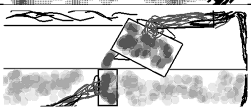
Sketch	Action	Dialogue	Notes
	Building internal. A fairly bare living room with very simple furniture. A round table, an armchair, a cupboard and a painting are the only remarkable pieces of furniture visible. On the table there is a glass jug, while on the cupboard a carafe full of water is well visible just below the painting of a sea view with two sailing vessels. **CHARACTER A** is sitting in the armchair while **CHARACTER B** is standing nearby the cupboard.	None	Wide shot, key lights centred on characters, back light avoids most shadows
	**CHARACTER A** takes the jug and drinks its content almost all the once.	None	Wide shot, key light centred on **CHARACTER A**, no key light for **CHARACTER B**, back light avoids most shadows
	**CHARACTER A** is rather thirsty and seems surprised to notice that the jug is empty. **CHARACTER A** looks at the empty jug, places it back onto the table and looks around.	None	Mid shot of **CHARACTER A** using Camera 2, spot light on character, backlight is soft
	**CHARACTER A** picks up the jug and stretches the arm towards **CHARACTER B**.	**CHARACTER A** Excuse me! Could you please pour me some more water? **CHARACTER B** What?! Yes, of course, just a second.	Mid to close shot of **CHARACTER A** using Camera 2, spot light on character, backlight is soft, fade out
	**CHARACTER B** moves slightly to the right and picks up the carafe.	None	Fade in, Mid shot of **CHARACTER B** using Camera 3, spot light on character and carafe, backlight is soft
	**CHARACTER B** stretches towards **CHARACTER A** jug and pours some water into it.	**CHARACTER B** Here you are! **CHARACTER A** Thank you so much!	Camera 3, Zoom-in on the carafe, spotlight on the action very soft background

Fig. 3. Example of a typical storyboard

(possibly preceded by some clue in the action), which will intuitively justify a change in perspective, will be perceived not as a jump in location but as a consequence of a viewer movement [12].

Depending on the adopted shooting settings (i.e. stereoscopic, 2D+Depth, or Omnidirectional) the previous script will lead to different shooting procedures as summarised in the following table.

Table 1. Different shooting of the sequence and related set-up depending on shooting mode

	2D standard	**Stereoscopic**	**2D+Depth**	**Omni-directional**
Cameras	3 cameras (fig.2) either shooting in parallel or in sequence depending on DOP choice.	2 cameras shooting in parallel mounted on a special rig (either side by side or at 90° using a semi-transparent mirror).	1 master camera and a number of satellites cameras. The number of satellites (from 2 to N) depends on the adopted algorithms used for depth and disparity maps extraction.	A number of cameras determined by the desired level of quality and adopted stitching algorithm.
Transitions	Shooting transitions achieved at post-production time.	Shooting transitions are replaced by camera movements (this may imply the usage of a dolly for mowing the rig in a smooth fashion also avoiding re-calibration).	Shooting transitions can be achieved in post-production as usual; however the need to mount the cameras on a special rig may require repositioning of the rig for the various sequenc-es implying re-calibration each time.	Shooting transitions are not necessary but instead is require distortion correction and image stitching at post-production time.
Calibration	Standard calibration (B/W) proce-dures are needed.	Specific calibration is needed to ensure correction of align-ment and differences in the master cameras.	Specific calibration is needed to ensure correction of align-ment and differences between master and satellite cameras (resolution, position, etc.).	Specific calibration is needed to ensure correction of align-ment and differences in the array of camer as.

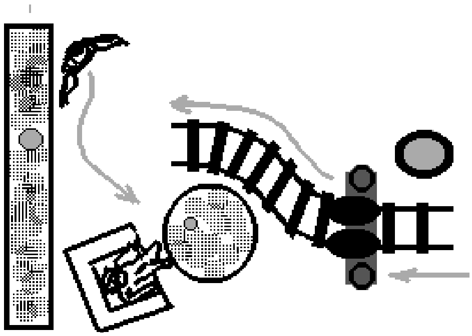


Fig. 4. Typical 2D settings for the shooting (close-up)

What is reported above clearly explains the differences occurring among traditional setup and the various possible approached.

An example of a setting used with the proposed script while using in parallel all abovementioned techniques is reported in fig. 4. It explicitly required the adoption of a dolly to handle the camera movement instead of transitions. Such a setting was evaluated to achieve in a single shooting the acquisition of the 3D, stereoscopic, 2D+Depth as well as Omni-directional sequences to be used for the documentation of the "making of" the scene in a much more intriguing fashion than the usual one where specific crew staff uses stills and shooting with other cameras to gather material that can be used for marketing and other purposes. However, the related additional cost was too significant and not justified in the context of the project and therefore this specific approach was dropped.

3 Conclusion

The paper has introduced the a unified test procedure designed for preparing the experimental settings to be used for producing and monitoring 3D and stereo productions as developed in the context of the 2020 3D Media Spatial Sound and Vision project.

The procedure was specifically designed to support quality assurance via result comparison during the experimentation phase where different methods were combined and it was necessary not only to take into account such combination but the progressive evolution of the used tools (all or a subset of them) thus posing a real challenge in terms of understanding origin and causes of improvements or defects encountered. The introduction of a standardised, repetitive set of actions used to set up the environment and naturally complementing the calibration procedures, has proven beneficial.

It is clear that the proposed procedure requires still a significant amount of time and would have a direct impact in any live-production also in terms of budget. However, the advantage is that the suggested approach provides the possibility to have an objective measure of the achieved quality by confronting comparable results gained while experimenting with several shooting methods (or settings), thus greatly facilitating the quality assurance process during an experimental production or the development of new methodologies. It has therefore been decided to limit and focus the use of this experimental setting to the teaching environment.

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Cuban Theater Digital Archive: A Multimodal Platform for Theater Documentation and Research*

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Abstract. The Cuban Theater Digital Archive (http://cubantheater.org) is a unique digital collection of Cuban theater resources established by Dr. Lillian Manzor at the University of Miami. Working at the intersection of humanities and digital media, its purpose is threefold: it is a resource for teaching, learning, and research; a digital repository for important Cuban theatrical materials little known outside the island; and a forum to foster scholarly communication in this field. This paper presents a theoretical overview of CTDA's design and development, its technical infrastructure, and its role in research, teaching and learning.

Keywords: Cuba, theater, performance, performing arts, digital archives, digital humanities, community archives, multimodal writing.

1 Introduction

The Cuban Theater Digital Archive (CTDA, http://cubantheater.org and http://teatrocubano.org) is a unique digital collection of Cuban theater resources established by the first author in collaboration with the University of Miami Libraries and the College of Arts and Sciences. Working at the intersection of humanities and digital media, the CTDA's purpose is threefold: it is a resource for teaching, learning, and research in Cuban theater and performance as well as in related fields; a digital repository for important Cuban theatrical materials little known outside the island; and a forum to foster scholarly communication in this field. As such, the CTDA participates in a virtual culture that allows for communication and exchange to take place between communities that are often politically separated. CTDA includes materials digitized and filmed in Cuba,

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as well as resources and information related to Cuban theater in the diaspora with a special focus on theater produced by Cuban communities in the United States. At present, the site contains links to 2,800 digital objects, including photographs of theater productions, theater programs, stage and costume designs, and other ephemera. Of these, 92 are filmed theatrical productions. This paper presents a theoretical overview of CTDA's design and development, its technical infrastructure, and its role in research, teaching and learning.

2 Background

Live theater and performance are probably two of the most evanescent forms of cultural heritage. They are always provisional, ephemeral, and non-repeatable. This non-repeatability points to two salient characteristics of theater as live-art performance: 1) It is a transient and fleeting art form. The ontology of each performance is, of course, the present. It exists insofar as it knows itself to be a representation without reproduction [1, 2]; 2) it is collaborative rather than individualistic in nature. Live-theater involves collaboration from a wide range of participants such as playwrights, designers, directors, actors and performers, musicians, technicians, administrators, etc. It also includes the collaboration of critics, analysts, theorists and reviewers. As intangible cultural manifestations, they transmit an embodied memory that is extremely fragile and risks disappearing. This non-repeatability presents challenges to any theater researcher and theater artist in relation to documentation, challenges that are exponentially increased in the case of Cuban and Latino/a theater.

Researchers know that the fleeting nature of performance transforms research for historians and scholars of theater as live-art performance into a search. As Patrice Pavis has suggested, theater research is, indeed, a search for a lost object: a non-locatable and inaccessible representation[3]. Any writing/research on theater is partly a search for documentation that serves as a trace of that non-repeatable performance. Documents for theater re/search are comprised of the researchers own notes of the spectacular text (representation) and published or unpublished verbal texts. Other important elements are photographs, video recordings, sketches for costumes and stage design, program notes, directors' notebooks, newspaper clippings, and oral histories with audience memories. This ephemera is a trace of the live representation, the missing object of the re/search, and, as José Muñoz has argued, is "a kind of evidence of what has transpired but certainly not the thing itself. It does not rest on epistemological foundations but is instead interested in following traces, glimmers, residues, and specks of things [that] maintain experiential politics and urgencies long after those experiences have been lived" [4, p.10].

U.S. Cuban[1] and Latino/a theater artists, cultural institutions and theater companies also recognize the need to create archives of their work. Documentation on U.S. Cuban theater exists but it is scattered in different personal collections. Resources may be available at different institutions. However, the drive for many institutions traditionally has been to collect. With limited budgets, theater collections may not have finding aids and other organizational elements

[1] For the use of U.S. Cuban instead of Cuban American see [5].

that accompany full processing, serve research, and provide the infrastructure necessary for digitization projects and broader access. Only in rare circumstances is there collaboration between librarians, archivists, theater faculty and artists in the processing of theater collections.

The Cuban Theater Digital Archive was developed precisely to facilitate the search for that missing object, to document and preserve part of this intangible cultural heritage, and to be able to write a theater history that takes into account live performance.[2] It considers and constructs Cuba following Ana López' notion of Greater Cuba, that is, it takes into consideration theatrical work on the island and in the diaspora. In addition, we use Greater Cuba to suggest that "border zone" in which citizenship is reformulated as a result of the encounter between competing national jurisdictions and the global economy[6]. Finally, CTDA is conceived as a research, teaching and learning program that integrates classroom education in Cuban theater, new media, and archival primary research with an online scholarly publishing effort that provides a unique view of contemporary culture in Greater Cuba.

3 Entering the Archive

The construction and development of CTDA involves five components:

– **The physical archive**, primarily a repository of theater related materials housed within the Cuban Heritage Collection (CHC) at the University of Miami Libraries, includes published and unpublished play scripts, playbills, posters, reviews, photographs, videotapes, DVDs, and other ancillary materials.[3]
– **The filmed theater collection** contains over 200 VHS, DVDs, and mini-DVs of selected productions and staged readings as well as rehearsals and interviews of plays produced in Cuba, the US, Spain and Latin America.[4]

[2] Initial conversations for a digital archive started in 2002 between Manzor and the library. The main collaborator at the Library was Lyn MacCorkle–a faculty librarian in the Digital Initiatives section of the Library who was responsible for designing and developing digital projects and had done interdisciplinary research on the Cuban community in the United States. In Spring 2004, the library funded Manzor's proposal and the legacy site began to be developed. The Cuban/Latino Theater Archive was launched in 2005 at `http://scholar.library.miami.edu/archivoteatral`. The new, more robust archive is being developed since 2009 with funding from the Andrew W. Mellon Foundation, the University of Miami Libraries and the College of Arts and Sciences. Information on staff and project participants can be found at Cuban Theater Digital Archive - People.

[3] The physical archive holds over 47 collections. For highlights of these collections see [7]. The reader may also consult the Cuban Heritage Collection Theater Research Guide (`http://libguides.miami.edu/chctheater`).

[4] Producers and artists donated the videos to the founding director over the years. The DVDs and mini-DVs are a result of the documentation project associated with the archive. DaLi Media Lab, artists and others have donated them. See the CTDA Productions Collection in CTDA's Digital Objects
`http://cubantheater.org/digitalobjects/collection/cta0009`

Manzor has also worked with community videographers and two student videographers and has developed best practices for filming and editing theater performance for the purpose of scholarly documentation. Our results can be found in CTDA Guide to Filming Live Theater [8].

– **The video-streaming database** includes moving images. Part of the filmed theater collection has been digitized and video-streamed and is available on the theater website [9]. Those streams are sent from a separate video-streaming server.
– **The image database** also includes the master copies and lower resolution derivatives of still images that are displayed on the site. To make analogue images accessible, they are subjected to a digital image scanner. The scanned images are stored in content-DM, the digital content management system of the Richter Library, and reviewed by digital collection librarians to ensure that the required quality standards are met. Lower resolution derivatives are ingested and displayed in CTDA. Presently the archive contains over 3,000 digitized images of selected materials in the physical collections, and images received from theater practitioners in Cuba, the United States and elsewhere.[5]
– **The directory database** is the main component of the theater website and is accessed from the homepage. The database contains information on playwrights, plays, directors, productions (including actors and roles, as well as different designers), theater companies, theater venues, theater festivals, and awards. A user can navigate through the web site using the preset directory entries (creators, productions, venues, written works, and digital objects; awards and theater festivals available June 2013) as well as conduct a complex search to generate a custom list of objects. This directory database has a back-end data-entry module that is used by the project collaborators to add information to the directory.

4 Database Design: Theory

Our research on other digital archives as well as on technical communication and multimedia corroborated that collaborative teams of artists, humanists and scientists are usually behind research on, and development of, databases and multimedia systems. These teams have identified three paradigms of system architecture: the database paradigm, the communications paradigm, and the hypertext paradigm [10–12]. CTDA's development team was faced with intellectual and technical challenges very early because a theatrical performance is an activity, an event in real time. However, the design paradigms and the existing standards for archiving and cataloguing are not designed to capture or describe temporal concepts.

[5] Alberto Sarraín, the theatre director who participated in the first phase of the project, was the main contact with our colleagues in Havana. Odalys Moreno under the direction of Jesús Ruíz in Havana was in charge of the digitization of the Cuban materials.

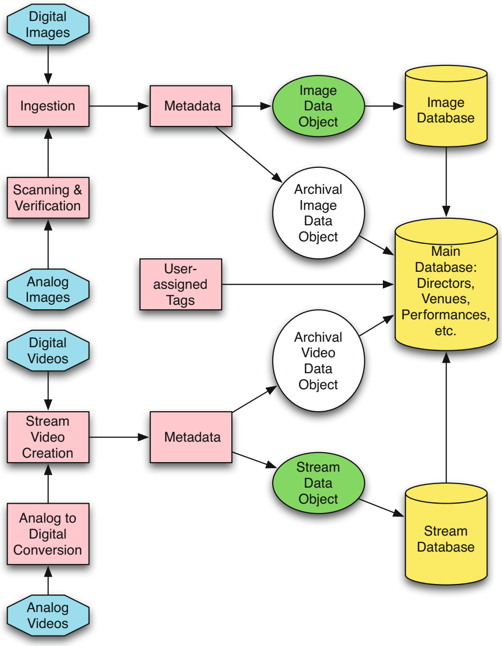

Fig. 1. Interaction between CTDA components

The database paradigm assumes that knowledge about objects and events can be categorized, formalized, and then retrieved as a set of "facts." The role of technology in this paradigm is to enable the accumulation and retrieval of information. As we developed our database, however, we realized that some facts can be organized and retrieved as "data" (information considered universal, in this case author, title, director), but others could not. From the very beginning, the category author was inoperable. How do we assign authorship in the case of translations and adaptations, even *creación colectiva*, specific to Latin American theater? In spite of the fact that it is an unproblematic term for librarians, theater scholars and historians know that there is no single author/creator of a live performance. Thus, as soon as we moved to productions, the events in real time, we were faced with the fact that our two basic categories - "author" and "text" were insufficient to capture the specificities of live art performance. Thus we abandoned the notion of author-text and organized our "data" based on the concepts of creators, creations, and places and spaces of creation. From the onset, we realized that databases, as Tara McPherson now argues, strip things from their context; their ontology depends on the loss of the thing itself [13]. They become meaningful only when interpretation is included, in other words, when accompanied by an information base. Interpretation, of course, implies choices, decisions about what stories to tell and how to tell those stories, an approach antithetical to databases, but one that lead us to the second paradigm. The communication paradigm approaches the computer and new digital media as a medium by which humans communicate knowledge. Thus, the role of language in this paradigm is critical. The implication for multimedia design is that the designers need to study the user's professional language and incorporate it, as far as possible, as the language of the system. Finally, the hypertext paradigm is based on the viewpoint that knowledge is infinite, and that we can only have a limited access or perspective on it. A scholarly hypertext, an argument based on bodies of linked texts, constitutes an attempt to access knowledge through the linking of multiple nodes. This is why hypertext has been described as “the art and science of linking.” These three paradigms tend to operate discretely. As a matter of fact, digital archives and websites that document theater as live art performance are usually developed using one of the above paradigms. One of the most salient innovations of the Cuban Theater Digital Archive is the fact that it is based precisely on the interaction of these three paradigms.

5 Technical Infrastructure

Our program objectives centered on developing the data model, software tools, hardware expertise, and best practices to support future phases of intensive multimedia content collection and collaborative content authorship with partners in the United States, Cuba, and internationally. The development process began with the creation of a data model for theatrical performance based in part on the site’s legacy relational database structure as well as on user needs for improved site navigability. This data model guided the creation of a modular system architecture, built using existing open source software to ensure interoperability with other tools or modules being developed elsewhere to support digital humanities initiatives.

CTDA’s content management framework, named Romeu after the Cuban musician Armando Romeu, was made live at http://cubantheater.org in early 2012, with access to the system opened to all significant content contributors. In addition, the Romeu software powering the CTDA was made available as open source software at https://github.com/umdsp/romeu. Romeu is built on the Python-based Django framework and it aims to be a simple but powerful content management system for multilingual theatrical archives. Vaunting itself as a “web framework for perfectionists with deadlines,” Django allows for the quick, elegant deployment of textual data-driven websites. As another plus, the Python programming language which underpins it has always been at the forefront of internationalization, a distinct advantage when compared with certain other options on the open source market. This new infrastructure provides rich interaction and easy navigation of site content, facilitates contributions of text and multimedia content from geographically dispersed partners while placing intellectual property rights at the forefront of the content submission workflow, increases capacity to create and deliver video content, and allows for the peer review, approval, and innovative scholarly interaction with and publication of site content.

The search on CTDA is processed using Solr by way of accessing the metadata stored in an XML format. It is in an alpha test mode and will be completed soon. For information exchange the site allows its users and administrators to leave comments on specific entries. In the next 12 months we plan to add to the site a publication capability, that is, a system for a user to author a multimodal scholarly essay with embedded videos and photographs from the archive on CTDA’s Web-Scenes / Red-Escenas.

6 CTDA and Digital Humanities

CTDA is a leading Humanities 2.0 publication at the University of Miami. Humanities 2.0 "refers to a humanistic practice anchored in creation, curation, collaboration, experimentation, and the multi-purposing or multi-channeling of humanistic knowledge"[14]. Digital Humanities 2.0 is possible thanks to Web 2.0 platforms offering us new publication models that are not limited to print culture. Participatory scholarship and collaborative, interdisciplinary research are at the heart of these publications.[6] Kathleen Fitzpatrick discusses the changes introduced in 2.0 digital publications in the second chapter of [16]. She summarizes these paradigm shifts as:

- from product to process
- from individual to collaborative
- from originality to remix
- from intellectual property to the gift economy
- from text to something more

As a Humanities 2.0 publication, CTDA participates in and contributes to the above paradigm shifts. We would like to focus on the ways in which the very design of CTDA responds to three of the above.

6.1 From Individual to Collaborative: Community Archives

Since the Cuban Theater Digital Archive tends to approach culture not only as something that we inherit, but also as something that we create and experience, it invites community participation. Thus, we work with individual artists and theater companies acknowledging that "by collecting, preserving and making accessible documents, photographs, oral histories and many other materials which document the histories of particular groups and localities, community archives and heritage initiatives make an invaluable contribution to the preservation of a more inclusive and diverse local and national heritage" [17]. We expect contributions of other unique collections of either previously digitized or "born-digital" images, which may not meet technical archiving standards. Since our work involves digitizing for preservation, digitizing for access, and preserving born-digital information, we are cognizant of the fact that that research needs, community interest, cultural heritage and preservation considerations may occasionally take precedence over best practices in determining if an object will be added to CTDA.

The above concerns demonstrate our shared "post-custodial mindset for archives" [18]. This paradigm approaches the physical record in relation to the context of its creator and creation process (who created it, why and how) underscoring its multilayered hidden meanings and its connection to power, memory, and identity construction instead of the traditional focus on the physical record

[6] For an analysis of the development of Digital Humanities in the U.S. see [15].

as neutral and objective evidence under custody of institutions [19–21]. It is precisely this mindset that has guided our appraisal and selection of born-digital and other images and has framed the following questions of context: 1) we have to take into consideration what these images mean in the context of why and how they were created; 2) we are cognizant of the fact that one of the most important aspects of this project, beside preservation, is to enable access to information.[7].

This post-custodial concept has long been an ambition of the CTDA, even though its previous iteration lacked the technical and organizational structure to make it a reality. Many libraries and archives, realizing the limitations of the content-ownership model are beginning to establish digital presences that cast a wider net outside the walls of their own physical collections into the communities they serve. CTDA, as a community archive, complements and extends the role of traditional archives and special collections in virtual space. Thus, beyond a digital portal to access content, it works with a more inclusive paradigm for the curation, distribution and dissemination of Cuban performing arts materials.

6.2 From Individual to Collaborative: Artists, Students, Scholars, and Archivists Working Together

CTDA has developed effective and innovative collaborations between teaching faculty and digital library specialists in building and deploying new scholarly resources for teaching and learning in the performing arts. Activities include defining conventions particular to live art performance in the Latin American and Latino/a context that impact on database design and metadata as well as training student researchers who enter data and efficiently provide clips from filmed productions. The participation of several theater artists in the early phases of the project was crucial for the redefinition of fields for the database as well as its conceptual design.

At the center of this collaboration are student contributors. As one of its key strengths, the CTDA provides students with rich experience, through classroom assignments, in the research, editing, and on-line publication of directory entries on the CTDA website; processing and researching archival collections at the CHC; developing new media projects based on digitized archival materials and digital video of theatrical performances; and gaining a first-hand view of Cuban culture on and off the island through research interaction with Cuban theater companies and theater artists.

CTDA collaborates regularly with the CHC to provide students with unique learning opportunities related to collections of original theater materials in digi-

[7] The question of who should be responsible for digital preservation is key to issues of preservation and access: "Much current 'archiving' is done by individual researchers, research and development units, etc., and many researchers wonder why they would have to depend on others to archive data. As long as research results are merely shared among a handful of colleagues, this approach has a proven track record. But, clearly, it is not fail-safe and it can leave much to be desired if we expect universal accessibility. What happens when the research project folds, or when the researcher retires or dies?" [22].

tal and physical formats. These projects introduce undergraduate and graduate students to the rigors of academic research in a digital context, and provide many with their first experiences in archives and special collections. Since the CTDA's inception in 2004, Manzor has offered service-learning projects for course credit to students interested in theater materials. Students have worked with a number of CTDA and CHC collections. In the course of their service-learning projects, students have helped process selected collections, and have authored biographical and/or historical essays on the theater companies and artists published in CTDA, as well as documentaries and new media projects repurposing the digital assets.[8] They have also selected visual materials to be scanned and have provided original information needed for metadata. Most of the digital material now available in CTDA originated in these projects.

Whether it is in theater, cultural studies, or language instruction, the CTDA has opened up many research and learning opportunities to students. Long-term benefits of participation in CTDA projects include: improved research skills and techniques; enhanced methodology and problem-solving skills; knowledge of effectively accessing original records in archives and special collections; experience creating a research plan, using finding aids, and reading and interpreting visual material; first-hand knowledge of information technology and its social, cultural, and political implications; development of a high level of engagement, sense of ownership, and enhanced skills with technology.

6.3 Intellectual Property

Faced with the myriad difficulties of intellectual property laws for filming theater and putting performances online as well as the challenging gray area of Cuban IP law, CTDA stakeholders sought a simple framework for managing intellectual property which would promote the sharing of open content when possible while also placing the rights of content creators in the forefront. As a solution, CTDA is using Creative Commons categories to manage the submission of new content into its digital archive. Creative Commons is a nonprofit corporation dedicated to making it easier for people to share and build upon the work of others, consistent with the rules of copyright. They deliver free licenses and other legal tools to mark creative work with the freedom the creator wants it to carry, so others can share, remix, use commercially, or any combination thereof. Creative Commons has been very successful at addressing copyright from a practical, hands-on approach. It has a global reach and impact that is based on the same sort of trust implicit in the creation and maintenance of the Archive. It offers a predictable way to provide attribution, and encourage use with appropriate stewardship of the content.

[8] For an example of a representative student project, view this profile (`http://library.miami.edu/chc/scholars/marcelaarcosholzinger/`) of 2010 CTDA/Goizueta undergraduate scholar Marcela Arcos and her work with the INTAR Theater Records. For examples of new media projects see the documentary on Teresa María Rojas (`http://cubantheater.org/creator/594`) and the video "The Business of Being Exiled"(`http://cubantheater.org/creator/7025`).

6.4 Beyond the Text: Database-Driven Scholarship and Multimodal Writing

Two of the ways in which CTDA has contributed to the shift from text to something more are data-driven scholarship and multimodal writing. Data-driven scholarship employs "the database logic of new media, in which textual and media objects can be created, combined, remixed, and reused" [16, p.32]. The key elements of database driven scholarship are annotation, organization, analysis, and visualization; these allow us to explore a topic and present scholarship in ways that were previously unavailable. It is this logic that informed Manzor's conceptual design of CTDA's technical platform in order to open up a space for the creation of video documentation, and the inclusion of pre-existing texts and images along with different genres of original commentary. As a Digital Humanities 2.0 site, the remixing of materials presents "curation as a sophisticated digital scholarly practice" [16, p.32]. Most importantly, CTDA allows others to repurpose the "originally" curated materials and to create their own, networked arguments.

The need to develop a space for multimodal writing (Web-Scenes / Red-Escenas, currently in development) comes out of the limitations imposed by the printed page on the teaching, documentation and research of live-art performances. While there are several examples of pioneering multimedia and hypertext projects in the Humanities, when we started CTDA there were only two examples of innovative documentation/research projects on theater. One is a CD-ROM produced and directed in England by Dixon, documenting and presenting theoretical background on his own production of Chameleons. It includes rehearsal footage along with critical and conceptual commentaries on concepts that are key to the performance such as Surrealism, and Theater of Cruelty [23]. The other ones are the Cuadernos and other publications of the Hemispheric Institute of Performance and Politics at New York University (http://hemisphericinstitute.org/hemi/). The Cuadernos are on-line hypermedia publications on performance and politics in the Americas using a combination of photos, videos, texts, hyperlinks, bibliographies, and audio recordings. CTDA is currently working with the Scalar team (http://scalar.usc.edu/scalar/) in order to incorporate Scalar's multimodal authoring platform for our Web-Scenes.

7 Paradoxes of Archive Fever

It could seem paradoxical to attempt to "stabilize" a fleeting, collaborative art form in an archive-- primarily a repository of physical documents. Live theater and performance transmit knowledge in non-written fashion. Since the knowledge privileged by traditional archives is that of the permanence of the written text, what Schneider has called "the patrilineal, West-identified (arguably white-cultural) logic of the Archive" [24, p.100], we lose the knowledge that "embodied" performance of the repertoire transmits, "the memory passed down through bodies and mnemonic practices" [2, p.35]. Acknowledging the constructed nature of a digital archive as well as the simulatory impulse inherent in digital images, we propose digital documentation as a possible way to expand our notion of the archive, as a way to give space to the gestural and mnemonic practices transmitted by live performance. The digital capture and presentation of ephemera challenges performance studies' commitment to an ontology of presence. They approach "performance not as that which disappears (as the archive expects), but as both the act of remaining and a means of reappearance" [24, p.103]. Indeed, the glimmers, traces, and memories that inhabit the digital archive, and the users' interaction with them in the present, are proof that there are "other ways of knowing, other modes of remembering, that might be situated precisely in the ways in which performance remains, but remains differently" [24, p.101].

8 Conclusion

Although the focus of CTDA's first phase is one particular community (Greater Cuba) and one particular form (theater/performance as intangible culture), the technical platform is available to other communities of scholars, historians, and artists interested in the preservation of live theater and performance as intangible cultural heritage. Following the etymology of the word archive, our aim is to make this digital archive be the "beginning", "the source" of any research on theater in Greater Cuba first, and then on Latino/a theater, as well as a source for multimedia theater documentation and research. This archive, like theater, aims to be collaborative, always in progress. Faculty members with student interns are working with the Library's staff and the Digital Media Library to provide an ever-expanding digital collection of visual materials, primarily videos and photos, as well as performance texts-both published and unpublished. The design is enhanced based on input and feedback from librarians, theater practitioners, and artists in the US and in Cuba, and scientists from the Center for Computational Science at the University of Miami. Scholars, professors, and students from any university, who are interested in collaborating, can help build it as part of their class projects.[9]

As a cultural heritage initiative, the archive is part of a virtual culture that lives beyond cyberspace and allows communication and exchange between two communities that are politically separated. Like other virtual communities, "our constructed communities live within and around the relationships we form by moving within an electronic space that connects us with others. Virtual cultures extend, rather than exclude, our physical contact with each other" [26, p.32].

[9] Spring 2008, Gwendolyn Alker at New York University's Drama Department gave students the option to develop pages on María Irene Fornés. Students wrote analysis of the Signature Season dedicated to Fornés and their advertising strategies, critical responses to plays, and interviews with several cast members. See, for example, Harrison Hill's analysis of the critical response to "Letters from Cuba"(`http://cubantheater.org/production/2195`) and Harrison Hill and Maurya Scanlon's interview with Beth Whitaker, Associate Artistic Director of the Signature Theatre Company (`http://cubantheater.org/creator/7967`). For the advantages of archival research at the undergraduate level, see [25].

By capturing the non-verbal memory of a fleeting event, this archive reflects changes in the practice of theater as it serves as a witness for thousands of productions via programs, photographs, video clips, video-streaming, newspaper reviews, cards, etc. As an interactive pedagogical tool, it offers professors and students the opportunity to use these materials in the classroom, and it allows students to be involved in research as they can add information to the database as well as author specific pages or Web-Scenes. Researchers in theater and in other fields - African American Studies, Anthropology, History, Latin American Studies, Political Science, Religious Studies, Women and Gender Studies - have access to materials otherwise unavailable to them that they can now annotate and rearrange in order to create other interpretative histories and "stories." Finally, it provides a useful link to the artistic community who can build their pages and use CTDA as a showcase of their work and as a reference point for potential publishers, directors, casting agents, and grant agencies.

The Cuban Theater Digital Archive is unique, then, because of the range of materials it encompasses, the ways in which it combines the database with digital documentation, and the space it offers for innovative multimodal publication in theater research. CTDA's goal of preserving and providing access to evanescent performance materials while fostering scholarly communication between "communities that are politically separated" will continue to push the boundaries of what is possible at this time of potentially changing attitudes in U.S.-Cuba relations. It is creating a virtual community in which common goals operate outside of the cold world rhetoric that guides US-Cuba relations. Through this process, the CTDA may even find itself in a position to serve as a model to other digital initiatives exploring US-Cuba collaboration.

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How Are On-Line Digital Libraries Changing Theatre Studies and Memories?

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Abstract. The on-line access to digital video allows for a new management of Performing Arts documents. The audiovisual document, conceived in the past by its creator as a complete work in itself now has to be flexible and open to suit the needs of its on-line users.

Information Retrieval's activities for Performing Arts have to be improved by finding new tools and by developing a specific P. A. semantic.

We have to be aware that the abundance of available items on a given subject could transform an opportunity into a challenge.

A new pedagogy of abundance has to be reshaped, based on User-generated content, not losing track of the first original document, via an authenthicity assessment of the digital record. Original works - first created electronically now through digital technologies - have to be reconsidered as new content, not as old content on new platforms. From Antonin Artaud's radio recordings of 1947 to portable Electronic Arts of the Seventies, ending with the Digital New Media of the new millenium, a new aesthetic and a new imaginary are rising, and it is strongly different from the old way of describing the world.

The Performing Arts studies are shifting from scarcity to abundance of digital data, witnessing the scarcity of available funds to preserve culture.

The more the digital archives will be open to new formats and free downloading, the more we will encourage the diffusion of European primary values and, in the same time, get a chance to preserve the millenary history of the Performing Arts.

1 The Digital Era Is Transforming Performing Art Studies

> The computer as hypertext, as symbol manipulator, is a writing technology in the tradition of the papyrus roll, the codex, and the printed book. The computer as virtual reality, as graphics engine, as perceptual manipulator, belongs to and extends the tradition of television, film, photography and even representational painting.
>
> Jay David Bolter

This essay will underline the new challenges that opened up for Performing Art studies in the digital era.

The quote by Bolter regards the complex reality of computers as new media. Cyberspace is not one place or one thing, and digital theory struggles with its multiplicity, hybridism and fluidity.

P. Nesi and R. Santucci (Eds.): ECLAP 2013, LNCS 7990, pp. 151–163, 2013.

I will focus mainly on the preservation of audiovisual records for Performing Arts studies. In order to do it, I propose a “five steps” reflection starting by five simple statements we all share.

Performing Arts universities and archives - due to the phenomena of digitization and on-line access - share awareness of the deep change facing production, restoration and conservation of the audiovisual records.

1.1 From Antonin Artaud’s Radio Recordings to New Media

A first basic statement: *The record of a performance or a conference if digitized and uploaded on-line, is more easily accessed by a greater number of users than the original item conserved in an archive.*

In comparison with the thousand-years old history of theatre, the section related to the use of electromagnetic and digital technologies is relatively short. Only in the last few years the attention of scholars’ research multiplied, thanks to the rise of audiovisual, which is multiplying forms and formats of the Performing Arts records.

Few examples:

1-The access to video has allowed for a massive growth of the analysis and theories about the actor’s playing techniques, analyzing his recorded body gestures and voice sounds.

2-The birth of a new Performing Arts discipline, Theatre Anthropology, was connected with the growing access to moving images of actors and dancers playing in different cultures, to compare with.

3- One of the seminal event for the theatre’s avant-garde was the clandestine listening of an audio recording, the 1948 radio program “Pour en finir avec le jugement del dieu” by Antonin Artaud[1]. This was one of the most important contributions to theatre’s studies of the second half of XX Century, enriching the vision of people doing theatre and preparing them to the innovation introduced in their theatrical practice.[2] The recording of Artaud’s voice enabled theatre professionals who were hearing it, to project his body from a past memory into the future of their own theatre utopia.

In France - and all over Europe - the Antonin Artaud surrealistic movies and radio recordings boosted avantgarde theatre of the Sixties and Seventies.

Performing Art is an ephemeral art. From millennia the show is meant as an event that burns in its «liveness»[3].

The Performing Arts community gathered around the *event*, in the meaning of the show, not around the recording of it, as in movies.

Performing Arts documents are keeping traces of something that is no more there, never replacing it.

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1 Antonin Artaud, “Pour en finir avec le jugement de dieu”, radio program recorded in Paris at the French Public Radio Experimental Studios in November 1947 and broadcasted in 1975 (text published by K editeur, Paris in 1948).

2 About the great potentiality of audio technologies for Performing Arts studies, see Valentina Valentini, (ed. by), “Drammaturgie sonore”, (2012), Bulzoni, Roma.

3 See Philip Auslander, “Liveness, Performance in Mediatized Culture”, Routledge, London and New York, 2008.

The creation of a Heritage for Performing Art Studies was an important issue all along the Modern Era, when many Performing Arts libraries and archives, both public and private, were built. Those large repositories collected texts, books and photos about the Performing Arts for the use of a few selected and privileged scholars, historians and academics. It was a niche community.

In Italy one of the oldest humanities' public library is the Biblioteca Marciana, founded in Venice by Francesco Petrarca in 1362[4]. According to UNESCO, the first audiovisual archive was Austria's Phonogrammarchiv, founded in Vienna in 1899[5].

Bibliographic studies have an advantage of at least seven centuries over audiovisual archiving.

Recording of live performances and events was a limited possibility. Before the middle of the XX Century, due to the high cost of shooting in film, only a few Italian theatres could afford to have a film library.

A first big change was introduced by the use of portable audiovisual media (audio and video cassettes, 16mm. film). The spreading of portable audio and video technology was multiplying the access to the performance's audiovisual documentation.

In Italy interactive performance in Opera Theatre - using sensors and computer vision devices - was experimented by Studio Azzurro from 1997 in "The Cenci" a text by... Antonin Artaud!

1.2 Theatre and Television History: Evolution of Formats and Supports from Public TV Archives to Video Collections in Italy

Nowadays, inside our public archives, films, Radio and TV programs on Performing Arts are scarce in number and quality.

In 1924 Istituto Luce was established to collect film newsreels for national propaganda, also news on Performing Arts.

16 mm films are available in archives of our RAI, public Italian TV, only starting from February 21, 1966. TV programming was exclusively addressed to provide information about theatre seasons of the time, mostly with short news. All what is left of the previous TV programming about theatre - from November 1952, day of the first Italian TV broadcasting, to 1966 - is only a few meter film transferred with the use of a vidigraph.

This leftover are like "scattered images of a forgotten memory", quoted Ciro Giorgini and Caterina D'Amico in their significant biennial study about TecheRAI, the Public Italian Television Archive.[6]

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4 Its holdings include important collections of ancient *librettos*.

5 "The Historical Collections (1899 -1950) of the Vienna Phonogrammarchiv." `http://www.unesco.org/new/en/communication-and-information/flagship-projectactivities/memory-of-the-world/register/fulllist-of-registered-heritage/registered-heritagepage-8/the-historical-collections-1899-1950-of-the-viennaphonogrammarchiv/#c191394`.

6 Caterina D'Amico, Ciro Giorgini, "Cronache del teatro in tv", (1996 and 1997), catalogue of 11th and 12th Riccione Teatro Televisione Video Festival, Riccione, p. 4.

The adoption of electronic technologies allowed the opening of Italian Public TV's Archives, TecheRai, in 1976. It was the beginning of a more systematic audiovisual documentation: the birth of an audiovisual memory - although we have to remember that access was still restricted to few professionals and scholars.

In the 80's, Electronic Arts produced *videoteatro*, an uncertain border for the Performing Arts (*no theatre no TV)* using the new rhythm of video art imaginary. It was a critical remix against a "never changing" TV giving very little information about the activity of theatres, and even less about the innovations of contemporary Performing Art.

In Italy the relation between theatre and television has been quite difficult. TV programs on Performing Arts have been rarely broadcasted on current TV and even in thematic channels; the multiplication of channels did not help solve the situation.

At the end of the XX Century a structural change arose when, to record and save textual or audiovisual data, the format changed to digital file. Soon afterwards, digital data began to be freely available on-line.

1.3 New Media Tools Are Transforming the Way Researchers Are Doing Their Work

A second statement: *The recent introduction of new audiovisual and hypermedia tools is deeply transforming the way Performing Arts researchers are doing their work.*

• The remote access to data has a macro effect

With the remote access to data there is a gradual and fundamental shift in the practice of academics, from scarcity to abundance, from a niche community to general public, and on-going changes in the way research is made.

A macro effect of this change is the remote access to data. According to available statistics, today users largely prefer to access records in a virtual mode rather than in first person.

• A starting point

We are at a starting point for an endless work of re-editing aimed to teach, study or analyze a performance through its audiovisual records.

This is changing at the maximum level the status of a Performing Arts record.

• A turning point or a dead-end?

The move from analogical to digital media created a turning point for archives, libraries and museums. But it also offers the opportunity for interesting studies about the on-going changes in the way research is made.

The work of Martin Weller (2011)[7] about the gradual and fundamental shift in the practice of academics is one of those. Every aspect of scholarly practice is seeing changes opened up by the adoption of new technologies. We should explore these changes, their implications for higher education, the openings for new forms of scholarly practice and the lessons that can be drawn from the application of new technologies in other fields.

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[7] Weller M., 2011 see chapter *A Pedagogy of Abundance*, in "The Digital Scholar: How Technology Is Transforming Scholarly Practice", Bloomsbury Academic, e-book, pp. 466–78.

Digital items are accessed on-line to create new data very different from its original source, to follow the users' personal needs, destinations and scopes.

This is a new phenomenon in the history of Performing Arts' studies. And it is the starting point for an endless work of re-editing aimed to teach, study or analyze a performance through its records. This interdisciplinary exercise is changing at the maximum level the status of a Performing Arts record.

Are we witnessing a no-return point?

1.4 On-Line Public Access Is Changing the Status of Performing Arts Documents and Is Multiplying Audiovisual Authors

Third statement: *The on-line access to digital video opens the way to a new management of Performing Arts documents.*

An *omni-comprehensive* on-line platform as ECLAP is, allows the conservation and distribution of records far beyond specialists' world, opening to free access to the records. The introduction of new media is very important in order to *offer* the Performing Arts Heritage via web to all kind of users (students, artists, practitioners, scholars, academics, etc.).

A few observations concerning digital archiving:

- **Format is Content:** the selection of appropriate data formats, search engines and platforms appears to be as important as the content, because (as McLuhan[8] taught us) formats and supports are an important part of the content itself.
- **Uniqueness of the Performing Arts document:** reflections on the specific nature of a Performing Arts document – in fact an unfinished record compared to the live performance it pertains to - seem to have an increasing relevance. Because of its *multisensory* dimension, the audiovisual record of a *performatical* event, in comparison to the textual description used in the past, may better recall the artistic quality of the event itself.
- **The creator of a performance record is a new author himself:** video creators always interpose their point of view to the performance authors'. This makes the creator of the record a new author himself. It was also true in the past – with the use of chronicles, diaries, articles, reviews, essays, photos, etc. but it is the false status of "*real and thus objective*" given to the audiovisual record that might confuse us.
- **How to preserve the historical value of the ancient Performing Art recording?** The audiovisual document, conceived in the past by its creator as a complete work in itself (a photo, a video, a TV program, a film or a documentary related, for example, to a Shakespeare play) it has now to be flexible and open to the needs of its on-line users. They want to modify and re-use the digital data, becoming themselves authors of numberless new versions of it. The Performing Arts community at large, not only the on-line community, should find ways to evaluate the quality of available data.

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[8] McLuhan M., 1964 "Understanding Media: The Extensions of Man" New York: McGraw-Hill.

- **We face an endless growth of accessible items, continuously multiplying:** through on-line processing images may be fragmented into semantic units and re-aggregated. But being aware of it doesn't mean to be able to deal practically with the endless growth of accessible items, continuously multiplying.
- **A deep change in the status of Intellectual Property Rights:** authors' rights regulation is facing many challenges in managing this new reality that is deeply changing the status of Intellectual Property Rights. In DRM[9], regulation of rights is slowly moving its focus from the property of the data to its use.
- **Not all digital documents are equivalents:** on-line preserving should not understimate the problem of intellectual and immaterial value of a Performing Arts document. Significant documents are not equivalent: sometime the record is more valuable than the performance; sometime it is only a pale shadow of an important event. But a poor quality record of an important performance still is more precious of a shiny document about an unknown performer.

Above all, the on-line documents aim to booster the creation of new performances in real stages, as Artaud radiorecordings did. The journey from real to virtual should include a round trip ticket.

1.5 Audiovisual Records Are Related to Something Missing: The Performance Whose Happening They Witnessed

Performing Arts' documents relate to an absence more than a presence: the absence of the performance of which they are just a *residual* track. The researcher may be seen as an archaeologist who, starting from the remains collected, tries to reconstruct something that will never come back.

The record cannot replace the unique quality of a performance.

The digital record - thanks to its reproducibility - is no more connected to its physical correspondent artifact (i.e.: any type of photo, text, video or audio recording), and thus it can be easily distributed to different channels, both on-line and off-line, on the screen of an educational environment.

But who is going to pay to keep the original records safe off-line?

While distribution of the European's Performing Arts cultural heritage becomes more and more global via Web, its preservation is linked to funds obtained from national and regional institutions. Funding agents are usually based in the same physical territory where archives or libraries are based.

Sometimes the word "territory" may include also its social and contextual meanings. Funding often depends from the power of different recipients the collected records were meant for.

Nowadays funding, essential to keep libraries and archives alive, is becoming - on a local, national, European or global scale - *the* scarce resource. The cultural heritage public repositories, beyond the boundaries of TV and video publishing markets, are experiencing a hard time.

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[9] Digital Rights Management.

We are producing new content; we are allowing on-line users to create it from our video although we do not want to dilapidate our off-line heritage. Thus the restoration of the analogue recordings is a very important aspect of our study and research's activity.

The need for preservation includes not only to allow on-line access, but also to work for conservation and restoration of the original support. Archives and libraries need to preserve their traditional activity.

We are facing an underestimated problem. European funding is helping but not permanently, as it would be needed.

2 Information Retrieval for Performing Arts

2.1 A Best Practice Network Is a Way to Deal with the Danger of a "Fallacy Due to Content Abundance"

Fourth statement: *What was scarce in the past is now more and more abundant and easily accessible not only to experts but to everybody.*

We welcome abundance as an opportunity, knowing it can raise new puzzles to P. A. scholars.

The round trip journey to this huge change can be accomplished only with a constant critical effort through the continuous re-definition of the paradigm, theories and methodologies.

The fact that through on-line access the users (students, scholars, amateurs, professionals) have such an abundance of records available to their aims raises a peculiar problem. According to Hubert Dreyfus (2001), given the immense size of the Net "the mistake is to think that just because you got some useful documents the *Information Retrieval* system is performing well. What you don't know is how many better documents the system missed"[10].

And this was stated in 2001!!!

It implies the risk, unknown in the past, of losing the thread of a search due to the abundance of available items on a given subject.

In order not to fall into such traps, we need experts in Knowledge Organization to help us identifying appropriate models and tools for Information Retrieval in our fields. Models and tools to be adopted should consider that Performing Arts is - from its millenary origin - a space of freedom and collective thinking that cannot be restricted into market driven formats and models.

One perspective of relevance to the educational field is the effect that a sudden abundance of content and resources has on how educators approach teaching.

Now it is the users' time and attention that becomes the scarce resources.

[10] Dreyfus H. L., 2001 "On the Internet", Revised Second Edition. London and New York: Routledge, p.84.

2.2 A Best Practice Network Is a Way to Perform an Accurate Retrieval Process of the Performing Arts Records

As Martin Weller (2011) is stating, Web 2.0 tools such as blogs, wikis, social networks and content-sharing sites, or actions as tagging, re-mixing or doing mash-ups, are examples of a new user-centric information infrastructure that emphasizes participation (e.g., creating, re-mixing) over presentation. New retrieval models are emerging from action and not out of passivity, as it was the case with traditional learning approaches.

A new pedagogy of abundance would then, Weller continues, be based on the following assumptions:

- Content is free – not all content is free, but increasingly a free version can be located. So an assumption that this will be the default is more likely than one based on pay walls or micro payments.
- Content is abundant – the quantity of content is now abundant as a result of easy publishing formats and digitalization projects.
- Content is varied – content is no longer predominantly text based.
- Sharing is easy – there are now easy ways to share, so the 'cost' of sharing has largely disappeared.
- Social based – and this may not necessarily entail intensive interaction, since filtering and sharing, being a by-product of individual actions, constitutes a social approach to learning.
- Connections are 'light' – as with sharing, it is easy to make and preserve connections within a network since they do not necessitate one-on-one maintenance.
- Organization is cheap – Clay Shirky (2008)[11] argues that the 'cost' of organizing people has collapsed, which makes informal groupings more likely to occur and often more successful: 'By making it easier for groups to self-assemble and for individuals to contribute to group effort without requiring formal management, these tools have radically altered the old limits on the size, sophistication, and scope of unsupervised effort'.

A key point of the above is User-generated content: the ease of content generation will see not only a greater variety of formats for content but courses being updated and constructed from learner's own content.

A series of gigantic changes are happening in a very short time.

2.3 Preparing Performing Arts Studies to Remote Fruition

We need to preserve the peculiarities of the P. A. audiovisual record facing the increasing abundance of content. Many questions arise about how to prepare it for remote fruition:

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[11] See Shirky C., 2008 Here Comes Everybody: The Power of Organizing Without Organizations, London: Penguin.

- When comparing them to other types of documents, what is specifically needed in the elaboration process?
- How to retrieve all information contained in audiovisual documents? The content as a Performing Arts record is retrieved using textual metadata but how to index the specific level of the audiovisual format, being it «new content» in itself?
- When the audiovisual document is on-line, how to integrate these differences into the general digital cataloguing process?
- How to take into account the different searching, analysis and staging needs of audiovisual documents accessed from the same digital platform of texts and photos?
- How to give a hierarchy to structural differences that keep each media item apart from the other?
- Using the available bibliographic metadata descriptors how to adapt, modify and make functional to the Performing Arts complexity, the digital retrieving tools?

These are the questions we formulate to experts in Knowledge Organization.

In fact a correct on-line archiving of the audiovisual documents regarding Performing Arts asks for the consideration of the multiple layers of Knowledge's Organization the item contains in itself. Cataloguing of the given audiovisual object needs to record both the creative content's descriptors (using DCTerms) and the original format's descriptors.

The original format (film, tape, etc.) is a very important data that testifies the historical, social and cultural values inscribed and preserved in the item via its technology.

The same goes for the specific semantic of the original data (editing, shooting, sound treatment, scenario, etc.).

The Performing Arts community needs:

- To take the *intermedia* issue as a significant starting point.
- To consider how to apply existing tools to the specific purpose of Performing Arts research.

The new ways of searching, specific to the audiovisual - moving images and digital sound in general - are mainly related to three main areas:

- To find new tools of Information Retrieval
- To establish an appropriate vocabulary
- To implement specific multimodal interfaces.

2.4 Developing a Specific Inter-codex Semantic for Performing Arts' Items Description and Aggregation

Stakeholders need not only to find new tools, to elaborate a specific vocabulary and a new key word list for Performing Arts metadata, but also to take into account specific difficulties related to the *ekphrasis* and *intermediality* issues. These issues arise when facing the task of describing with alphabetic metadata a non-alphabetic media (audiovisual versus alphabetic). This is a complex and original aspect to deal with, compared with existing librarian and documentalists studies that established metadata fields to describe a bibliographic record.

The inter-codex inner quality of the Performing Arts asks for a polysemic and multi-codex description of the audiovisual item.

It is still very difficult to process an audiovisual document using computers without human intervention.

2.5 Finding New Tools and New Theories for Information Retrieval in the Performing Arts

On-line archives offer users some interesting multimodal interfaces in on-going development, with growing fields of applications. Among them, special attention should be given to the experimenting of new tools for the recognition of sounds and images through characteristic signs - from *vocal recognition* to *frame searching tools* - for the creation and organization of open collections and authorial aggregations of audiovisual documents.

The specificity of the Performing Arts' audiovisual document and of the numberless variations of its production models demands a strong re-framing of the field's theories. Research cannot be limited to experimenting new technologies' and applications' tools.

Theoretical studies on Performing Arts' documentation and conservation are undergoing a big challenge:

- Considering modularity, flexibility, granularity of the data (see Manovich L., 1996)[12]
- Including user-generated content though separating it from the first author's record.
- Building pre-fixed paths to easily identify content's aggregation related to the same subject.

3 Best Practices in the Audiovisual Research for the Performing Arts: A Variety of Research Paths

3.1 The Example of Centro Teatro Ateneo

Centro Teatro Ateneo, now led by Prof. Valentina Valentini, was established in June 1981 as an Inter-faculty Research Centre at the Università La Sapienza of Rome. The centre was at the time directed by Prof. Ferruccio Marotti.

The archive of Centro Teatro Ateneo is one of the best Italian repositories for Theatre and Performing Arts' audiovisual records. Its collection is a dynamic witness of the live performance activity that took place in Italy in the second half of XX Century.

[12] Manovich L., 1996 "Cinema and Digital Media." `http://jupiter.ucsd.edu/~manovich/text/digital-cinema-zkm.html`

The peculiarity of CTA contribution to ECLAP is that – with the exception of the important photographic images from the Forties – it consists of documentaries and videos -- produced between 1967 and 2012 -- that systematically document research activities of the *Istituto del Teatro*, University Department of Performing Arts, and of the Centro Teatro Ateneo. This archive produced over the years in all kind of formats, from 16 mm film to different magnetic tapes (1' tape, ½' tape, ¾' U-Matic and BVU, Betacam Oxid e SP, Betamax, Hi8, VHS, S-VHS) to digital (Mini-DV, HD, computer graphics, etc.). Thousands of videos on theatre, with documentation of workshops, seminars and theatre show and rehearsals are stored in CTA archives.

From 2010 the Centre entered a new phase, and - thanks to the funding of the ECLAP project - is part of an European Network of Best Practices aimed to create an European Performing Arts Digital Library. Together with several European *Content Aggregators*, leaders in various Performing Arts fields (theatre, dance, cinema, performance) CTA gathers audiovisual content at www.eclap.eu.

3.2 The Role of a Best Practice Network for European Performing Arts Digital Libraries

What is the role of a Best Practice Network for the Performing Arts?

At first it was to allow new forms and formats for Performing Art audiovisual productions to flourish. The migration of our collections unto a unique platform (http://www.eclap.eu) is a way to facilitate users' new productions for creativity and learning purposes.

In my opinion more interesting paths of research were made possible through ECLAP:

- Adopt new tools for audiovisual research in Performing Arts, as MyStoryPlayer, and verify their functionality.
- Reflect on Dublin Core fields: are they good enough in indexing Performing Arts content? Do we need more fields? In our experience the 5 basic content types (following DC types: audio, video, text, image, database) are not enough to describe the available audiovisual formats.
- Work on an accurate taxonomy helping us with Information retrieval.
- Look for specific clustering models following the needs of Performing Arts studies.
- Consider the "moving image" as a new kind of historical document.

We realized that, once users' requirements have been identified, the activity of *content enrichment* and *aggregating, uploading* and *downloading, embedding, tagging* and *annotating*, to be performed at their best, would need a more complete metadata scheme, more fields and more descriptors.

Through the three-years activity of the ECLAP Best Practice Network we tried to enter a new phase in Performing Arts' research that looks at the "moving image" as a new kind of historical document.

4 Conclusions: Are We Facing a New Age of Freedom for Performing Arts Cultural Heritage?

Fifth and last statement: *Electronic Arts and Digital New Media forecast a new aesthetic and imaginary, different from the market driven way of describing the world.*

Far away from the old Television standards, New Media gets the audience closer to new ways of seeing the contemporary world. Public institutions do not encourage the adoption of measures to endorse distribution of this kind of images and products. New images go beyond the definition of cinematographic work or TV program and beyond the standard lengths of audiovisual formats (i.e. short, medium and feature films).

These original works, first created electronically and now through digital technologies, have to be considered as new content, and not as new means of transmitting old content.

Breandán Knowlton on Europeana reflects on how the web is changing our cultural heritage with these words:

> The culture that we create now is often born digital, an expression of a connective society threaded across distance and culture by tools enabling a new and transformative synthesis. My hope is that platforms like Europeana can shape this new ecosystem, spurring the creation of new cultural artifacts born from an appreciation and remixing of the past. Whatever the era, at our best we humans are storytellers, and as the tools change around us we retain a perennial desire to transform impression and information into narrative.[13]

New Media's innovative works (those adopting interactivity, modularity, flexibility) and the virtual platforms available online, such as ECLAP and Europeana, allow for the distribution of new formats and genres, foreseeing new content without the limit and censorship of the TV standard *palimpsests*.

It is now up to on-line users to establish if this change will bring new cultural freedom. The more they will exploit on-line archives' opportunities for all kind of different purposes, the more we will have a dynamic and flexible cultural content available to preserve our past. The more the digital archives will be open to new formats, to new productions and to free downloading, the more we will encourage the spreading of European primary values and get a chance to preserve the millenary history of Performing Arts.

Finally a quote by Martin Weller that I found, of course, on-line:

> We are witnessing a fundamental change in the production of knowledge and our relationship to content. This is producing an abundance of content, which is unprecedented. Google CEO Eric Schmidt claims that society produces more information in two days than was created from the beginning of human history until 2003, stating 'the real issue is user-generated content' (Siegler 2010). Many of our approaches to teaching and learning were developed in a different age, and this basic shift from moderate scarcity to excessive abundance constitutes a challenge to higher education and to individual information processing abilities. [14]

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[13] Knowlton B., 2013 "How is the web changing cultural heritage?" Available at `http://pro.europeana.eu/pro-blog/-/blogs/how-is-the-web-changing-cultural-heritage`

[14] Weller M., 2011 "A Pedagogy of Abundance", cit.

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Multimedia Performance Reconstruction as a Challenge to Theatre History Writing

Using Interactive Models of Historical Theatre Performances in the Education of Performing Arts

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Abstract. Based on my digital reconstructions of two historical performances from Hungary, I am trying to investigate how these could form the basis of designing e-learning content for performing arts students, both for course room and self-study use. The reconstructions use rich audio-visual resources, arranged along a multi-dimensional mind-map, to facilitate understanding and to support further analysis. By presenting some earlier and contemporary attempts of performance reconstruction from Hungary I investigate how these could bring new approaches to theatre history writing. By looking at the relationship of narrative and image, I argue that a radically new approach is needed in how multimedia content is presented, if we wish digital tools to offer new experiences and alternative reading strategies of theatre history. I present several ways of using these materials for pedagogical aims, as different walkthroughs of the same mind map. What are the specific tools and steps that could bridge e-learning tools and live courseroom interaction? How could the presentation of bygone theatrical events give room to creativity and activate personal opinions and insights? Finally, I present a few very specific task types which can be implemented by teachers in these models, to raise and keep the interest of students of the visual generation in the performing arts of their parents' times.

Keywords: digital performance reconstruction, theatre history writing, Hungarian theatre history, e-learning.

1 Performance Reconstuctions in Theatre History Writing

The Hungarian habitus of theatre history writing, still heavily grounded on positivist theory, seems to be using multimedia records only as resource or illustration to a narrative account, which rarely gives more than the history of performing arts institutions or biography of theatre personalities. This historical narrative, without even problematizing the mediality of representations, also seems to neglect the importance of how the 'suspension of time' (Gadamer, 1986) is carried out by the formal decisions of the artistic event. Hungarian theatre theoretician, Gabriella Kiss, summarises the problem in a review written about a recently issued volume of theatre history, titled

P. Nesi and R. Santucci (Eds.): ECLAP 2013, LNCS 7990, pp. 164–174, 2013.

Theatre and Dictatorship: "At the beginning of the 21st century it can nearly be considered a commonplace the tenet of historiography that any theatre history can only be written as a history of theatre performances of the time, while continuously reflecting on the changing notion of theatricality. What concerns the usage of resources, one has to keep in mind the question of what a certain era/culture considered to be 'theatre', while on the other hand, the event-like nature of spectacle has to be sensitively shown." (Kiss, 2012) While the discourse of theatre theory has been flooded with various theories: hermeneutics, deconstruction, gender theories, new historicism and different branches of theatre sociology and cognitive sciences; sadly these theories did not permeate the discipline of theatre history writing.

It has to be said, however, that some tradition in event-based theatre history writing does exists, but it usually does not extend the reconstruction of one or two performances. In 1984, Mária Bódis attempted to reconstruct very significant performances from the beginning of the century, one of which is the operetta version of János Vitéz (John the Valiant) at the Király Színház in 1904, which was an unprecedented commercial success in the Hungarian theatre running 689 times in the following years (Bódis, 1984). The booklet offers a rare and considerably broad analysis of the cultural context, the theatrical context of the work, reflecting on the usability of theatre photos of the time as resources of theatre historiography, and even tries to reconstruct the system of movement of the actors. In 2012, theatre sociologist István Szabó attempts a different approach to the reconstruction of the same performance, using the gramophone plates of the songs in the operetta, which were extensively sold at the time, making the young protagonist Sári Fedák, the cross-dressed actress playing the male leading role, an instant star (Szabó, 2012). Szabó links the analysis of the (comic) singing style and diction with an explanation of how the earliest attempts of immortalising the evanescent theatrical event could also be used as effective tools of theatre distribution. Theatre historian Zoltán Imre's reconstruction of the first staging of the Tragedy of Man at the National Theatre in Budapest (1883), offers an in-depth analysis of the social context, the changing role of visuality, the concept of the national theatre and national identity in a Foucaultian power discourse (Imre, 2012).

These sporadic examples of theatre history narratives are symptoms of a paradigm shift in the thinking of what a theatre history should be and how it should be constructed. They do not only give a detailed analysis of the theatrical event itself but testify of a very conscious awareness of the complexity of such an event, equally focusing on the domains of production, distribution and reception, rather than just prioritising one or another field: theatre aesthetics, the institutional system or the work of the actor.[1]

A more systematic approach to performance reconstructions is in progress at the Theatrology Department of the Károli Gáspár University in Budapest. The three-year research project titled 'Philther', wishes to be a continuation of the three volumes of Hungarian theatre history covering the period 1790-1945. They would differ from the work written mostly in a positivistic attitude by not only recognising the event-like

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[1] A possible model for the interaction between the three domains can be seen in: van Maanen 2009, 242-244.

nature of the theatre performance but also making this insight the foundation of their methodology. The array of concise performance analyses would result in an online publication targeting "the generations which have been socialised in the global infrastructure of the internet, creating a system which offers an adequate reading strategy for the audiences growing up after the visual turn. (…) The end product will be a network of analyses which differs from the book format only offering a linear reading, whereas our network, due to its complexity, would encourage a layered reading."[2] (Kékesi Kun, 2011)

Right from the start, the project chooses to distance itself from certain productions and artistic personalities: "we are not looking for the performances with the biggest effect, – therefore no one should be looking for Cats, the musical at the Madách Theatre, for instance – but we select the performances which demonstrate the traditions with the greatest effect from the past decades." (Kékesi Kun, 2011). The exclusion of commercial theatre and of some drama theatre which is judged less innovative could be justified as a conscious decision of the historiographer wishing to draw up a line of excellence in Hungarian theatre culture of two conflicting traditions. But from a sociological perspective it is at least questionable: doomed to missing the very point of an event-based theatre history, which is to give a parallel analysis of two synchronic performances, which represent very different aesthetic traditions. Referring to Jauss's concept of the coexistence of the contemporaneous and the non-contemporaneous, one can argue that any given theatrical moment is mixture of the obsolete and of the Avant-garde, performative events living together in a 'heterogenous multiplicity.'[3]

Although the historical narratives of the 'Philther' project are written after a detailed research into the available multimedia documents of a performance, in the final output only a minimal amount of these resources will be visible: a few performance photos and minute excepts from video recordings. The reconstructions are made by scholars and students who have no first-hand personal experience of most theatrical events and must rely on recorded observations of other spectators. However, in the resulting textual narrative the multitude and sometimes discrepancy of these first-order observations will not be reflected upon. Even if the limitations are due mainly to copyright restrictions we have to realize that the relationship between the historical narrative (text) and the different representations (multimedia) is that of the illustration. Even if the analyses will be published in the form of an online network, the publication will preserve the traditional relationship between text and image present in printed books. Moreover, it is a question to what extent these analyses will manage to provide an equivalent representation of the inner temporal structure of the performances: the changes in atmospheres, rhythms, transitions of set design elements, proxemics of actors, voice pitch and timber changes. Only a very graphic and lengthy verbal description could model the experience, which can so easily given back by even a technically imperfect fragment of sound or video recording.

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2 A similar theatre history project, consisting of a network of short analyses and performance reconstrctions, is also being implemented in Poland: `www.teatrpubliczny.pl`

3 "For the audience that perceives them and relates them to one another as works of its present, in the unity of a common horizon of literary expectations, memories and anticipations that establishes their significance." (Jauss, 1982)

The challenge of theatre reconstruction has also been in the limelight of Polish theatrology. Buchwald and Adamiecka (2008, 183.) note that despite the utopia of Zbigniew Raszewski and Stefania Skwarczynska, who set up a list of 26 different types of documents which should be produced and collected in order to facilitate the reconstruction of a performance, the theatre of our times tends to be less and less conscious of its future heritage: “Paradoxically today’s theatre is even more ephemeral than the theatre of fifty years ago. (…) Set designers rarely draw designs (not to mention models), set designs and costumes are often made out of purchased, ready-made pieces; directors do not leave the scripts they have worked on in the theatres.” Agnieszka Kubas (2012), researcher and archivist from the Polish Theatre Institute, summarizes: “Thus the paradox of documenting theatre nowadays consists of an excess on the one hand, and of a lack, on the other.” Speaking about the challenges of the contemporary theatre archivist in the times of ‘liquid modernity’ (Zygmund Bauman), she also reflects on the gains offered by the digital tools, also commenting my reconstruction of the Seagull performance: “Contemporary technology gives us the possibility to reconstruct old performances quite precisely but these reconstructions do not answer the questions raised by the science nowadays. The possibility of adding a second and a third dimension, as well as the possibility of combining various documents help our archaeology of the past, but it is worth doing only in particular cases, when we know what kind of research such a reconstruction should serve.” Naturally, a comprehensive theatre archive, built on a daily basis, can hardly do more than trying to integrate as much as possible the resources collected digitally from very different sources, as greatly exemplified by their digital archive, e-teatr.pl, linking performance metadata, reviews and visual sources in an easily searchable manner. However, the digital reconstruction of a well-chosen performance can encourage and support certain interpretations of a bygone performative event which can be highly relevant in the context of the theatre historical and theoretical thinking of a given theatre culture. Contrary to an interpretation, however, such a reconstruction offers enough ‘direct’ access to source documents and representations that it gives space to test, validate or even refute the reading suggested by the maker of the reconstruction.

2 The Digital Reconstructions

In my attempts of performance reconstructions I do not wish to give supremacy to multimedia resources only to the detriment of textual explanation. But if we are searching for an added value in using digital technologies to comply with a new reading strategy in a visual age, the role of the multimedia content has to be re-evaluated in the discourse of theatre history writing. The relative abundance of audiovisual records of the performances from the 1950-1989 period could serve as a temptation for the researcher to try and reconstruct somehow the inner temporality of the event but putting side by side the different elements of the puzzle. And by doing so, also try to reflect upon the inherent differences of these representation media: what is it that they make visible and what they omit to record? I was looking for a model in which conflicting views (reviews) and conflicting visions could be shown side by side: still shots versus videos, or photos made by different photographers, set designs. A model which could shown in the same system of coordinates all the different domains as congruent formal decisions which all shape a certain experience (production, distribution, reception, architecture, set and costume design, posters, playbills, etc.). I would argue that a new type of reading would only be triggered if the readers (browsers) could choose their different paths in how to walk through the reconstruction, deciding what to zoom in on, and oscillate back and forth between images, videos, sounds, textual explanations, contemporary reviews or the playtext. In such a model content and metadata would fit into a complex network of annotations. A video except can be annotated by a photo of the same scene or by an excerpt from a review. In such a neural structure of content the relationship between text and image becomes more balanced yet does not disappear.

The coupling of content/image and metadata is not a contemporary phenomenon, a novelty of the digital era. The relationship between lecture and image contemplation is one of the main concerns of image theory. Art historian Louis Marin, with reference to a painting by Nicolas Poussin performs a parallel analysis of Poussin's painting Gathering of Manna (1640's) and a contemporary letter the painter had written to his friend and commissioner of the painting. In this letter Poussin explains how the painting should be displayed, contemplated and interpreted, while Marin investigates how a painting can be read, just like a text, pointing out how the apparent simultaneity of a depicted biblical scene needs to be interpreted as a linear process spread out in time, legible from left to right, just as our writing. (Marin, 1885)

So far I have carried out the reconstruction of two performances. The 1972 Chekhov's Seagull at the Madách Theatre in Budapest, directed by Ottó Ádám, was challenging since no video recoding was available, yet the archives hold two series of performance photos by different photographers and an audio tape of the radio broadcast.[4] After having decided on the main conceptual lines, I chose the most significant scenes and I coupled the photos with the corresponding sound sequences. I also tried to further animate the still shots with a zooming and scanning effect I added to the photos, which acted as meaningful cuts to create a lively, film-like effect. This post-editing also tried to follow and emphasize the meaningful patterns identified in the still shots: following the vectors of glances, zooming in on important body postures and positions of actors vis-à-vis each other and the set. I organized the four acts as four branches of a tree, inserting in between, as a sort of virtual intervals, the reviews and fragments of reviews relevant to the given act. Finally, as a further study focus, I added an analysis of the patterns of diction the actors used, which I contrasted with the observations of the reviewers (Figure 1).

The second reconstruction was the Álomkommandó (Dream Commando) by Transylvanian Hungarian playwright András Sütő, played at the Vígszínház in 1987. Here a colour video recording was also available, as well as a radio broadcast. The importance of the performance is given by the fact that the play, manipulating with a quite

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[4] The reconstruction can be accessed online on Prezi.com: Sirály 1971 (előadás-rekonstrukció) http://prezi.com/zsxkopy6_t3j/siraly-1971-eloadas-rekonstrukcio/?kw=view-zsxkopy6_t3j&rc=ref-15128143

complex system of time layers, is quite openly critical of the Communist regime, drawing up a very direct parallel between the atrocities committed during the Holocaust and the following communist dictatorship. All this in a historical time when the communist regime was close to collapsing in Hungary, but still keeping power until 1989, and in neighbouring Romania (where the playwright Sütő was born) the harshest period of the Ceausescu regime was thriving. Although set in the times of the Stalinist fifties, already condemned after the death of Stalin in the whole communist world, it was not difficult to see that the criticism of the play was also aimed at the 'milder' dictatorship of János Kádár, offering bread but no freedom (of speech and travel). Sütő's artistic attitude as an ethnic Hungarian in communist Romania is definitely emblematic for the Hungarian theatre history: it was general for playwrights to cover their contemporary ideas in historical plays.

In view of this context it should be evident how such a performance could have been revelatory for the people domestically refusing the dictatorship but officially subscribing to the lies that the Soviet invasion in 1945 was a Liberation from the Nazi forces and that the forthcoming communist dictatorship had any legitimacy. The show could have been a performative justification of resistance and indirectly of the 1956 Revolution. However, the play was performed by the actors of the Vígszínház, trained on situation comedies and preservers of the conversational elegance of Ferenc Molnár's universe. As the contemporary reviewers also point out, this manner of acting and mise-en-scene destroyed the momentum of the dream-like and symbolically revelational choir parts, which could have been metonymically identified with a nation's rage against an endless row of oppression.[5]

The digitized archives of the Hungarian Theatre Museum and Institute provided rich materials for such an interpretative reconstruction (photos, videos, audio recordings, press cuts, posters, set and costume designs). Most of the resources have already been published in the online theatre database of the Theatre Institute (www.szinhaziadattar.hu). Naturally, sources have been selected and abridged to keep the educational goals focused. For further study, full sources are referenced by links leading to large scale digital libraries (ECLAP, Europeana), which not only provide detailed metadata but also give students the possibility to study the sources in an international context.

I decided to use Prezi as a presentation environment, since it is an increasingly used software on the market, which started as a small Hungarian venture, very easy to implement even for non-programmers, and the results are instantly ready to

[5] According to the plotline, a theatre in the first years of the communist dictatorship is preparing play about the horrors of the Nazi concentration camps, where a member of the Sonderkommando decides to sell the dreams of his sibling son and daughter as research material to dr. M, pathologist and medical researcher in the camp. In the meanwhile, in the other time layer the playwright of the Holocaust play tries to save his son from imprisonment by the communist police, for political reasons. There is also a layer of dreams, poetic and eerie, but, as it turns out in the plot, not entirely free of "censorship", since the memory of the gas chambers, even if symbolically transposed, cannot be tolerated. The three layers clash at a final crucial moment, making the bereft father a radicalist avenger, against his will.

share online. Prezi offers a special license for students and teachers and a large repository of education materials is being accumulated, of which my reconstructions will automatically be part of[6]. Teachers of this community are given the permissions to online edit and customize a copy of my reconstructions – highlight a different educational focus and implement several walkthroughs – easily incorporating these materials into their theatre curricula.

My choice went for Prezi also because it offers a multimedia modelling environment very much in line with the concepts I wished to develop in my performance reconstructions. Instead of a linear reading offered by a simple slide show, Prezi, the 'zooming presentation' offers a two-dimensional surface and several levels of zooming in and out. This simple concept not only makes presentations visually stimulating but it also offers a virtual architectural metaphor, encourages the modelling of the theatrical event as a mind map, juxtaposing in a three-dimensional virtual space disparate elements of the theatre world. Finally, a For the Dream Commando I tried to develop this virtual topology even further by setting up a model which would comprise the domains of production, distribution, reception, the theatre venue and its architecture, the cultural and theatrical context and the societal values and functions realized by the performance. All this centred on, and revolving around the present time of the theatrical event, which comprises scenes reconstructed from fragments of different media, recorded during the performing arts event (Figure 2).

This map-like structure coupled with the path creation option of Prezi can enable the registration of different walkthroughs in the structure. The following examples are just suggestions as other walkthroughs can also be easily implemented:

A) The Contemporary Spectator – This walkthrough tries to model how the spectators in 1987 could have experienced the theatrical event. After presenting the venue of Vígszínház (outside and lobby) and the open air theatre where the play was premiered the virtual spectators can see a 30 minute reduction of the two-hour performance oscillating between video excerpts and performance photos. During the 'interval' they are given access to original promotional materials and they can read some reviews, related to the given act.

B) Coming to Terms With the Past – This walkthrough does not give a full reconstruction of the performance but rather tries to underline the historical potentials of the performance in the process of coming to terms with the communist dictatorship and the events of WWII. The walkthrough would try to analyse how a theatrical performance could be (or fails to be) successful in encouraging the social and public elaboration of historical traumas.

C) Clashing dramaturgies: conversation play versus multi-layer dramaturgy. It is a challenging approach to analyse Sütő's play as a dramaturgy at crossroads between the muli-layer play[7] and conversation play, pointing out the ways these traditions collide. It can be pointed out how the actors of Vígszínház are well trained in a certain

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[6] More on the educational features of Prezi:
`http://prezi.com/prezi-for-education/`

[7] The concept of the multi-layer dramaturgy was developed by theatre theorist Tamás Bécsy (Bécsy, 1974) He presents three types of dramaturgy: conflict-based, centripetal and multi-layered.

form of conversation plays but the mise-en-scene struggles with the visual rendering of the several layers and the complex transitions between them. As a certain synthesis, the blend concept developed by the cognitive approach is drafted, to try to understand the effects on the perception of spectators when confronted with this complexity of time layers, characters and dramatic models (Seress, 2012).

3 Uses Cases in the Theatre Teaching Practice

In order for the potentials of these materials to be fully exploited in an education environment, dialogical and interactive aspects should be implemented. Even if the walkthroughs presented above do define some pedagogical targets, the abundance of original data about the performance makes it possible for students to test, validate, or even disagree with the observations of the teacher/author of the reconstruction. A possible interpretation/contextualisation of the material is suggested, but there is plenty of room for other approaches and opinions. The structure of the material itself is created in a way to present different viewpoints, different media and conflicting opinions. This way, instead of a frontal transmission of content, the course design would encourage the creation of an intersubjective space, which does not necessary require agreement.[8] Interactivity would be added by adding specific e-learning tasks to each walkthrough.

In the course room environment the group of students and the teacher can maximally exploit the interactive possibilities of the material. Each student would have a personal computer access to a copy of the presentation and the required input would be digitally transmitted to the teacher's computer, who could single out a few and share it with everyone through the common (larger) screen. Here are some of the possible task types:

- questions: opinions and interpretation can be asked in the form of simple questions at any point of the reconstruction, and a short textbox is given for the student to formulate an answer, which is immediately submitted to the teacher, who can single out and clash the opposing views, later discussed in a small debate. Fragments of contemporary reviews can greatly be used at this point to illustrate the difference of how interpretation strategies have changed between then and now. Students can also be asked to guess what they expect to happen in the following scene, or who is going to arrive, what the set would be like etc.
- rearrange the photo sequence: a sequence of performance photos are presented and they have to be rearranged in the order they were taken. Some odd-one-outs from

8 „Judgement is released from the constraints of consensus, while its relation to the object is preserved. (…) Art permits a kind of playful relationship to questions of reasonable consensus or dissent. It avoids degrading or excluding those who think differently. And it does so in such a way that doubts about whether or not one communicates about the same thing never arise. The measure for adequacy is not a consensus determined by a "shared symbolic system" (Parsons), but resides instead in the question whether the viewer can follow the directives for adequate observation embedded in the work's own formal decisions." Luhmann, 1995, 75.

different scenes can make the task more challenging. A fragment from the playtext could be used for reference. This task would encourage meticulous observation of the details and the ability to match gestures, mimics, proxemics with the text. This is a very good way of memorising gestures and body positions. Finally, the video sequence can help check if the order was correct. In another version lines taken from the play have to be matched with the photos (pairwork).

- listen and sketch: a short excerpt of the radio recording is played but no image is shown, the task is to submit a sketch about: a) how the student imagine the set design b) how the space and the position of actors can be reconstructed or several other modelling tasks could be given. The use of a tablet computer with a stylus or smartphones could ease this task, but the simple drawing applet could also offer a few set elements (circles, squares etc) to ease modelling. Finally, the drawings are compared to the actual set design/space, or the video recording of the same scene could give more input.
- guess the lines: in this task only a key video fragment is played without sound. Students (preferably in pairs) have to write what they think the actors are saying. Then the teacher can select which pairs would openly present a dubbing of the scene with their versions of the text. Finally, the original video sequence can be played for reference, with the sound.
- act and compare: an important sequence is performed in pairs based on the playtext, then compared to the sequence in the performance. Discussion can follow about how the means of vocal and gestural expression have changed or are perceived differently today. A good tool to raise awareness of the means of vocal expression (intonation, rhythm, stress) and also to note some peculiarities belonging to one or another actor. Students can be either asked to present the scene the way they would or to anticipate how the actors in the performance would. This requires "thinking along" with the performance, and understanding how the main formal choices of the given performance work.

A self-study version would keep some of the same tasks but would also give sample answers for reference. While the course room material is designed to maximise interactivity and offers shorter excepts, in self-study readings can be longer, just as the selected video and audio excerpts. An audio recorder can be implemented which could record the performance of the student in the dubbing scenes and play it back to him/her. The answers can be easily submitted to the teacher online for revision.

My experience with teaching performing arts students is that tasks which keep students active and interactive can also be fruitfully used in the study of historical subjects or theoretical parts. Anticipation, or the creative tasks which require to be "involved" in the creative process of a performance from the past can prove to be great motivating tools by constantly preserving interest ('did I guess right?') and giving the impression that they are somehow present in that historical context. Keeping students constantly active and creative would be a great approach to preserve the liveliness of theatre history education.

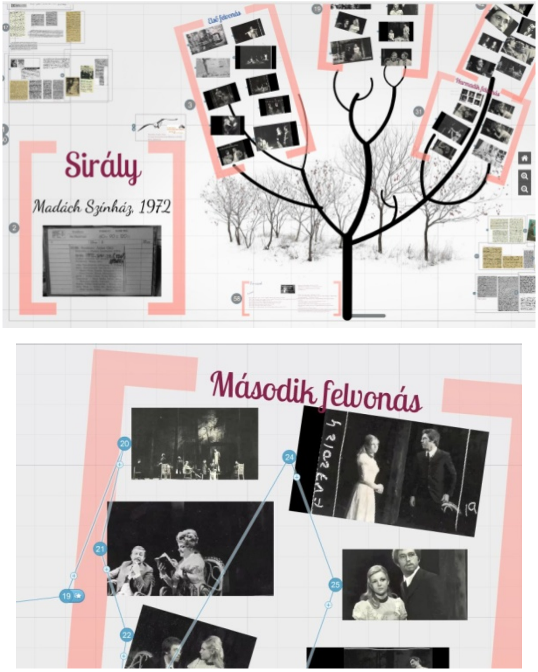

Fig. 1. Close-ups from the Seagull reconstuction, a numbered path showing the order of the scenes played

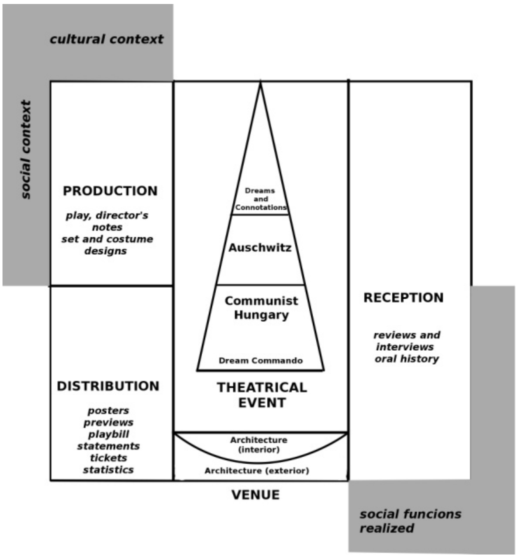

Fig. 2. Model of the Dream Commando reconstruction structured along the different domains of the theatre world

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Education-Performing Arts-Information Technology: An Impossible Triangle?

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Abstract. Integration of IT in performing arts education is often considered to be lagging behind in comparison with other educational fields. This might very well be somewhat of an exaggeration: as Koehler and Mishra (2008) point out the problem of integrating IT in educational settings is ubiquitous. The question this contribution tries to answer is whether on top of these general problems there are specific ones for IT within performing arts curricula that can be held accountable for the perceived arrear. In order to answer this question some main characteristics that determine the nature of the performing arts are briefly discussed: transitivity, collectivity of production and reception, multimediality and the principle of ostension. From these the particular difficulties for integrating IT in performing arts education are traced, mapping the (im)possibilities and pointing out some of the reasons for the relatively slow pace of IT integration. Having thus assessed the major problems and challenges the conclusion discusses the immediate and mid-term developments that would be welcomed by teachers and students in the field of the performing arts.

Keywords: Education, performance, theatre, dance, performing arts, IT, information technology.

1 Introduction

Integration of IT in performing arts education is often considered to be lagging behind in comparison with other educational fields. Nevertheless, when one takes a closer look it's doubtful whether this is actually true. Computers, smartphones and tablets are everywhere now, and they certainly are ubiquitous in education. Students use information technology to produce their papers, to look for information on the internet and in online libraries and archives, to communicate with their teachers and peers, to get their schedules, to pay their fees, to do tests and so on. Likewise teachers would not be able to function any more without recourse to PowerPoint, to wired classrooms that allow them to access the internet live, to virtual learning environments, to plagiarism detection tools and so on. In using all these programs and tools education in the performing arts is really no different from any other subject area. However: the idea that IT still has to catch up in performing arts classes still looms large. There is a persistent notion that the full potential of the new media technologies hasn't been

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reached yet and that there is still a very long way to go before one is on a par with other subjects. How come?

2 The ‘Wicked Problem’ of Integrating IT in the Classroom

First of all we should realize that the alleged lead of other areas is often exaggerated In their seminal work on TPACK Koehler and Mishra (2008) analyze the problems that come with integrating IT in any educational setting.[1] They argue that the integration of new, digital technologies in the teaching process is complicated by the fact that these technologies are characterized by affordances and constraints that are *protean*, *instable* and *opaque* in nature. The protean aspect refers to the fact that computers are multi-tools; capable of manipulating visual, acoustic, textual and numerical sign systems. In other words: the digital revolution is that of a meta-medium resulting in the fact that computers find a multitude of applications in almost every field of human endeavor. In the words of Koehler and Mishra: “(…computers) can be a tool for communication (…), a tool for design and construction (through software for scientific modeling or software for designing websites, themselves very different activities), a tool for inquiry (such as through digital libraries and digital probes), and a tool for artistic expression through image, movie, and audio design software programs).” (Koehler & Mishra 2008: 7) The opacity of digital technologies (i.e.: the fact that the inner workings of computers and programs are hidden) complicates things even further and makes learning a quite difficult process. Besides, most software tools are designed for business and work so that before they can be used in the classroom they often have to be adapted for educational purposes. A third characteristic of digital technologies is the fact that they are instable -expanding and changing constantly- so that users have to keep up continuously with ever new hardware and software (often not very compatible with former versions). A consequence of these rapid developments is also that the ‘new’ tools are often unreliable, not very well tested and full of bugs. As a result this instability of digital technologies requires that “teachers become life-long learners who are willing to contend with ambiguity, frustration and change.” (Koehler & Mishra 2008: 8) And all this in a context where (university-)teachers have increasingly busy time schedules and where a lot of them -still- grew up at a time when the digital revolution was in its early infancy. Finally, when enumerating the difficulties of integrating digital technologies in the learning process, one should take into account:

- that there are important social and psychological differences between the worlds of technology and pedagogy that may hamper fruitful cooperation between the two.
- that classroom contexts are varied and diverse and that hence “(…) integration efforts should always be custom-designed for particular subject matter ideas in specific classroom contexts.” (Koehler & Mishra 2008: 10)
- that there exist ‘divides’ between *digital natives* and *digital immigrants* as well as the *digital divide* between those who have access to the latest technology and those who do not.

[1] For the following cf. also Eversmann, 2012: 84-86.

All these different aspects and factors lead Koehler and Mishra to describe the integration of technology in the classroom as a so called “wicked problem”[2]. These kind of problems have incomplete, contradictory and changing requirements. They are often very hard to solve “because of complex interdependencies among a large number of contextually bound variables (…) Moreover ‘wicked problems’ have no stopping rule - and solutions to wicked problems are not right or wrong, simply ‘better’, ‘worse’, ‘good enough’ or ‘not good enough’. (…) In contexts such as these the best we can hope for is satisficing, i.e. achieving a satisfactory solution, an outcome that, given the circumstances, is *good enough*.” (Koehler & Mishra, 2008: 11)

But the complexity of the wicked problem of integrating technology in educational processes of teaching and learning is ubiquitous and applies in principle to any educational field. Math or languages are no different in this respect than biology, history or, for that matter, arts classes. So the question remains whether there are specific problems in integrating IT with performing arts curricula that can be held accountable for the perceived arrear of the latter. In order to begin to answer this question we first have to look at the nature of the performing arts. Once having specified their core characteristics we can then surmise the particular difficulties that the integration of IT in performing arts education faces.

3 The Nature of the Performing Arts

Therefore we first turn to a brief discussion of some features generally acknowledged by theoreticians to be key criteria in distinguishing performing arts from other disciplines. They are: transitivity, collectivity of production and reception, multimediality and the principle of ostension (iconicity) as an important means of expression.[3] None of these four should be considered absolute or essential characteristics of performing arts, but rather as aspects that play important roles in production and reception.

3.1 Transitivity

Perhaps the most characteristic aspect of performances is the fact that they exist only for a limited amount of time. After a while the show is over and with the applause the work of art ceases to exist. This implies that production and reception are parallel processes in time and that the work of art (the performance) is dependent upon the performing artist – all this in contrast to other forms of art such as literature, painting and sculpting, where production and reception occur in different time-spans and the work of art exists independently of the artist. Of course there are some elements in the performing arts which may last longer and in that regard we can note a similar kind of independence from the artist. Examples would be the (written) drama text or the music score, the set (and its design), and/or the costumes. However, the

[2] The term is originally coined by Rittel & Webber, 1973. See also: `http://en.wikipedia.org/wiki/Wicked_problem`

[3] The following paragraphs are adapted from Eversmann, 2004: 140-143.

performance as such is finite and this means that (with the exception of a few phenomena such as tableaux-vivants or some static forms of 'performance art'), the work of art is really a process, which changes continuously during its existence. The stimulus for the spectator is not static (as in the case of paintings or sculptures), but develops over time. That is to say it develops up to a certain point in time, after which the stimulus ceases to exist altogether and is no longer available for direct referencing or for a renewed encounter. At most the memory of a performance event can be supported in an indirect way; by the traces it leaves in time and/or by forms of documentation.

Finally one should remark that the development in time, so characteristic of the performing arts, implies that the work of art can only be perceived and appreciated in its totality once the show is over. The final interpretation and evaluation of the stimulus can only take place at the end - when all the elements are known and have disappeared.

3.2 Collectivity of Production and Reception

A second distinguishing feature of the performing arts (again, not an essential characteristic, but one that almost always is to be reckoned with) is that usually more people are involved in the event – both on the production side and on the reception side. In contrast to the production process in the plastic arts, it is very rare that only one individual is responsible for the creation of an entire theatrical work of art. This collectivity in the production process leads to a situation where communication can take place at different levels between audience and 'the artist' in the performing arts. Traditionally the most prominent levels of communication are seen to derive from the leading players (or soloists, prima ballerinas), the director (choreographer, conductor) and the playwright (choreographer, composer). Of course one can identify a number of other theatre makers (dramaturges, designers, technicians, etc.) as well, but it is remarkable how often we find that theoretical studies point to (one or more of) the first named three as the possible 'authors' of, or individuals responsible for, a performance. Likewise, discussions on issues such as how to do justice to the intentions of a playwright (cf. the concept of 'werktreue'), who owns the copyright, or who should get the most publicity, almost always tend to focus on one (or more) of these three functions.

When we consider the matter of reception, it is safe to say that it is normally a collective experience in the performing arts - much more so than in the plastic arts or literature. The individuals watching a performance are (either consciously or unconsciously) subjected to certain processes deriving from the group dynamics whereby such entities as 'tonight's audience' are formed. The reactions of others are able to influence the individual spectator's reactions to a large extent. Of course it is certainly possible that other viewers may influence the individual viewer's experience and evaluation of the plastic arts - and therefore the apparent singularity of the performing arts in this regard is only marginally so – but everyday practice tends to demonstrate that there does seem to be a substantial difference. At any rate, a collective, often physical, display of emotion - such as a burst of laughter - is much more common in the theatre than in a museum.

A third characteristic stemming from the collectivity of production and reception is that the performing arts usually take place in a restricted space that encompasses both the artists and the audience. Although there have been instances where makers and spectators are in places far away from each other -only connected by auditory and/or visual (new) media[4]- these are rare exceptions. The same goes for experiments where actors or dancers are in different locations but nevertheless perform together in real time by means of digitally supported live interactivity – sometimes even in a 'second world' cyber space that only exists in electronic form (see for example Bajcsy et al. 2007). However, the usual manner for performing arts to be produced and enjoyed is within places where stage and stalls are combined: a theatre, a concert hall or a site-specific environment that nevertheless unites performers and onlookers.

3.3 Multimediality

This feature too is not exclusively found in the performing arts, although it is generally associated with this art form. Differentiating between the different sign systems that can play a part in performances and identifying their relevant codes and techniques is a (semiotic) endeavour that many theoreticians have embarked upon (for example: Kowzan 1975; Pfister 1977; Fischer-Lichte 1983 and Martin & Sauter 1995). However, a systematic enumeration of the different sign systems is not only a theoretical game, but often also forms the basis for performance analysis, in which the researcher tries to describe the way in which sign systems may at certain times be redundant, supplementary, or opposed to each other.

Indeed, various theatrical forms are differentiated by the specific (dominant) relations that the sign systems have to each other in each case. In dance, for example, prominence is given to music and movement, while linguistic signs are subordinate. In opera (sung) language is important, but often proxemic signs have a secondary role to play. Mime eschews language and (at times) music, but makes up for it by foregrounding proxemic and gestural signs. In all these cases however, we are dealing with a multiplicity of disciplines presented to, and interpreted by, the audience at the same time.

3.4 Ostension and Iconic Identity

It is generally recognized that theatre is a form of art that communicates mainly by means of ostension. The story on the stage is not told but shown and the audience looks directly at the action. Intervention from something like a narrator or 'painter' exists (i.e.: actors are not only characters but also artists that consciously construct their behaviour on stage), but is less visible and is often less consciously experienced by the spectator. One of the main reasons for this transparency of the narrating

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[4] Cf. for example the *Call Cutta* mobile phone theatre experiment by *Rimini Protokoll* (2005; cf. `http://www.rimini-protokoll.de/website/en/project_2766.html`) or in a more traditional vein productions that are streamed live to television or -a recent development- to movie theatre audiences.

instance in the theatre resides in the fact that the material signs that are used in the medium may be (and can be) identical to their referent. The table on stage is also a real table, the actor does not only *look like* a human being but he actually *is* one. The technical term for this phenomenon is 'iconic identity': elements from reality are placed within a theatrical frame where they refer to themselves in reality.[5]

This process -together with the simultaneity of production and reception- might be responsible for the fact that spectators experience a heightened sense of immediacy and realness that not only pervades theatre but also applies to the other performing arts.

All in all we can summarize the characteristics of the performing arts as follows:

- Collective endeavour
- Production and reception develop simultaneously
- Take place in an absolute here-and-now
- Local: in a restricted timespan and within a restricted 3-d space
- Dependent upon live performer(s)
- Multi medial
- Ostension: heightened sense of immediacy and 'realness'

4 Specific Problems with IT in Performing Arts Education

Having thus assessed the typical nature of the performing arts we can now begin to glimpse why the integration of IT within their education, training and study has experienced particular difficulties.

4.1 Multimediality

To begin with: for quite a number of educational purposes it is necessary to have reliable records of the performances. Although in the course of the 20th century the means to capture performances with the aid of film, video and digital cameras have seen a spectacular increase in the technical possibilities and their -democratic- availability, the use of these recordings within educational contexts have been hampered by either the cost/lack of appropriate playing devices and the problems to obtain the physical carriers (film reels, video tapes, etc.) or by the fact that it took relatively long for the bandwidth of computers/the internet to be able to handle multimedial products in a qualitatively acceptable manner. Streaming a theatre performance through a computer and interactively engaging students with tasks about that show is much more difficult than having a monochrome display with exercises where pupils have to fill in answers (words or figures) that, moreover, can be easily checked by the program. Besides: for a really good assessment and understanding of a performance the two-dimensional recording on a screen clearly has its drawbacks. Not only is the inherent 3-dimensionality lost, but also the fact that in attending a real life performance the spectator has freedom of focus can hardly be acknowledged by the mechanical

[5] Cf. Elam 1980. Also: it goes without saying that these elements from reality are three dimensional so that in the theatre we often see a combination of 2-d and 3-d elements; for example a painted backdrop together with real furniture.

camera. Either an overview of the whole stage is given or one zooms in on a particular actor, but by doing so one loses either the finer details of movement and expression or the overview of the ensemble within the whole stage picture - leave alone that the reactions of ones fellow spectators are left out. To be sure: there have been successful efforts to minimize this drawback (usually consisting of having more than one camera and then editing as to reflect what a 'natural' or 'ideal' spectator would look at) but for analytical purposes this may still be problematic and access to various 'tracks' by a number of cameras could very well be preferable – but this is by no means standard practice.

Working with multimedial performance recordings had another disadvantage for education that becomes apparent when we compare it to, for example, working with texts. Using IT to accommodate students and researchers with their analytical efforts was much earlier instigated for (digital) textual materials than for moving images. One has only to think of the ease with which texts can be annotated, automatically indexed or compared to other texts in order to realize that for analytical purposes of videos IT software seems to be still in its infancy. Only recently more powerful and flexible annotation tools based on timelines[6], on hotspots or on overlays[7] have been developed and are put on the market for reasonable prices or for free (Figs. 1 and 2). But automated indexing of a film or even making a shotlist still poses a number of problems – leave alone automatic recognition of similar scenes or shots from other film materials. No wonder then that educational programs concentrating on the texts of Shakespeare for example abound much more than those that confront students with contemporary audio-visual materials[8].

An interesting development in analysing performances is that digital recordings can be considered as data that can then be translated and transformed into new objects that visualize certain structural qualities of the original performance. This process and the ensuing results are illustrated in an exemplary way by the Synchronous Objects project (http://synchronousobjects.osu.edu/) in which the organizational structures found in William Forsythe's dance *One Flat Thing* are examined. The visualisations of this dance performance that was recorded by three cameras (fig. 3) draw on techniques from a variety of disciplines and algorithms. As such these transformations are able to lay bare the structural principles behind the performance in novel and often surprising ways – although it is not always immediately clear how scholarly analysis is furthered by them (fig. 4).

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[6] Such as Lignes de Temps (`http://www.iri.centrepompidou.fr/outils/lignes-de-temps/`) or ECLAP's own MyStoryPlayer (`http://www.eclap.eu/drupal/?q=en-US/node/3748`).

[7] For example: the annotation application that is being developed within the framework of the Transmedia Knowledge Base for contemporary dance project (TKB) of the Universidade Nova de Lisboa:
`http://citi.di.fct.unl.pt/project/project.php?id=89`

[8] Explore for example the Teaching Resources in the 'Teach and Learn' section of the Folger ShakespeareLibrary (`http://www.folger.edu/Content/Teach-and-Learn/Teaching-Resources/`) to discover how much of the educational materials are still text driven.

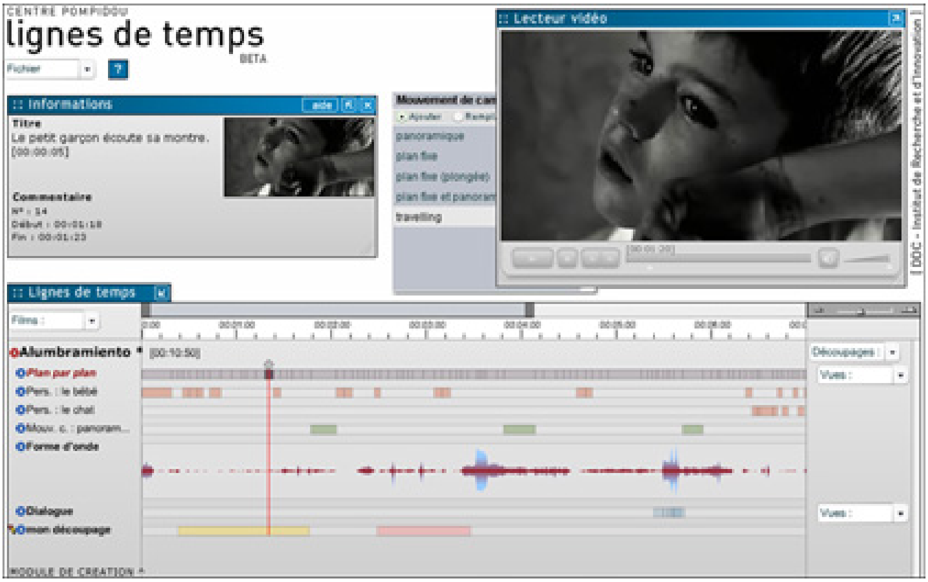

Fig. 1. Screenshot from annotation tool *Lignes de temps* (source: http://www.iri.centrepompidou.fr/en/)

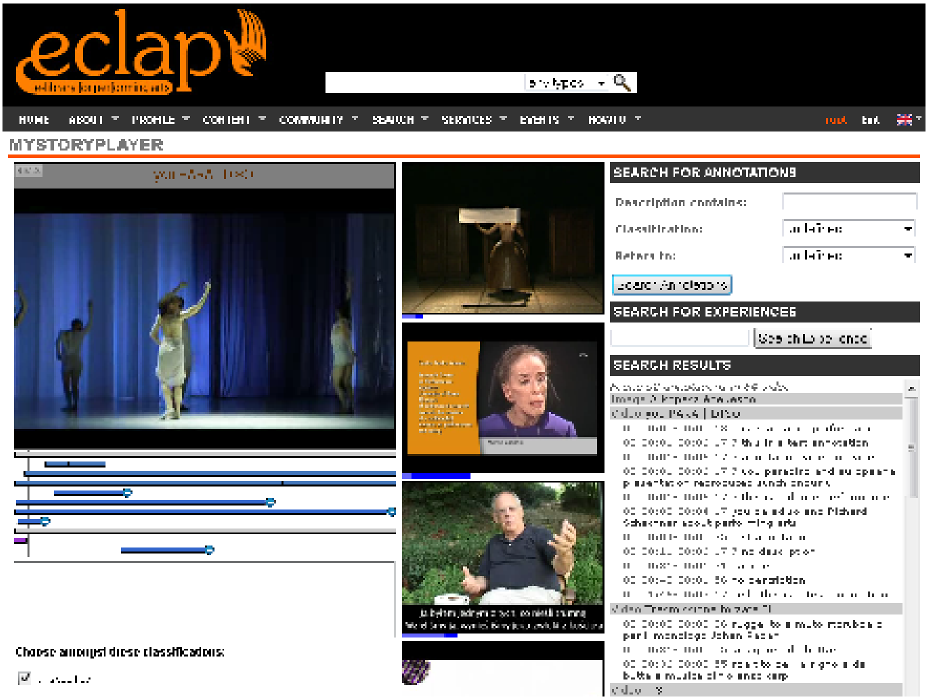

Fig. 2. Screenshot from annotation tool MyStoryPlayer (source: http://www.eclap.eu/drupal/?q=en-US/node/3748)

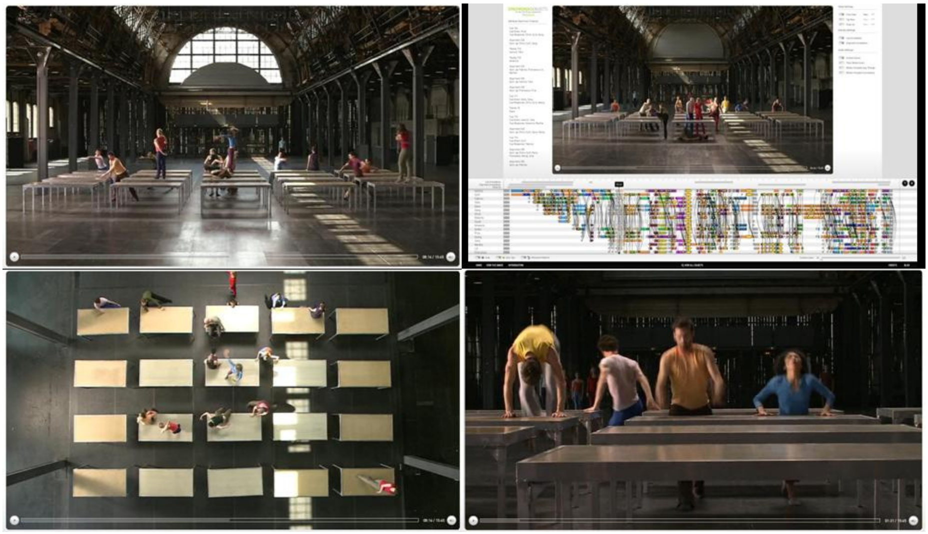

Fig. 3. Stills from *One Flat Thing*. Clockwise from top left: front camera, front camera with annotation, close-up camera, overhead camera (source: http://synchronousobjects.osu.edu/)

Fig. 4. Four of the nineteen visualizations of *One Flat Thing*. Clockwise from top left: 3d AlignmentForms, MovementDensity, DifferenceForms, StatisticalCounterpoint (source: http://synchronousobjects.osu.edu/)

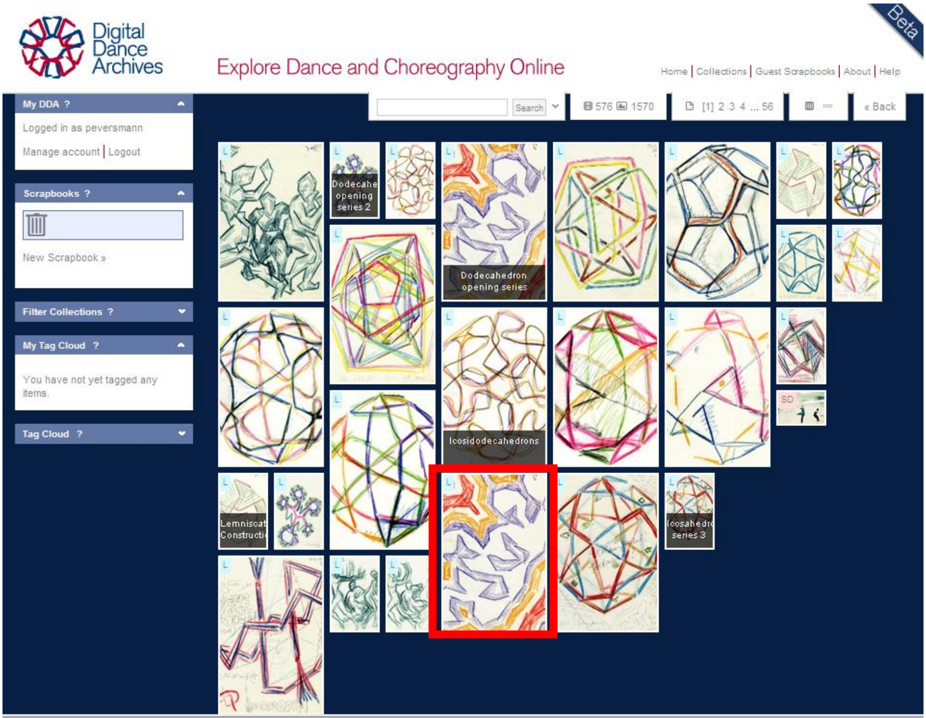

Fig. 5. Result of a visual search in the Digital Dance Archives. The original image from which the search was started is outlined in red. (source: http://www.dance-archives.ac.uk/index.php)

Where the tools that can assist with the annotation and analysis of individual performances are slowly becoming available, also dealing with the 'intertextuality' of performance arts is a problem that is only recently being attacked. Visual recognition programs allow researchers to search archives or the internet for similar images[9] (fig. 5) - although to my knowledge similar 'sequences' of videos still poses near insurmountable problems. Another approach whereby the software relies on numbers of users to suggest alternative and/or related materials ('users who viewed this fragment also looked at …..') might also be helpful here and is becoming more and more commonplace. But again one should conclude that such algorithms were developed within other contexts and were adopted for the art worlds at a relatively late time.

4.2 The Absolute Here-and-Now

The fact that performing arts always take place in the absolute here-and-now brings with it another set of problems hampering the integration of IT within education. To begin with this feature emphasizes the inherent 'locality' of performing arts – being

[9] The digital dance archives website (`http://www.dance-archives.ac.uk/index.php`) provides a beta version of such a 'visual search' feature where, after having selected a picture or part of it, one can then search for images with a similar color scheme or with a similar posture.

bound to a particular place and culture. For educational purposes this means that the preference of choice for a lot of the materials that one wants to confront students with are performances that they can assess directly – in a live situation within venues located in their immediate surroundings and in their native language. Videos from other cultures (or from the past!) risk the danger of being viewed as ‘alien’ and often need additional explanatory materials. Besides: especially in smaller (linguistic) regions there is a lack of resources to ensure that local performances are digitally recorded and made available to larger audiences. Performances that rely less on spoken language (dance, mime), tour globally (circus, opera) or are designed to be produced with a number of local casts (musicals) have an advantage, but even in these cases the use of their recordings in the classroom is often limited – precisely because the locality of theatre is stressed within the curricula.

A further particularity of the performing arts that ties in with their actuality and liveness lies with the artists themselves. With a lot of them there seems to be an innate distrust of recording their work and storing it in a public archive. The idea here is that the processual nature of their ever evolving career cannot be captured in fixed products. Or, as was related at a recent conference by Sarah Whatley about the attitude of the English choreographer Siobhan Davies: “she associates the archive with being put in a box, with definite labels and essentially with death!”[10] And it is telling that the archive of Davies’ work on the internet is not to be found under that name but rather as ‘SiobhanDaviesReplay.com’. Luckily such attitudes are no longer endorsed by a host of younger artists who are becoming more and more accustomed to archiving their work in digital portfolios (and who learn to do so as integral part of their training in theatre schools), but releasing the content of these personal archives to more public spaces in cyberspace where it is visible to the public eye is still a different matter…And this is especially true for content that is explicitly sought after in educational contexts – namely rehearsal material in which one can see and study the artistic process at work. A record of how a performance slowly takes form, with all the detours, trials and discarded errors is invaluable for the researcher who is interested in how a work evolved from its early beginnings, but only few of such records exist[11] and artists are often reluctant to show this delicate and in their eyes often embarrassing work in the rehearsal room – they rather expose their performances in the more or less definite form that was reached at opening night.

4.3 Collectivity

Yet a third set of problems pertaining to the integration of IT in performing arts education is encountered when one considers the collectivity of production and reception

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[10] Sarah Whatley at the ‘Symposium On New Ideas for Dance Archives’ – a Labo21 event held in Amsterdam, the Netherlands on 24-11-2012 (cf. `http://www.labo21.eu/ICKAmsterdam`); paraphrase by the author.

[11] A notable exception is given by the Siobhan Davies Replay website (`http://www.siobhandaviesreplay.com/index.php`) which lists as one of its main features “Filmed records of choreographies, in performance and in the studio, including rehearsal 'scratch tapes' where reproduction permission has been obtained”. Especially interesting in this respect are the so called 'Kitchens' of Bird Song and Plain Clothes which provide presentations that include a multitude of materials pertaining to the creation of these works.

that is so characteristic of the performing arts. To begin with one has to realize that on the recording side the reactions of audiences are often neglected. The tendency is to focus on the performance itself as the work of art, thereby ‘forgetting’ half of the theatrical event – at least when one defines performance as the interaction between presenters and onlookers. Of course this is a problem that is not new, but the possibilities offered by the new media to systematically collect and expose demographic data and/or the reactions of spectators to a show are scarcely used by theatre companies and venues and even then they often do not find their way into the archives. In this respect researchers are still dependent upon the more official reviews in newspapers and journals in order to assess some of the public acclaim or disclaim of theatrical shows and by far not all archives that collect performances complement them with (links to) press reactions or audience surveys (if these are available). It is for example one of the severe drawbacks of the ubiquitous You-Tube performance recordings - next to the often somewhat unreliable metadata- that are nevertheless widely used in performing arts education. However, this is a situation that researchers and students are accustomed to and there are ways to at least partly overcome these problems – especially with the modern day search engines and with newspapers and journals going digital and becoming digitized retrospectively at quite an astonishing rate. A much more troublesome problem in connection with collectivity is the intellectual property rights one. The fact that performances are collective efforts means that in principle all creative co-workers have to give permission in order for recordings of these performances to be put online. So it are not only the director and the principle actors that should consent to worldwide public viewing, but in principle also all other actors and dancers, the lighting, costume and set designers, the playwrights, the translators, the musicians, conductors and composers, the dramaturges, the producers and so on. Needless to say that obtaining permission from all these people -or from their agents or heirs!- is often a gigantic task that can severely frustrate and obstruct the efforts of archives and museums to put their performance materials online. It is much easier to do this when only one artist is involved or when the art works are more than hundred years old, but for contemporary performances that are so important for educational purposes this is really a drag and audio-visual material of over a hundred years old is scarce and far between…. To be sure: it is a somewhat different matter when archives could be ascertained that their materials online would be only used within a restricted educational context and not for commercial use, but present day technology makes this demand very volatile. Hence there is a clear trend of internet publishers offering performance materials to be used in the classroom for a subscription fee (see for example: the *Routledge Performance Archive* or *Digital Theatre*[12]), but it remains questionable whether smaller schools and universities possess the means to afford these.

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[12] The Routledge Performance Archive (`http://www.routledgeperformancearchive.com/`) offers institutional subscriptions only. It’s online collection has been created in association with Digital Theatre (`http://www.digitaltheatre.com/home`) where individuals can download or rent performance recordings from a host of British theatre companies. The latter also provides subscriptions for Digital Theatre Plus (`http://www.digitaltheatreplus.com/`) - designed especially for students and educators and providing educational material next to the performance videos. .

4.4 The Computer as Teacher

The above paragraphs discussed IT problems in relation to performing arts characteristics and education. However, one should also consider at least two areas within education itself that present huge problems to IT programs, namely teaching and assessing creativity on the one hand and physical skills on the other. It is easy to see that both areas are important for education in the performing arts. The former for the artists as well as for the more ‘passive’ or ‘academic’ researchers, the latter for the practitioners that need to acquire physical skills. Where in some other areas teachers can be replaced with simulations that can teach students to behave in a certain way – and can assess their performance and give feedback on it – this is impossible for areas where creativity is involved as one of the main components to be mastered. For example: students of medicine can learn to perform operations on screen, whereby the computer tells them how they are doing and whether the patient will live or die[13]. Likewise computer programs can teach mechanics the steps they have to go through when diagnosing failures with a car engine. However, it is infinitely more problematic to develop algorithms that enable computers to give meaningful feedback on a set design for the Hamlet, on the argumentation that is used in the review of a performance or on the creative solutions involved in an essay comparing the work of two directors. For all these tasks and educational exercises the interference of a human agent -the teacher of flesh and blood- is (still?) an absolute necessity[14]. The same is true, to a certain extent, for physical skills that have to be mastered by performing arts students involved in practical work. A computer might be able to function as a mechanical teacher for a beginning student wanting to learn how to play the piano or how to perform certain dance steps, but if one reaches higher levels where interpretation and personal expression are required human feedback is indispensable. To be sure, this might be greatly helped by giving students insight in their own functioning through the means of recording their effort and throwing it back at them so they can see or hear where improvement is still needed, but such procedures are educational tools and cannot be confused with teaching itself. Besides, here again other fields with much higher financial stakes and with much greater resources but depending less on creativity, such as sports, have preceded the performing arts in introducing these methods as a matter of fact in their training schemes (compare for example the use of video analysis in speed skating, golf, etc.).

Another interesting development within this area is given by the emergence of live interactive creative tools and agents that allow performing arts students to interact with artificially intelligent entities – such as virtual theatrical characters. The research is aiming to, for example, “create intelligent, interactive characters for storytelling,

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[13] A comprehensive overview of medical simulation in medical education is given by: `https://www.aamc.org/download/259760/data/medicalsimulationinmedicaleducationanaamcsurvey.pdf`

[14] Of course this is not to say that the teacher has to be actually present in the same space: telecommunication possibilities make it possible to interact live with ones students from large distances.

games, and Web-based worlds" or is trying to build "technology and art to create high-quality interactive drama. (…) they are interested in believable agents and computer-generated narrative".[15] However, at the present state it is hard to imagine these virtual characters as real teachers. At most they might function as partners in more or less improvised scenes (and this might lead students to reflect on their own behaviour and actions), but actual learning processes requiring personal feedback on creativity are something else.

5 Conclusion: IT Solutions for Performing Arts Education 2.0

Such an assessment of the major problems that integrating IT in performing arts education faces not only clarifies why the use of computers in this area lags behind compared to some other educational fields, but it can also help to get a clear perspective on the challenges, setting the agenda for future solutions. So in the following paragraphs we will take a look at what developments the digitally wired performing arts students and teachers of today and tomorrow would welcome.

5.1 Recordings, Portability and Annotations

First and foremost then is the demand for excellent multimedial recordings of (recent) performances that one can freely use and manipulate in an educational context. Playback of these recordings should be via streaming internet (and not be dependent upon cumbersome machinery such as dvd players) so that they can be viewed on laptops and other mobile devices outside the traditional classroom – in theatres, rehearsal studios, libraries and so on. Preferably these recordings should be embedded within contexts that provide extensive, reliable metadata and also easy access to other digital materials pertaining to the production, such as posters, reviews, photos, designs, rehearsal materials, drama text and so on. Ideally recordings should be made with multiple cameras (and then the material from all cameras should be available on request) or the quality should be such that one could zoom in at will in order to study the mimic of separate actors. And maybe a little bit further into the future full 3-d representations of performances should become the norm, but restrictions of computing power, bandwidth and costs make that outside some experiments the realization of this will be a dream for quite some years to come.[16] (fig. 6) Further one should realize that for educational purposes the recordings and other materials pertaining to performances should not only be viewed as mere illustrations but also have to be used as raw materials that have to be manipulated, re-used and re-contextualized by students and researchers. In order to do that it is important to have flexible tools that besides cutting and pasting will allow users to annotate video materials in an easy way – by drawing on overlays or inserting notes on multiple timelines.

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[15] Citations from `http://www.ksl.stanford.edu/projects/cait/othershows.html` that gives a short overview of projects in this research area.

[16] For a description of such a 3-d recording cf. Kuchelmeister 2009.

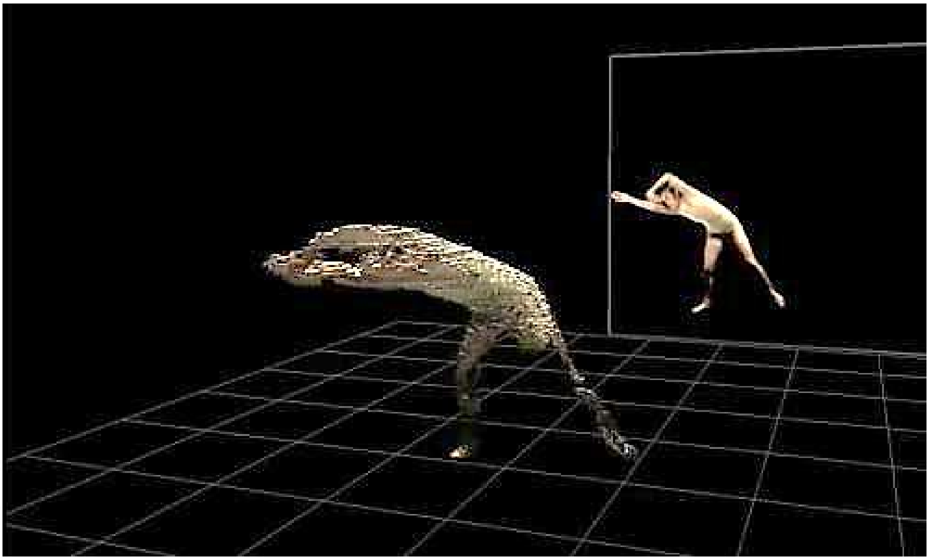

Fig. 6. Dance recording: composite Voxel visualisation with live action video in the background (monoscopic version) (source: http://www.kuchelmeister.net/prj_voxel.html)

5.2 'Smart' Programs

Other desiderata for software that come to mind have to do with smart search engines and with programs that can help with analyzing audio-visual materials. Basically digital archives should incorporate search strategies that can help researchers with finding what they look for in about the same way as an expert librarian would; thinking along with visitors who come in with a question, offering suggestions and -in the case of long standing customers- alerting them to new materials that they might be interested in. This is not to say that one would need a virtual librarian with which one can discuss things on the screen, but rather that even knowledgeable researchers who are familiar with advanced search strategies will be offered useful help. Also archives could try to build in a certain serendipity for their visitors enabling surprising insights and comparisons - for example by fostering visual recognition programs or 'other-users-also-were-interested-in' strategies. Finally the development of programs that can help with or automate certain analytical procedures (such as making shotlists, notate choreographies, visualize rhythms of speech, etc.) would provide welcome additions to the digital toolkit for students of the performing arts.

5.3 Visualisations

As to this latter area -the analysis of performances- it is my contention that visualisation or auditory techniques from other (scientific) disciplines might be able to provide new and possibly unexpected insights. The digitisation of performance recordings and other materials used in performing arts education means that these objects of interest are translated into binary data that in their turn can be transformed in all sorts of other visual or auditory objects. However, precisely which of these algorithms will help researchers with their enquiries is yet to be seen.

But visualisations can do more than help with analysing performances - they already play an important role in the education of practitioners in the performing arts and will continue to do so. Students of choreography, set- and lighting-design[17], directing and so on are using interactive modelling and simulations to give digital form to their creative ideas that are then assessed and discussed with their teachers. The more realistic and easy to use these programs will become, the more indispensable for training of young artists they will be.

All in all we should conclude that, although some characteristics of the performing arts are certainly not conducive for integrating IT in all areas of education in this field there are still a lot of possibilities to explore. Being aware of the limits set by the nature of performances and hav ing an idea of the ensuing needs of students and teachers in this field can however help in assessing the future steps to be taken and in not espousing unrealistic expectations.

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Dance in the World of Data and Objects

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Abstract. In this paper, we discuss the challenges that we have faced and the solutions we have identified so far in our currently on-going effort to design and develop a Dance Information System for archiving traditional dance, one of the most significant realms of intangible cultural heritage. Our approach is based on Description Logics and aims at representing dance moves in a way that is both machine readable and human understandable to support semantic search and movement analysis. For this purpose, we are inspired by similar efforts on other cultural heritage artifacts and propose to use an ontology on dance moves (DanceOWL) that is based on the Labanotation concepts. We are thus able to represent dance movement as a synthesis of structures and sequences at different levels of conceptual abstraction, which serve the needs of different potential users, e.g., dance analysts, cultural anthropologists. We explain the rationale of this methodology, taking into account the state of the art and comparing it with similar efforts that are also in progress, outlining the similarities and differences in our respective objectives and perspectives. Finally, we describe the status of our effort and discuss the steps we intend to take next as we proceed towards the original goal.

Keywords: Intangible Heritage, Semantic Web Technologies, Ontology, Dance Analysis, Labanotation, Performing Arts.

1 Introduction

Currently in Europe, significant projects are aiming at developing and bringing cut-edge information technologies to the area of digitization, archiving and dissemination of Cultural Heritage, e.g., Europeana [16], eClap [14] building communities e.g., eCultValue [15], and enhancing experience, e.g., CHESS [34] by combining expertise from both technical and humanities/creativity fields. Nevertheless, in many European countries with rich tangible and intangible cultural heritage, –despite the various significant, sporadic efforts in collecting the different tangible expressions of dance (such as text descriptions, audio testimonies, images, etc.)–, the exploitation of computer and web technologies in archiving, preserving and promoting dance tradition using a systematic framework, is making its first steps. The Greek Dance Pandect [35], which provides a website where the user can search for text, images, bibliography about traditional dance of the different regions of Greece, makes a good example of these efforts. Thrace Research Program [36] is another Greek initiative for

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collecting, studying and promoting music and dance tradition. The records are available online through a relational database system, so the registered user can browse and search the material which includes videos, images, text information and interviews with locals, lyrics, music and Labanotation scores. In the cases mentioned above, the user may browse and search the material by name, dance genre, region, type of record (video, image, text), but in no case can search by the dance movement and its characteristics, e.g., “dance extracts that include many deep bents of the knees, or very small, quick steps in the same direction”. The idea is to develop a human understandable and machine searchable “language” to transform the knowledge that one can find in the “black box” of a Labanotation score or other formal notation score, into a comprehensive format so that the created annotation can serve as an input for further automated analysis, similarity search, and alignment with other informal or style specific vocabularies. To explain why the term “black box” was used above for the score we mention the following: 1) Labanotation scores are closed to non-experts of this language and 2) the exchange of such files is limited to specific formats. There is only one widely used editor to digitally produce scores (LabanWriter), which is available only for Mac OS exports files only in image or codified non-human readable ascii formats [27]. LabanXML [26, 29] and MOVEMENTXML [21] were two examples of efforts towards moving Labanotation to a more human readable format. As early as almost ten years before (2004), at the international conference for exploring research and programming potential for Labanotation [24] the need of an "interlingua" to enable communication among the different technologies that existed was discussed. A good question, however, is why the proposals to move towards a more human readable file format, or any other “interlingua” have never been applied or further investigated since then, although the Labanotation community still raises the topic of the need for “open formats” [10, 39].

2 Related Work

The great choreographer Merce Cunningham [30] was one of the first to use computers in the choreographing process. Since then many others have followed, like William Forsythe [33], and Wayne McGregor [9]. Currently many choreographers (Bud Blumenthal [5], Siobhan Davies [31], Emio Greco [18, 23], Deborah Hay [28]) are collaborating with technology research teams to support the investigation of pioneering methods for capturing and documenting dance. These collaborations with projects such as Siobhan Davies Replay [31], Inside Movement Knowledge [23], and Motion Bank [28] are aiming at designing tailored methods to capture the individual dancing vocabulary of each creator, and document his “idiosyncratic vocabulary”, to use a term used by the Transmedia Knowledge Base TKB project team [37], during a process which can lead to new cognitive paths on movement perception. Dance Digital Archive [8] is another web platform collecting and organising dance material. One of its goals is to provide the user with a kind of personal digital notebook for “scoring” choreographies” and give the opportunity to access this material for further inspiration. A very interesting point about this project is the development of tools which allow the user to select a specific part of an image which depicts a body shape or a pose and search for “similar” material by image processing. What is common and worth to mention in all of the above projects is the following, first, the notion of "score" or "notation" is used in a wider, less formal manner. Score in these cases is no longer a formal script to be read and interpreted in a specific way, but a collection of an individual's material and ideas selected during the creating process. In addition this kind of scores are open to many different interpretations if "read" by another dancer or choreographer. The second interesting common point is that they are not focused on specific technologies or methodologies that are pre-decided, instead, they combine different media and approaches according to the needs of the documentation itself.

Nevertheless, many dance analysts, anthropologists, or dance therapists still prefer formal archiving methodologies expressed in standard languages like Laban Movement Analysis, and Labanotation, which provide a common vocabulary that enables communication among researchers for comparative analysis. Motion capture technologies, on the other hand, can generate 3D animation with extreme accuracy and can capture the 3D dimensionality of the motion [32]. Nevertheless, MoCap is not appropriate to capture the movement of an onstage performer or a dancer in real-life environment. For example, it is not the same to have a professional dancer or a student to wear the equipment and recreate the local dance, instead of the local person, if we need to capture a traditional dance for ethnochorological research, as there will occur many differences in the movement style and quality of the dance that will be captured. This is where video in combination with Labanotation or other formal movement analysis is far more useful. Moreover the motion data that is produced is not reflecting any conceptual model about the movement in a way the movement creator or analyst can perceive. Numeric expressions, physics equations, and data about joint rotations and positions, are of no help, unless they are annotated or indexed using an upper level of conceptualization, to extract similarity and common knowledge about the dance [2, 32].

3 Dance OWL in the "Dance Data" Ecosystem

In addition, videos are still the main carrier of dance digital content. They can be annotated or processed through image recognition to extract information on dance movement [5]. Many digital files for Labanotation or other scores, and verbal descriptions of the movement are available worldwide in printed or digital formats in different databases or small digital libraries. Although the collaboration of dance creators, archivists and ICT experts is young, usually hard in communication and probably immature, it is also of no question that different forms of "dance data" (and metadata) is created every day.

While working in building and enhancing the DanceOWL, there was the need to locate this approach on the map of current "dance data" ecosystem where inputs for storing and processing techniques and possible outputs of the different forms is depicted (Fig.1). Fact is that although there are some standard "input-processing-output" schemas e.g., from Motion Capture to 3D animation, from notation to 3D animation [38] or from video recording to annotation and abstract visualization, the different forms in this map are mostly ad-hoc solutions which lack communication with each other. The DanceOWL approach is working on bridging one of these links: "from Labanotation Scores to the concepts of DanceOWL", by representing the

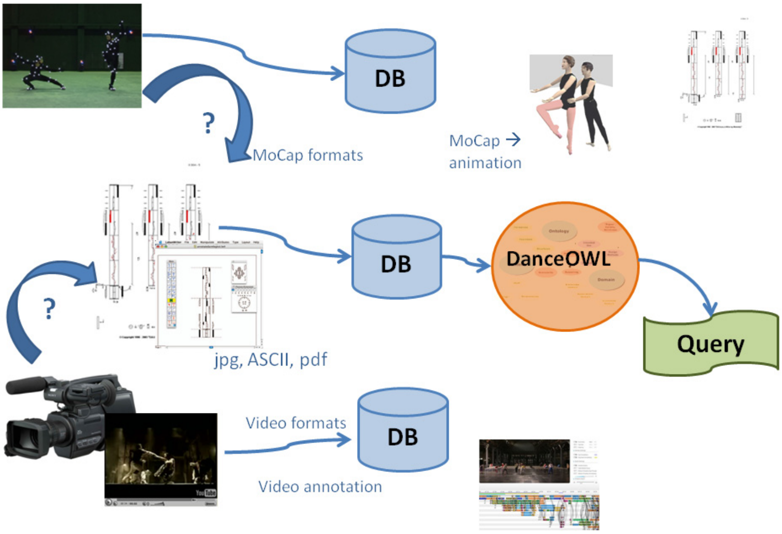

Fig. 1. The Dance Data Ecosystem

semantics of these symbols, to make this description of the movement, its characteristics and synchronization readable and searchable. At this point the user interface is not designed yet, but one can search by quering (using SPARQL) the ontology and experimental knowledge base, by posing questions like “Give me all dance expressions or extracts that are originated from Kastanies village and include a crossed arms hand grasp, or very small light steps”.

4 Ontology Based Data Modeling

Usually in other cases of IT solutions for Cultural Heritage or Digital Libraries, ontologies, as formal conseptualisation of a specific domain seems to give the answer to the different syntactic and semantic interoperability issues. Ceusters & Smith [6] state that ontology engineering can play a great role in making digital dance knowledge accessible, searchable and meaningful. As they consider videos to be the main form of “dance data”, they propose to have two ontologies: the first describing real world phenomena relevant for the domain of dancing and the second covering how these phenomena are exhibited in videos through image and sounds. This statement enforces the argument to distinguish between the act of dancing, the performance and the recording media, as when annotating a video about a dance we do not describe the dance we describe the video that records the dance. The creator of the file is the creator of the digitized or born digital media, but is not the creator of the dance or the movement.

In addition, the question that is going to be discussed later on is the following: can we say that any kind of these “data” is indeed a digital form of the dance itself, or all these are nothing but data related to dance? If the answer is the latter, and dance does not exist in any physical (or digital) form once the performance of it is over, maybe we should compromise with the idea that in the case human movement the best we can archive are metadata and related objects, and not the dance itself as a digital object.

As described above one of the aimed functionalities of the Knowledge Base is to query similar movement elements, motives or more complicated units within the different scores, but before searching for "similar" things we need to define what these things are. Of course this stands for any conceptual representation, but dance as been intangible has its own peculiarities. We stressed above on the importance of building bridges between one description, representation of dance to another, but this process is highly challenging, as we are not only translating from one language to another e.g., Labanotation to OWL, but in addition the referent is intangible, is movement.

In all kind of representations, we have the semantic triangle which was introduced by Ogden & Richards (1923) and depicts the relation of the Concept (Reference or Thought), the Object or Referent and the Symbol (Word or Lexeme in Linguistics, or Sign) and here is the tricky point when using any kind of language to describe dance: the object is not an object, is dancing, an act which after the performance, the end of dancing, is not there anymore. In Fig. 2.the relation between an extract of the Labanotation score is shown, in particular we have a Jump with preparation on both feet apart in low level, touch of both feet in low level in the air, and landing in both feet apart in low level, so in this case the reader interprets this as a "Jump" a concept referred to the "object" the act of jumping in this particular way. Here we need to stress that the concept "Jump" is not the word "Jump" itself (words are symbols as well), but is the concept, a general class of "jumping moves" one brings in mind when using the word jump or reads related score. If we take into account the different interpretation one can give to concepts, the use of words might be confusing, although unavoidable. For example S. Fdili Alaoui [18] uses the term "jumping" metaphorically to express one specific quality of movement in Emio Greco's dancing vocabulary. Therefore we have same word, but different concept.

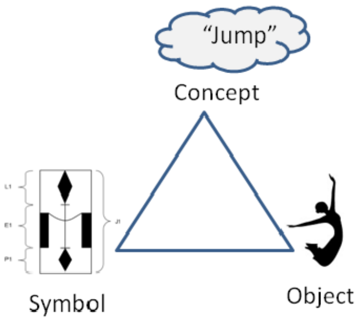

Fig. 2. The Labanotation triangle of meaning

We address this challenge by basing our model on the Labanotation system and its terminology, writing rules in Description Logics, otherwise a concept (or a Class in a an owl ontology) is not of clear "meaning". Even if we humans can understand the difference from the context, a machine cannot. For example, in DanceOWL the hierarchy of a Hop is as follows: *Movement hasSubClass Action, Action hasSubClassJump, Jump hasSubClassHop*

The definition of concept "Hop", in Description Logics, is the following

$$Hop \equiv Jump \sqcap ((\exists hasPreparation.SupportOnLeft \sqcap \exists hasLanding.SupportOnLeft) \sqcup (\exists hasPreparation.SupportOnRight \sqcap \exists hasLanding.SupportOnRight)).$$ [17]

So in DanceOWL, a Jump and its subclasses have specific semantics for the machine, which is also open to integration with other kind of vocabularies, if we of course formally describe their "meaning" in the same language. Coming back, however to the semantic triangle, no matter how well defined the concept will be, the object itself, i.e., the movement performed in the real world can vary if performed by different people, or even by the same person in different circumstances. We are aware of the fact that no matter how much detail one can add to a Labanotation score what he gets might be a detailed useful representation, but this is still a script [3, 13] about the choreography. It is not the performance, but only a description or a prescription of it. In addition, no matter how formal or consistent one wants to be in a translation, there is no guarantee that in the semantic triangle of these two languages changing from one symbol to another won't cause a small shift and that the alignment will be perfect, especially now that is about something that is difficult to talk about. Therefore I quote Z. Brown's comment [10] on Labanotation: "It's not a technically rigorous system. A lot of the ideas expressible in notation rely on subtle poetic interpretations. Often the meaning of a piece of notation can only be understood by asking, "what might the author have meant when they wrote this?". Well, this is true. This is why this translation is very challenging. On the other hand the goal of interpreting Labanotation into XML, RDF, OWL or any other semantic computer language is not to substitute the work of notators, and dance experts [3, 39], is to create tools that enhance and enable the communication between one form of digital dance descriptions and another [10]. Semantics about dance and human movement is not the meaning of the dance or the movement, is simply to add common knowledge on data that otherwise is not searchable or usable. It might be useful for a dance student to search for a specific dance motif, e.g., "right turn, fall, then jump" which is available in different dance extracts, although this "similarity, on the motif level does not mean that all the above dance extracts are the "same" or "similar". If one wants to go deeper in the similarity of these dance extracts he has to go for the context and the provenance of these dance extracts.

5 Modeling Dance: Existing Schemas for Performing Arts

At this point, we briefly discuss existing Cultural Heritage models, and their possible application in the field of Dance. Although the following models are created for Museum and Libraries, we examine these schemas as a Library shares the objective of our Knowledge Base to help user to *find*, *identify* and *obtain* [11] things. The CIDOC Conceptual Reference Model (CRM) [7] provides definitions and a formal structure to enhance interoperability between different data and metadata models in cultural heritage documentation. The FRBR model (Functional Requirements for Bibliographic Records) was designed as an entity-relationship model by a study group appointed by the International Federation ofLibrary Associations and Institutions (IFLA). The IFLA model distinguishes four level of abstraction from ideational content to the physical (or digital) item: The *Work*, the *Expression*, *Manifestation* and *Item*. Nevertheless, in the case of dance the realized and embodied "object" is the last thing one can have in hand: it is not an object such as a book or a file, it's an event. Here there is a kind of paradox when we try to apply this model on Dance, stemming of the fact that Manifestation is defined as "The physical embodiment of an Expression of a Work" [19]. If we want to be semantically correct, the embodiment of an Expression of a dance Work is the dancing process itself, the ephemeral phenomenon which happens in a specific time and place incorporated by the performers. The embodiment of an Expression of a Dance Work is not the prescription, neither the description, or the digital object that is created by the recording of using video, motion capture or other media.

The FRBRoo [20] is a formal ontology intended to capture and represent the underlying semantics of bibliographic information and to facilitate the integration, mediation, and interchange of bibliographic and museum information. FBRoo is the outcome of FRBR/CIDOC CRM Harmonisation. In 2008 M. Doerr and C.Bekiari [11], presented an FRBRoo for perforiming arts. FRBRoo declares therefore three classes: F20 Performance Work, F25 Performance Plan, and F31 Performance, interrelated as follows: F20 Performance Work R12 is realized in (realizes) F25 Performance Plan, and F31 Performance R25 performed (was performed in) F25 Performance Plan. In the case of theater as a form of performing art there is also the need to differentiate between Performance-Work e.g., Shakespeare's Hamlet, the Production and the Individual Performance, as C. Doty [12] states. Nevertheless, in the case of theater, especially if we talk about a famous classic written play, the script exists before any Performance Production or any Individual Performance in physical or digital forms (book, pdf, etc.). This is not the case with dance, which although it might have been documented using notation, usually one does not expect to have the movement of the Dance Work "written". Moreover, in most of the cases the Labanotation or other scores are created after or during the performance for documentation and archiving purposes. So score is rather a description not a prescription, which means that a score is more like a recording (F21Recording Work) rather than a script (F25 Performance Plan) [11]. Of course, any score which have been created as a F21 Recording Score can also serves later on as a F25 Performance Plan in performance reproduction from the score. In addition, the above discussion is meaningful in the case we are talking about *Dance Work(s)* e.g., Swan Lake where dance is considered a form of Performing Art, a subcategory of Performance Work, Nevertheless, another critical question is if the above vocabulary is appropriate to describe dance as a social phenomenon or a physical form of entertainment, therefore use these vocabularies to describe folklore, traditional or social and popular forms of dance. In common language usually we use simply the word "dances" to describe the different types of dance which have specific name e.g., jig, or mambo and specific "steps and variations", referring to specific Dance Types, or Dance Genres. Later on we will discuss the relation between the notion of "dances" with *Dance Type* and *Dance Record*, as represented in DanceOWL.

6 DanceOWL: The Dance Ontology

The DanceOWL is based on the concepts of Labanotation [22]. It is built to provide an expressive machine understandable schema to arrange formal and common knowledge about dance movement. The concepts of Labanotation about movement are used to translate original Labanotation scores into DanceOWL *Scores* to make them accessible, searchable and subject to further analysis and complex computational processing. The open world assumption of Description Logics fits perfectly to the domain of dance description, as our aim is not to provide a close template to define what dance is, but to build a core data model about the movement that is open to possible integration for different applications, e.g., video annotation, motion capture indexing or wikis enrichment for educational purposes

The ontology was engineered using OWL-2, within Protégé 4.1 which supports SHOIQ(D) expressivity, combined with Pellet reasoner which is capable for Sound and Complete Reasoning. SPARQL queries where executed within Eclipse framework for JAVA using JENA API. The current edition of DanceOWL, which is in progress and subject to continuous enhancements, consists of ~350concepts and rules, ~100 relationships , ~720 individuals (experimental data) and 4000 axioms.

The advantages of this approach are the following:

- *Reasoning & expression of complex rules*: As OWL is based on Description Logics, it provides a formal language to express complex inference rules and relationships, enhancing the expressivity of the knowledge-base. Reasoning capabilities support reuse of entities, and allow the system to infer new knowledge from the stored dance knowledge, e.g., a gesture is a movement, as being a subclass of the first.
- *Extensibility*: By using OWL, the knowledge model which is extensible and easy to be integrated with related knowledge, i.e., origin, history and music .
- *Searchability*: The Knowledge Base can easily searched by SPARQL queries or browsing within Protégé.
- *Movement Hierarchies:* The ontology allows to express movement categorisation , either by *Extension*, i.e., Step1 and Step2 isa Step Forward, or by *Intention* i.e., $Step \equiv Step \sqcap ((\exists\ hasDirection.Forward)$, therefore any Step which satisfies this condition is a StepForward.
- *Temporal Modeling*: In the DanceOWL time is represented in a similar way with Labanotation as it is expressed in measures, and beats. Movements are modeled as intervals and the synchronization of them is expressed with properties like

"hasNext", "isSimultaneous", ismetby" based on Allen's temporal relations of intervals [1].

- *Human Body Representation:* Based on the rich vocabulary and number of symbols that Labanotation offers a part of the ontology is dedicated to represent the Human Body and the relations between the various parts and perspectives i.e., joints, surfaces, points, areas.
- *Human Readability:* The terms that are used to describe the movements and their characteristics are simple words, based on the literature of Labanotation system. Although, someone can claim that someone has to be familiar with Laban Movement Analysis to fully comprehend the meaning of these terms, it is far more readable than an ascii file, or any other numeric expressions created by Motion Capture. Moreover, Laban Movement Analysis is an established system used worldwide since the 20's, supporting communications among movement analysts.

7 Modeling Movement: Linguistic Approaches

As also explained in detail in [17] the ontology expresses movement by Labanotation characteristics: Space (e.g., Level, Direction, Size), Time (e.g., ST01 hasNext ST02, ST01isDuring AG, ST01hasDuration Quaver), Body (e.g., Right Elbow, Upper Left Leg), Dynamics (e.g., Strong Accent, Tremolo), Effort (e.g., Flick, Float) and Type (e.g., Support, Turn, Relationship, Contraction). Nevertheless, when we talk about movement as spatiotemporal entity, or a specific activity, what's the "segment" we refer to? To this point we will introduce the dance- language analogy as it was presented by A.Kaeppler [25]. This analogy is in the terms that we can use the linguistic morphology analysis tools to study dance structures of a specific area or group of people, i.e., a dance genre's movement vocabulary. (Table 1)

What it is important in this segmentation technique of movement is that is based on what "makes sense" in a particular dance genre. For example if we consider Ballet a dance genre, one does not expect to find kinemata, i.e., movements of the pelvis in the scores of this genre, as they are not part of its movement vocabulary. This point brings to light the fact that dance segmentation is related to the knowledge of a specific language. For example, a ballet dancer can easily select a "pas de chat" on a Labanotation score and classify the symbols into a larger unit, because the "pas de chat" movement (or morphokine) makes sense to his dancing language. To this point, the DanceOWL serves as a dance genre independent "language" to describe the small simple movements and characteristics (at the level of elements or kinemata) in a way a score can do. Once the knowledge of the score, is inserted to the ontology, having the sequence and synchronization of these small movements, this knowledge can be subject to further analysis, by more complex temporal queries and aggregations. Nevertheless this analysis and search for larger movement units requires specific dance genre knowledge. Our future work includes the addition this kind of knowledge, starting with Greek dance expressions from Thrace.

Table 1. -Dance Language analogy

Language	*Kaeppler*	*IFMC*
Phoneme	Kineme	Element
Morpheme	Morphokine	Cell
Word	Motif	Motif
Language Clause		
Sentence	Phrase	Phrase
Larger Grammatical Unit	Larger Grammatical Phrases	MacroStructures
language or Language Genre	Dance Genre	Dance Type

In relation to Kaeppler's linguistic model, we would like to add, that the word *Dance* is not referring to dance as an art form in general, but to "a dance", a dancing language, genre or type which is danced in a studied area and era. This distinction between the notion of *Dance* as a general human cultural, physical and artistic phenomenon and dance genres (or "dances" in common language) is analogous to the distinction between *Language*, the general human capacity for acquiring and using complex systems of communication, and language(s) which is any specific example of such a system.

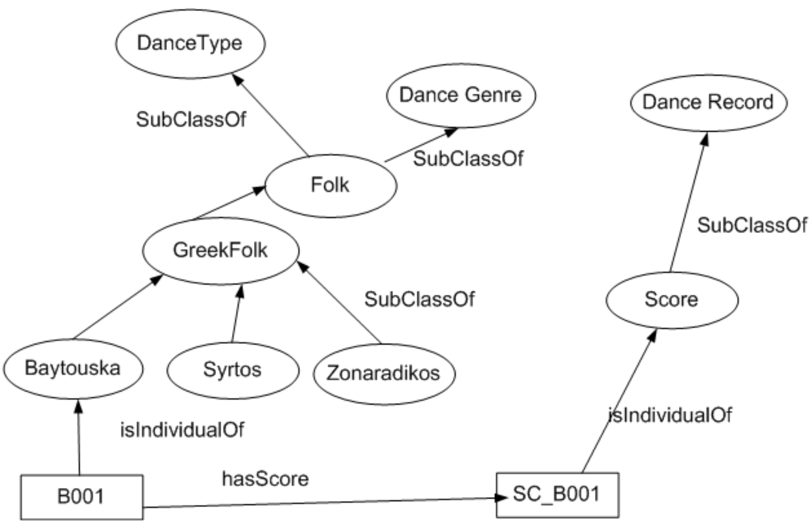

Fig. 3. Dance Type and Dance Record

Ceusters & Smith [6] state that if we want to "represent" dancing, we must have a good insight of what dancing is. In our previous paper [17] we presented a simple hierarchy under the notion "Dance". In fact what we were referring to with the word Dance was the Dance Type (IFMC) or the Dance Genre (A. Kaeppler) [25]. In the latest version of DanceOWL, the instances of this Dance Type Class are particular dance “expressions” of a very specific dance type which are scored, e.g., D001D isa (individualOf) GreekFolk as it was performed, recorded and scored at a very specific time and place, by specific people.

In the latest version of DanceOWL, Dance Genre or Dance Type is referring to the type of dance e.g., Ballet, Contemporary, Folk, Traditional, Greek Folk, etc. The subclasses of the Greek Folk help us represent a simple hierarchy. Example: "B001" is an (individualOf) Baytouska, Baytouska isa (SubClassOf) GreekFolk, GreekFolk isa (SubClassOf) Folk, Folk isa (SubClassOf) DanceType. In addition Folk hasOrigin some Region, and B001 hasScore SCB001 which is individualOf Score, which is SubClass of DanceRecord. So in this way: 1) we make clear that a scored extract e.g., B001 is not the dance type itself, but only one of many individuals of this dance type, an “expression” of it recorded in a specific place and time, and 2) we differentiate between the dance expression itself and the score which in this case is a type of Dance Record.

At this stage we are evaluating the ontology and experimenting with scores, from the repository of Thrace Dance. The interpretation of the scores is added manually according to the specifications –relations to Labanotation. These Labanotation scores are outcomes of anthropological onsite research and have been created onsite, after interviewing the local dancers. They represent different dance expressions of specific dance types and genres of Greek folk, e.g., the “Zonaradikos” dance. It is very important to test with such different expressions in order to later on find the similarities by comparing small amounts of dance reality provided that it is described in the same language (i.e., Labanotation) and by the same team with the same goals (in these case Thrace’s researchers).. The strength of a documentation tool lies on its ability to represent dance knowledge as it is coming from the creators of the movement or the analysts and not to provide a template on what a dance should be.

8 Conclusion

Since the nature of dance, either as a performing art form, a cultural, social phenomenon, or an entertainment physical activity, is an ephemeral event that exists once it is embodied by the dancers, we can only have tangible items which are related to the dance such as videos, descriptions, printed images, used objects and costumes scores and scripts about the movement in different forms. Nevertheless, “dance data”, including movement descriptions in a variety of forms and granularities are living and growing everyday in the web of things and objects, and recent research assesses the need for data models that are based on formal notation or other scripts, to exploit theoretical and practical dance knowledge. There is high need to organize data and make this knowledge accessible for further computational automated analysis and a basis for building user interfaces and tools for educational purposes [4], research or creative applications.

Having in mind that all notation are partial descriptions and that the different forms of movement descriptions are complementary, we took advantage of the semantic web technologies, to build an extensible data model that can be easily related to other similar models e.g., idiosyncratic vocabularies or history of the dance.

The contribution of this work is making movements of choreographies and dance extracts searchable in different granularities, in a machine understandable way while using terms that have meaning for the user. By developing a core model, based on a formal language such as Labanotation, we are aiming at putting another piece in the puzzle of dance knowledge which is available online in various forms. We envision a future where the dance related knowledge will be interlinked, machine understandable, human accessible and searchable by all users.

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The TKB Project: Creative Technologies for Performance Composition, Analysis and Documentation

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Abstract. This paper describes the TKB project (A Transmedia Knowledge-Base for the performing arts), an international research project running in Portugal since 2009 at the New University of Lisbon. While focusing on the development of a digital note-book for video annotation in real-time, designated as Creation-Tool[1] we will describe two original software applications developed in the framework of this project: a video annotator designed as a digital note-book for real time composition processes; and an archival platform towards an open and collaborative Knowledge-Base for the documentation of performing arts.

We will also explain the collaboration process between choreographers, linguists and software programmers during the iterative design and test phases of the annotation-tool.

By trying to converge methodologies from Cognitive Linguistics, New Media and performance studies, thus attempting to achieve a rich interdisciplinary dialogue, we show how video annotation practices, using both verbal language, and touch-pen drawings or customizable marks over the videos, contribute significantly to analytical processes of performing arts creations and to their documentation and transmission.

Keywords: New Digital Media, Multimodal Video Annotation, Performance Composition, Documentation of performing arts, Cognitive Linguistics.

1 The TKB Project

The TKB project aims at the design and construction of an open-ended multimodal knowledge base to dynamically document, structure, annotate and browse a range of recently created digital dance pieces. It offers above all a transdisciplinary university-based structure for reflection on new original documentation models for contemporary choreography and performance.

The TKB research project was conceived by Carla Fernandes at UNL-FCSH as a follow-up of the previously gained experience with the cognitive-semiotic analysis of Rui Horta's piece SetUp[2] in the framework of a Post-Doctoral research project. TKB is currently running under her own coordination with the invaluable collaboration of

[1] The Creation-Tool has been originally conceived by Carla Fernandes and Nuno Correia, designed by Urandia Aragão and programmed by João Gaspar with the support of Diogo Cabral and João Silva. Acknowledgements are due to all of them.

[2] cf. Fernandes, C. & Costa, R. (2010).

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several international research partners and consultants, namely: Universidade Nova de Lisboa: Faculty of Social and Human Sciences (FCSH - Linguistics Centre), where it is based, and Faculty of Science and Technology (IMG - Department of Computer Science, with Nuno Correia); Universidade do Porto (CLUP – Linguistics Centre, with Isabel Rodrigues); Espaço do Tempo (Rui Horta's Choreographic Centre in Montemor-o-Novo); University of Amsterdam – AHK (with Bertha Bermudez); Coventry University (with Sarah Whatley, Director of Siobhan Davies Archive) and Scott DeLahunta (Director of "Motion bank" at the Forsythe Foundation);

It situates itself in a hybrid territory between cognitive linguistics, dance research and new media technologies. Its initial motivation and start-up questions have been the following:

- How is a choreographer's imagetic and metaphoric type of thought translated into words during the communication with the dancers and further embodied into motion by them?
- Can choreography be interpreted as thoughts in motion?
- What is the impact of verbal language over the dancers' movements in the case of a more theatrical dance as is the case of the recent pieces by Rui Horta?

The global purpose of TKB is to extend the scope and application of the "documentation" concept to contemporary dance in different ways. It aims at developing a strong link between the recent dance-research community and the well-established communities in cognitive linguistics (since Lakoff & Johnson 1980) and computer science, by taking a closer look at the cognitive process of "choreographic thinking" (Stevens & McKechnie 2005) and therefore contribute to the domains of multimodal corpora (Kipp 2008), terminological ontologies, cognition and verbal-nonverbal relations.

The Knowledge-Base, to be launched online in 2013, includes three complementary components:

1 – The verbal annotation, by a research team of linguists, of three contemporary dance pieces by Rui Horta as a case-study, making use of the ELAN software to synchronize the videos with verbal annotations.

2 – A Creation-Tool: an original software application developed inside the project, to work as a digital note-book for video annotation in real-time, designed to support the needs of choreographers during their creative processes.

3 – The design and development of the first web-based archival platform for the performing arts in Portugal.

The motivation for this third component has started with a very first attempt to identify, analyse and systematically organize Rui Horta's choreographic signature (celebrating a 30 year-career as one of the most internationally renowned Portuguese choreographer) as a pioneering contribution to fill in a currently much felt gap in Portugal regarding the generally scarce documentation initiatives around what is called the Portuguese "Nova dança" (New dance), an artistic movement started in the 80's. The national Arts General-Directorate or the several dance-related structures have not as yet been able to start compiling a digital archive that could map and work as a hub or anchoring tool to document the extremely rich variety of choreographic styles and lexicons created in Portugal in the last three decades. Rui Horta has been our first case-study and he has therefore accepted to see his more recent work linguistically categorized, digitally annotated and indexed as an example of what we hope can become a long and regular series of future case studies in the same line, as a possible way of illustrating the young history of contemporary dance in Portugal.

For the purposes of this paper, we will focus on the software applications developed during the project, corresponding to the second and third components referred above: the Creation-Tool design and development processes, for which choreographers Rui Horta and Stephan Jürgens have decisively contributed, and the Knowledge-Base in general. However, since all the three components are closely articulated and indeed complementary, we will necessarily refer to and briefly explain the previous annotation process with ELAN as well as to the intentions and aims of the future online archive.

2 Theoretical Background

For the linguistic analysis of the video material from Rui Horta´s rehearsals and his finished pieces, the theoretical framework we have adopted contemplates studies on Multimodal Metaphor (Forceville 2006; Müller & Chienki 2009) and Dynamic Multimodal Communication (Müller et al. (eds) 2012), which brings together a cognitive linguistic view on speech and gestures and a media studies take on moving images. DMC regards the intertwining of audio and visual modalities in terms of temporally organized (i.e. dynamic) processes orchestrating meaning, cognition, and emotion.

Building on the differences between Conventional metaphors vs. Idiosyncratic ones (Müller & Chienki 2009), we have dealt with metaphors in the artistic narrative of contemporary dance, while attempting to describe the more recurrent metaphors encountered in the rehearsal videos (e.g. *life as a journey; life as a stage; love as war; body as territory/geographic map; emotions as forces; control as up; weakness as down; communication as a conduit*).

Departing from the tenet that "metaphor is not a figure of speech, but a mode of thought" (Lakoff 1993: 210) and therefore understanding that metaphor does occur in other modes than language alone, we frame our analysis of metaphors in dance within the findings of Multimodal Metaphor theory as presented in Forceville & Urios-Aparisi (2009). We suggest that conceptual metaphors find expression in the dance movements themselves, and indeed in some visual signs used by the choreographer, in ways that are not always translatable into language, and therefore may be taken as "direct" manifestations of those conceptual metaphors, unmediated by language.

However, and in line with the basic cognitive linguistics principles, we assume that language and attention are inextricably related and that the components of awareness and attention influence language structure and use in the same way they influence perception and sensation. Language, like perception, is a way of organizing what someone wants themselves or others to pay attention to. Linguistic constructions are not just empty syntactic vessels, but instructions for making something stand out as figure against a less differentiated ground.

From the choreographer‘s perspective this collaborative research can be situated in a field that Lycouris (2010) has recently called 'Interdisciplinary choreography‘ to integrate the work with several new technologies requiring an intense transdisciplinary dialogue between team members. Nigten‘s (2006) ‘Processpatching‘ methodology resonates with this approach as it originated from the close collaboration with digital artists and performers.

3 The Collaborative Work of a Research Team with a Choreographer

The up-to-now achievements of the TKB project have been the result of an inspiring collaborative process between choreographers, linguists, graphic designers and software programmers.

Our research material for Rui Horta’s case-study was filmed during his most recent creation processes, namely during his pieces *SetUp, Lágrimas de Saladino* and *Local Geographic*, produced between 2006 and 2011.

Since the very beginning, when we started the shootings of SetUp, we have had the privilege of counting with Rui Horta’s support for all kinds of prior knowledge that would not available to the general public (his private portfolios describing the piece, his texts, notes and script-boards). We were attending the rehearsals since the first day, together with the interpreters, on a 3 day-week regular basis and were allowed to film their work until the day of each première.

Although we have only been able to use a single camera, we have repeated the same shooting routine during the rehearsal periods of the other two subsequent pieces, having compiled a multimodal corpus of ca. 80 hours of manually annotated material from rehearsal videos and finished pieces presented on stage.

We have also filmed several hours of conversations between Rui and the dancers, as well as direct interviews with him.

During the linguistic annotation process on ELAN, Rui has regularly validated our choice of terms, concepts and categories of analysis, in a similar way as terminologists normally do with experts.

Throughout our close collaboration during the extremely time-consuming process of verbally annotating his pieces (often frame by frame) Rui has often been consulted by us to suggest ideas that could feed our original intention of building a TKB Creation-Tool (much more user-friendly than the video annotation software we were then using) to assist choreographers during compositional processes. His interest and enthusiasm with the first design sketches of the Creation-Tool have led us to change, improve and create many of the now operational functionalities of the CT.

As soon as the first version of the CT prototype was ready, Rui has been regularly invited to test the application in real-time, which has been fundamental for the iterative process of its design: he would advise us regarding the need for annotation marks and icons, for instance, or the need for a “delayed” annotation mode, amongst numerous other specificities of the tool that can indeed only be detected by the experts themselves in their work-specific situations.

Stephan Jürgens has then started to test the CT as the second invited choreographer, as will be described in the section “The TKB Creation Tool”.

Regarding the video annotation of Rui Horta's pieces, while the Creation-Tool was still not ready to use, we have used ELAN, a software normally used for studies on conversational analysis and which we have adapted to the analysis of the full body performance and of all the scenic elements occurring in the dance pieces.

There were two moments of research and analysis:

1. definition of the controlled vocabulary for the annotation of the several tiers (term used in ELAN for the identification of the categories for analysis) + identification and analysis of multimodal metaphors ;
2. annotation of the interaction between the interpreters and between their speech and respective gestures and body movements (regarding above all the proxemics phenomena. i.e. the spatial relations created amongst speakers and their interlocutors).

The annotation team (two Professors, Fernandes and Rodrigues, and two grantees, Evi Dimakopoulou and David Santos) have identified and categorized, with the choreographer's validation, the following units in a top-down approach: 22 main Sections, indexed with Horta's respective designations (to give just some examples: the spectator's eye / the audience face to face / creation of tension, a.o.) and sub-divided into Scenes (eg. curtains open and instructions are displayed on a stage digital screen / the spectators pick up their own chairs, a.o.).

The complete list of inter-dependent tiers (categories analysed) is the following:

Key themes
Sections
Scenes
Conceptual Metaphors
Emotions
Scenic Elements: music; songs; sounds; multimedia resources; props; costumes; lights; Stage design.
Body Actions
Body micro-analysis
Speech
Turn taking
Recurrences (repetitions/patterns)
Interaction between performers
Interaction between performers and audience

After such a detailed analysis, several interpretations and conclusions could be derived from the annotated multimodal data. We have found out, for instance, that multimodal metaphors are not linear; on the contrary, they unfold in time, sometimes across rather long sequences of action. In other words, an underlying conceptual metaphor such as "Argument as war" ("war" being the source domain to which "argument", the target domain, will be compared to) will only unfold and therefore become perceptible to the spectator after several different scenes, body actions, scenic elements and multimedia resources have been used: in the beginning of the scene three men are arguing, then they start hitting each other and one of them is badly injured; this man, wearing a military t-shirt, is carried on the shoulder of the strongest one, as if he was a wounded soldier (therefore triggering our imaginary of the war movies). When he is placed lying down on the stage, he seems to die; at this moment, a chair disintegrating into pieces as if it were a bomb exploding is projected on the stage screen. It is only at this point that the metaphor becomes complete, in a rather different way than the linear counterpoint of the verbal metaphor per se. (from the annotation of *SetUp*)

The second moment of linguistic analysis, which we have called the "microscopic" analysis (up to the video frame detail of 25 per second) was undergone by our partner Isabel Rodrigues and the grantee student allocated to the Linguistics Centre of Universidade do Porto.

This analysis has focused on the positioning of the dancers in space and the enactment of interpersonal relations in face-to-face interactions. These have been seen by Rodrigues (cf. Fernandes, C. 2012, forthcoming) as icons for dimensions like "myself and the other", "freedom and attachment". This aspect is directly related to the main theme of the performance: a criticism to the lack of true communication between men in our present society as well as a cry for space for freedom and for singularity (uniqueness) in the standardized society. The creation of personal or intimate spaces, interactional spaces, as well as external spaces play an important role in the transmission of this message.

The positioning of interacting people in space has been the object of research of some scholars, such as Hall (1969) and Kendon (1990), more recently Haviland (2000), Özyürek (2002) and Sweetser/Sizemore (2006). Kendon (1990) observed the occupation of space in multiparty conversations in time and describes the way participants adjust their positions in relation to each other during face-to-face interactions.

The different kinds of spaces created by the dancers, the way they approach or move away from each other, as well as the orientation of their bodies and faces toward or away from each other has been analyzed and annotated in ELAN. Concepts like Kendon's face-address system, or different classifications from other authors for "personal space, gesture space and interactional space" constitute the theoretical background for the description of the relation between body movements, speech and positioning in space. These have been annotated in regard to the way they express interpersonal relations and emotions.

The objective of this microscopic analysis was to find out how the choreographer unconsciously uses proxemics to express abstractions like freedom, the standardized society, and the relations between the single and the group.

Since the very beginning, we were led to question the terms and expressions we should use to describe and index dance sequences or other scenic elements, since they would most probably not reflect a common "shared meaning", unless the public were to have enough prior knowledge of this choreographer's lexicon and grammar. Although it is the case that in the "language" of contemporary dance there is not necessarily a predetermined search for linguistic meaning representation, both verbal and mentally structuring metaphors are unavoidably subjacent in any creative performance and therefore they can be deconstructed for the purposes of analysis and documentation of performance composition.

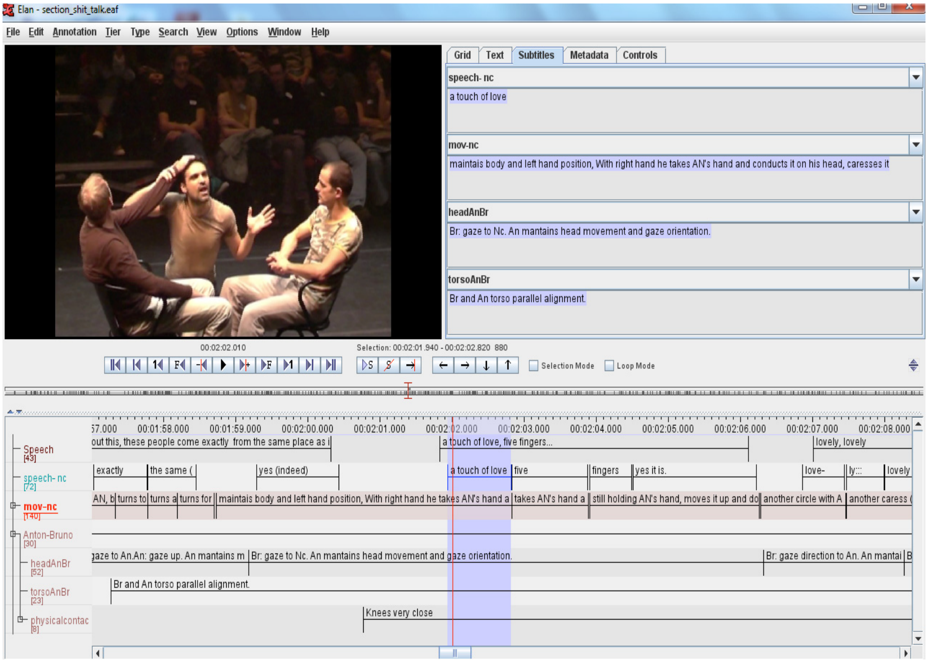

Fig. 1. an excerpt from the video annotation on ELAN (SetUp 2006, Rui Horta)

4 Relevance of the Annotations for the Knowledge-Base

The TKB web-based archival platform can be seen as an attempt to create a new paradigm for the documentation of performing arts. By being an Art&Science project, it tries to combine the experience insights of contemporary creators with scientific theories from cognitive linguistics and new media studies in order to come to an original model of visualization and dissemination of performing arts productions, where the conceptual principles of each artist are central for a dynamic archive's structure and indexation.

The archival collaborative platform will contain video materials from all the interested choreographers showing interest in this initiative, annotated or not, according to their own intentions.

In the case where a previous collaboration exists between an artist and our team, the videos may have been annotated and indexed by the researchers or annotated by the artist himself, making use of the Creation-Tool.

The basic principle of the Knowledge-Base is that not only the complete staged pieces will be available for online browsing, but also the videos of the respective creative processes, whenever that is possible. In such cases, the videos will be displayed together with the corresponding annotations that have been made either with ELAN (by the research team until now) or with the Creation-Tool, by the artists themselves.

All the annotated videos will be retrievable in the archival platform in a relational manner via their key-words and/or concepts serving as tags. We believe this can be interesting both for the artists (who will be able to see their work linked to their peers) and for the external user, in a didactic or research manner.

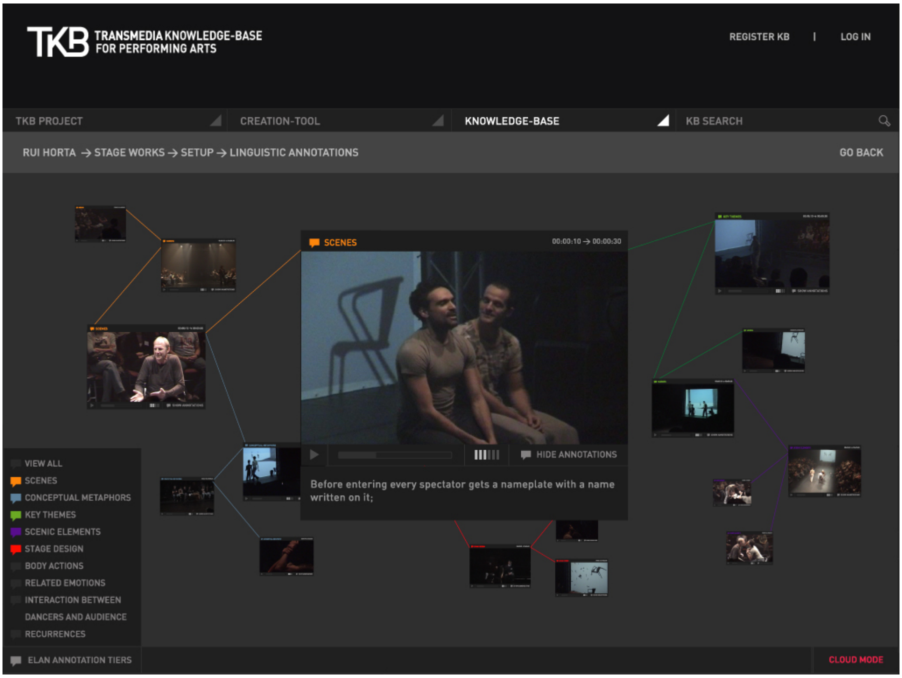

Fig. 2. Interface design of the TKB web-based archive showing its relational dimension (by Urândia Aragão)

Fig. 3. Example of how the search menu will look like in the Knowledge-Base

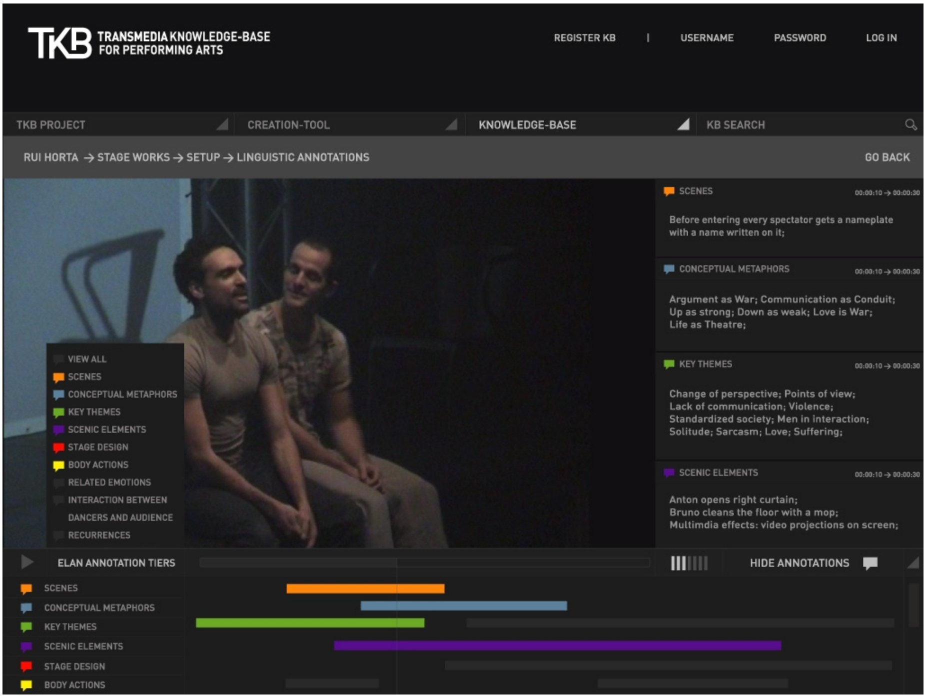

Fig. 4. Interface for browsing the annotated videos in the archive: the color code identifies the different categories analyzed

5 The TKB Creation Tool

The Creation-Tool, pictured in Figure 5, has been developed as a digital notebook that enables choreographers to annotate dance performances and rehearsals, thus allowing them to make their choreographic ideas more accessible, both to performers and to other choreographers.

This video annotator has been iteratively designed and developed between May 2010 and March 2012 by three grantees at the FCT/UNL under the supervision of Nuno Correia. It has regularly been tested in several LABs-in-residence and hands_on Labs of the TKB project[3] by choreographers Rui Horta and Stephan Jürgens and by a group of 12 professional dancers undergoing an MA course on Creativity and Choreography at Fórum Dança, Lisbon (cf. Diogo et al. 2012: an ACM-published paper on the evaluation of the tool).

The Creation Tool enables its users to annotate video with text, hyperlinks, audio notes, pen-based notes, and special user-configurable marks, all running on a Tablet.

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[3] More info at: `http://tkb.fcsh.unl.pt/tkb-labs`: accessed January 2013.

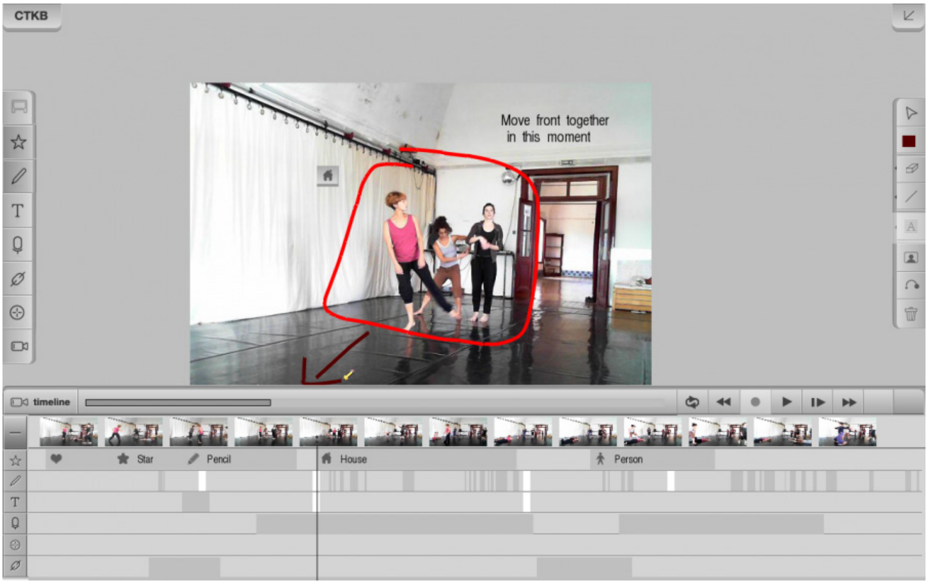

Fig. 5. Interface of the "Creation-Tool": real-time annotations drawn with touch-pen

The tool also presents two modes of video visualization: real-time mode, which is synchronized with the live event, and delayed mode, which displays the video with a small time delay. This application currently runs in a Lenovo X220 Tablet, with a 64-bit, 2.5 GHz Intel Core i5-2520M processor, with 4 GB of RAM. Since this tablet does not have a backward-facing camera, our current solution for mobility is to use a 720p HD camera with 360-degree rotation, which we have attached to the Tablet. This camera is a Microsoft LifeCam HD-6000.

The contribution and feed-back of both Rui Horta and Stephan Jürgens for the successful development of the current application has been of fundamental importance throughout the project.

Jürgens has been working for the past fifteen years on the integration of new media technologies in his choreographic projects, and situates his artistic research and work in the field of interdisciplinary choreography and digital live performance. Collaborating on developing and testing the design of the TKB Creation-Tool was particularly interesting for him, as multimodal video annotation is presently the most efficient way to support and document the workflow of artists in this field. During the TKB hands_on Lab at Maria Matos Theatre in Lisbon (June 2011), Jürgens has tested the Creation-Tool then available and suggested the introduction of additional features, such as a second live video input, and the possibility to view both video streams simultaneously (side to side, or in an overlay mode).

These features were programmed during the Lab, and tested regarding the specific needs of choreographers who wish to integrate new media technologies in the production of their artistic work.

The TKB Creation Tool has been evaluated as a powerful and sophisticated device for the entire team working on a digital live performance project, and may change the way involved artists reflect and organize their creative processes.

6 Conclusion

Creative processes of choreographers, or other authors in the performing arts, involve several rehearsal iterations where video-based annotation can significantly enhance the process. During the collaboration with both Horta and Jürgens, this has become clearly confirmed. Moreover, the process of video annotation by the linguists team has revealed itself fundamental for the development of the Creation-Tool, in the sense that the different annotation types now available in the tool have been decided exactly on the basis of the experience gained with the thorough verbal annotation process on ELAN. To give just an example, amongst numerous, the option of allowing to draw over the videos with either pen or touch was taken in order to facilitate and quicken the artist's work in real-time, instead of having him interrupt his concentration on the rehearsal to write notes down on a keyboard.

Moreover, different artists on the choreographer's team can use the Creation-Tool to annotate relevant information on customized tracks addressing the multiple aspects of the particular creation. In other words, the interdisciplinary dialogue usually taking place during the creation process of new works is reflected in the choice and organization of the available annotation tools for each individual project. A digital live performance work, for example, may be annotated collaboratively by the choreographer, digital artist, performer(s) and light designer, and will most probably make extensive use of the video overlay feature described above.

Beyond these clear advantages of working with multimodal video annotation as a powerful tool to support the creation process, there are further benefits emerging over time in often serendipitous ways. Such recursive way of working in an interdisciplinary team will inevitably raise new research questions.

In the foreseen extension of the TKB project for two more years, we have planned two main developments: 1. to enrich both the annotation space and the set of annotations of the Creation-Tool with 3D spatial information allowing for realistic composition of real and rendered objects or annotations, as well as with motion tracking resources. In this way we expect to provide an even richer annotation space in a tablet device to be used as a friendly too in all kinds of creative processes or real-time events where the performance of the human body is at stake; 2. to augment the possibilities of content visualization and representation in the new archive platform to be launched online, while maintaining a continuous flow of artistic contents onto the knowledge-base: this can be achieved with new forms of visualizations, digital scores, 3D environments and 3D annotations, which could allow free navigation, arbitrary points of view and object manipulation.

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The Challenge of the *Inter* in the Preservation of Cultural Heritage; The Intangibility of the Material and Immaterial Dancing Body in Performance

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Abstract. The intersection between the dancing body and digital technology produces new kinds of performative events that often exist only in the 'now' of event/user/audience interaction, resisting documenting and preserving in conventional ways, so are largely absent from our cultural heritage. As interlocutor, the artist is forever vital in the work existing and communicating, yet removed and absent in what remains; the living artist disappears into 'data'. How do these digital corporeal embodiments then generate new kinds of artefacts? Are these 're-enactments' more easily captured and preserved and if so, how do they disrupt what constitutes 'cultural heritage' and how we access and value our performing artists and their outputs? This presentation will explore these questions by drawing on the work of UK-based dance artist Ruth Gibson who uses motion capture technology to create visualisations of dancers for intermedial environments (exhibitions, installations and applications for mobile platforms). What does this work tell us about our relationship with the material and immaterial in performance, and our tools and methods for its preservation? I will argue that dance's contribution to our cultural heritage is intangible yet fundamental for emphasising the vitality of the corporeal, expressive body in our performing arts cultural heritage.

Keywords: dance, digital, motion capture, corporeality, intermediality, materiality.

1 Introduction

Prior to the availability of video, dance rarely survived beyond the moment of performance other than in the various documents that were left behind as the residue and remains of what was an effervescent, live and kinetic moment in time. Those residues would often include photographic images, critical reviews, performance posters, programmes and other marketing material. Less often there might be more scholarly analyses and on rare occasions some form of dance notation. Towards the end of the twentieth century there began what dance scholar and sociologist Helen Thomas described as a "minor industry in dance preservation" (2003, 32), which saw artists and scholars energetically reconstructing dances from the past. As the century drew to a close dancers began to fear the permanent loss of dances, the absence of

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dance from our art history and wider cultural heritage, and showed a desire to construct a physical and retrievable past. These reconstructions led to several scholarly analyses of the process of remaking and the politics of dance preservation became a subject of discussion.[1]

The interest in dance reconstruction led to lively debates about the meaning of reconstruction and its variants (re-creation, reviving, re-staging and so on) and the implication of those processes for how we know dance and its ontological nature. More recently there has been a much greater interest from dance artists in re-enactments and the body becoming its own archive, as seen for example in the work of Martin Nachbar's Urheben Aufheben (2008) and Richard Move's returns to several Martha Graham's work in the 1990s. These re-enactments are the subject of Andre Lepecki's essay on what he describes as the "current will to archive" (Lepecki, 2010, 31). As technology has become more sophisticated there has been a parallel process of dance engaging with the digital. On one hand dance is thinking deeply about how to organise dance content online so that the viewer/user can 'dig' into what might be an archaeological process of excavating a dance, to find connections between dance and other cultural practices and theoretical frameworks, allowing artists to capture and distribute much more of the process of making and choreographic thinking, thus encouraging viewers to experience the less tangible aspects of the dance making process. And yet at the same time, dancers have more and more incorporated new technological possibilities in their practice at the time of making new work, with the live dancing body increasingly removing itself from the live event.

This paper will focus on those performative events that are rooted in dance, or draw from the conventions of dance as a theatrical form, but which interface and interact with digital technologies. Moreover, these events[2] tend to evade 'capture' in conventional ways (video, audio, notation, photography etc.) and because they "produce new forms of hybrid human and machine subjectivities" (Salter, 2010, 29) they are not easily archived in a form that offers any real sense/access to the 'work' as it was intended to be experienced. These hybrid endeavours thereby defy categorisation and classification in terms of mode of performance (dance, theatre, music etc.) precisely because they "disturb boundaries of traditional performance and create new paradigms of emergent practice and discourse" (Chatzichristodoulou, Jefferies & Zerihan, 2009, 1). As a consequence, because these events are always in a state of becoming rather than existing as fixed events or objects they tend to be absent from our collections of cultural heritage. Subsequently, the artists who produce these cultural happenings are also largely invisible in the catalogues and indices of archives and museums. This chain of creation, realisation and evaporation provides an interesting challenge for artists, archivists and scholars alike.

2 Modes of Transmission

The developments in dance are not only questioning the ontology of dance as a performing art but are reaching towards other discipline practices that are similarly

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[1] See for example Jordan (2000)

[2] I use the word 'event' as a gesture towards neutrality and to avoid the inevitable associations with words such as 'performance'.

fugitive. Turning to how some of these other kinds of artefacts and events are archived is interesting. For example, the Gateway to Archives of Media Art (GAMA)[3] focuses on the archiving of media art and wrestles well with the complexities of how to 'pin down' artists' work that is emergent and often exists in multiple forms. GAMA provides a highly accessible multimedia resource that provides valuable access to textual and visual information on more than 10,000 works drawn from eight European media art collections. The archive provides in-depth descriptions of the content that ranges from films, video art, performances and installations. The characteristics of the collected archives are discussed in a short essay on the website by Ida Hirsenfelder, who tells us that " the meaning of the archives as a historical process is to develop a discursive field in which the context of the things and the events is understood within the discursive environment in which it was created, thus providing us with linguistic statements by which it is possible to conceive them" (2007).

So what might GAMA offer to our need to develop similar online resources for dance works that are similarly multiple; everywhere and nowhere? How does the online environment support not only the visual and audio record but also the sensation generated by the event/viewer interface; the particular visceral connection that is fundamental to how the work exists, because of its demands for a somatic mode of engagement? My own work in developing digital dance resources[4] has paid attention to the mode of transmission of the dance content; how the dance reads and communicates online, and in particular how having access to the dance online can both support artists developing their practice within an embodied studio environment and can enhance the viewer's experience of the live event. The method of capture for an online resource is always in my experience a thoughtful, curated and designed process.

Apart from the technical and legal conundrums that are an inevitable part of the digital archiving process, what is created may be the only lasting record of the 'original' dance work. Artists are therefore understandably anxious about fixing the work in a medium that is other than the one in which the work was first made, but the growing availability and proliferation of video content (on platforms such as YouTube) means that film is at least a reasonable method for recording a temporal and dynamic event that preserves a binary relationship between performer and viewer. But when the event does not uphold a common principle of performance (audience/actor division) there are different challenges. Using film as the principal medium of capture may misunderstand the intention of the work. Conversely, the camera may become another creative partner in the work's realisation. However, prioritising the visual record for single screen transmission might seem a poor representation of the art (dance) event.

Before looking at some specific examples I will briefly look to the growing discourse that seeks to articulate the particular nature of the human/technology

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[3] See `http://www.gamagateway.eu/index.php?id=home&color=&size=`

[4] Siobhan Davies RePlay (`www.siobhandaviesreplay.com`); Digital Dance Archives (`http://www.dance-archives.ac.uk`)

interface in performance and might contribute thought to how the material body comes into being through bodily expressions in myriad technological environments. Performance artist and scholar Chris Salter suggests that by "encouraging the separation between human and technical, culture purposefully 'banishes' the 'virtuality' (that is, the unperformed potential) of technical objects and processes by engaging in two contradictory treatments" (2009, 31). He describes these as treating technology merely as a tool for humans (so seen only in terms of their utility) or regarding technology as a threat to us and therefore to nature itself (ibid). Salter further asserts that "[p]erformances do things to the world, conjuring forth environments that emerge simultaneously with the individuation of the technical or living being" (2009, 35) and then provides a number of concrete examples from his own work that take place in environments that bring together in co-production technical ensembles and human forms of expression (ibid). Whilst Salter seems to point towards an ontological shift in performative expressions that offer up an experience that was not previously in existence (2009, 42), he does not specifically address how work that is made distinctive by its temporality (might or does already) enters and contributes to our cultural heritage.

3 Materiality and the Virtual

With this challenge in mind, the discussion will now specifically consider and reference the work of British artist Ruth Gibson whose practice draws from dance, performance and visual art. Gibson creates moving image and installation work, creating virtual worlds as locations for enquiry. Her work, made in collaboration with her partner Bruno Martelli, together as igloo, is exhibited worldwide in galleries and festivals. Her work sits in the interface between dance, choreography, film, gaming and interactive artwork using a wide range of media including print, video and computer games. She draws on her practice as a Skinner Releasing Technique practitioner and as an expert in using motion capture technology. Her current project[5] focuses on the metaphoric imagery cited in Joan Skinner's technique and how spontaneous movement data evoked through sensory imaginings can be captured and visualized to unearth the poetics in the pedagogy.

Before I look at some of Gibson's individual projects to illustrate some of the challenges involved in documenting work that is fundamentally 'about' (if it is about anything) the transformation from the material to the immaterial, it is perhaps valuable to consider some philosophical views about work identity and reproducibility in the context of performance art. Philosopher Graham McFee claims that for a dance work to exist it must be 'performable' (2011) and to be performable means that it must exist beyond a single moment of existence, which cannot typify the work; so any method of preservation needs to capture the features of the dance work and not merely a single performance/instant of the work (2011: 76).

[5] The project is the focus of Ruth Gibson's AHRC Creative Fellowship in Creative and Performing Arts at Coventry University, UK.

Another philosopher relevant to this discussion, Walter Benjamin (1892-1940), may have been writing at a much earlier time and could not have anticipated today's experiments with intermediality in the context of performance, but his thesis that mechanical reproduction might bring us closer to a work but destroys its 'aura' seems relevant when he asserts that "[e]ven the most perfect reproduction of a work of art is lacking in one element: its presence in time and space, its unique existence at the place where it happens to be" (1970: 218). So whether or not the work itself is reproduced, what might be the constituent parts that should be documented/recorded/preserved (in order that it might be repeatable)? And as with all technology, what impact will technological advancement (and redundancy) have on the readability and reproducibility or re-enactment of the work? Or is reproducibility itself a necessary condition for preservation? Might it be that the conditions and context by which the event comes into being is what needs to be recorded? As observed by Hirsenfelder in her consideration of GAMA: "If the purpose of the gateway is the dissemination of the content of the archives it cannot lose its immediate link with the media art works or else it might be in danger of deforming their initial context…" (2007).

The argument about the essential ephemerality and necessary 'disappearance' of performance and the condition of 'difference' or variability as a necessary ontological feature of performance has been famously picked up by others writing since Benjamin, including performance studies theorist Peggy Phelan (1993) who argues that a recording is always and inevitably different from the live event and therefore not 'the work'. Phelan's position has subsequently been challenged; Philip Auslander (amongst others) claims that recordings pose no ontological threat to performance (2009). Discussing mediatized performances (in other words recordings of previous performance events rather than other forms of mediatisation) Auslander offers "a way of understanding how we experience mediated performance as unfolding in our perceptual present even as we acknowledge their connections to events that occurred elsewhere and else-when" (2009, 82).

Just as the nature of performance is changing so is the discourse around performance, and particularly concepts such as liveness as we move further towards a mediatized and mediated performance environment. As Janis Jefferies observes, "the use of technology in performance does not merely add a new tool to an old discipline but rather challenges some of our most basic assumptions about performance itself" (2009, 199). She further suggests that the methodologies used by artists "reactivate the relationship between performers and audiences who can now share the same physical space, a space of becoming, a space of interaction and integration" (ibid). Many of Gibson and Martelli's projects frequently ask that the audience/user become active participants or players in the construction and realisation of the work. For example VISITOR/Vermillion Lake (2011) is made for various arts venues and takes the viewer into a log cabin in a gallery, but it is not what it seems; a plywood construction is made 'realistic' by the application of photographic imagery to the outside surface. Inside is half a rowing boat, which the 'visitor' sits in and takes hold of oars to row 'around a lake' that is made real through more photographic imagery. Real and invented panoramas depict the beauty and strangeness of the natural world; environments inspired by the snow-driven mountains of the Canadian Rockies.

As with other projects, VISITOR foregrounds “place, figure and landscape and the relationship between natural and artificial, transposing sites to create ambiguous topographies” (Gibson & Martelli, 2013). Being an interactive experience, the visitor not only sees, but also by being in an embodied connection with the hybrid physical/virtual environment, feels the relationship with virtual sky, trees and falling stars. The visitor becomes the performer her/himself in engaging with the work but the emphasis is very much on experience, and an experience that cannot easily be recorded and reproduced beyond the specific moment.

Whilst VISITOR may seem far away from what viewers might recognize as ‘dance’ or ‘performance’, Gibson’s current project is producing visualizations that might have no actual human presence but which embody the dancing body in the way that they seem to breathe, fold and fly through a virtual landscape. They take forward what were more clearly dancing avatars in her earlier project, Summerbranch[6] (2005) in which Gibson explored the extent to which dancing bodies, transformed by animations, might retain, reiterate or lose corporeality. Summerbranch is a 3D environment, which evokes an English forest and has camouflaged characters hidden within. Gibson describes her interest in movement/stillness and camouflage techniques, and how reactions to the work varied; some found it relaxing, others unnerving, but she liked the way it retains its own aesthetic (2010).

The dancers (or more accurately, the animations) in Summerbranch appear and disappear, emerging out of the foliage and conjure up an instinctual sense of breath, weight and gravity. There is a delicacy in the dancers’ motion; moments of pause draw attention to their (our) fragility then there is a surety in their fleet-footed dash through the ‘forest’. As with VISITOR, the blurring between real and unreal is hypnotic and dreamlike, and yet ‘uncanny and thus unsettling’ (Birringer, 2007, 48). By involving the viewer in the journey taken through the forest, the viewer may find that she reflects back on her own corporeality whilst probably being unaware of her own agency in determining how the work unfolds.

VISITOR is the second part of igloo's SwanQuake series, in which Gibson and Martelli challenge ideas of place and the understanding of it, transposing sites and designing sculptural, interactive experiences for audiences. SwanQuake:House (2007)[7] is also made for a gallery as an immersive experience and is built on a computer game environment. The visitor determines her own journey through the real/virtual ‘house’ with the use of a joystick. As s/he moves through a series of rooms, stairways, corridors and happenings s/he encounters dancing avatars in different spaces, moving through fluid sequences of contemporary dance phrases. On one hand the dancing creatures seem realistic but there is something mysterious in their sameness; these are all Gibson and yet not. A model of Gibson has been mapped onto motion capture sequences generated from other dancers (and then rearranged and reconstructed) who are effectively fused with the external ‘skin’ of Gibson. The

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[6] As with many of igloo’s works, the title *Summerbranch* is a pun; this time it is a play on the title of two choreographic works by Merce Cunningham, *Summerspace* (1958) and *Winterbranch* (1964).

[7] *SwanQuake* is a play on the well-known ballet, *Swan Lake* combined with a reference to the computer game *Quake*.

presence of these human forms is reassuring and yet out of reach and strangely ghost-like and inhuman despite the motion that seems to be deeply sourced in the body.

SwanQuake:House continues to be presented or 'exhibited' so in some ways endures and lives on in its 'original' form, much as a static artwork might continue to be shown in a gallery. As with so many works that are realized through digital technology, it is a work that can only be what it is in the work/viewer interface. However, there are various documents that provide a trace or visual marker or reminder of the work; 'screen grabs' from journeys and composite images that aim to capture something of the spirit of the work. A more interesting development came with Gibson and Martelli's publication that grew out of the project; SwanQuake the user manual (2007). Gibson explains: "The manual doesn't tell you how to play the game because there aren't any rules really […] We wanted to de- mystify the complexities to encourage others to have the confidence to try and make work like this themselves" (2010). The book is therefore also in hybrid form and deliberately plays with familiar modes (instruction manual, scholarly essay, critical review), much as the work itself negotiates between performance, exhibition, installation; and between realism and virtuality. The book collects together in physical form descriptions of the process of making the work and reflections by those who experienced the performative 'game'.

4 Bringing the Digital Back into the Body

Gibson's current project brings attention more firmly back to the materiality of the dancing body. By attending to the imagery that is so central to Skinner Releasing Technique, emergent visualisations in myriad forms transmit the experience of the expressive dancing body. Equally interesting is how these new visualisations (whether made for screen, installation or live events) might reveal something new about how dancing bodies embody particular pedagogies and philosophies of movement. Moreover, they invite critical engagement with our performance histories, how dance styles evolve and how technology develops over time, and how it intervenes and interfaces with dance. What will be interesting to discover is how these new dance inscriptions enter (or not) our cultural heritage records.

The new visualisations are based on captures using motion capture technology. They experiment with emphasizing stillness, interiority and close contact with the floor to explore the impact on audiences within interactive virtual performance environments and specifically the way in which they might encourage a more enhanced kinaesthetic engagement. Her project explores the dancer as subject and object of capture, and her own role as artist/ engineer/ programmer/ interlocutor in the creative process. The special attention given to experience is defined by Gibson as a *kinosphir* - a new methodology of giving audiences immersive experiences using a variety of techniques including game engine visualisations, motion capture, haptic interfaces & stereo projections to convey imagery derived from & relating to the Skinner Releasing dance technique (Gibson, 2013). She is also exploring how these findings can permeate the development of kinaesthetic human computer interfaces for mobile devices and large scale projected realtime 3D environments.

5 Conclusion

It is exciting to see how the work of our performing artists is responding to the ever-expanding possibilities provided by new technologies. Similar innovations are developing within our cultural institutions as new platforms and tools by which audiences can engage with performances are being developed. Digital libraries (such as ECLAP) are developing novel tools to enhance user engagement, to maximise and to encourage new interpretations via new navigation routes etc. But whereas at one time our cultural heritage was the responsibility of those traditional custodians of historical artefacts (museum curators, archivists etc.), we are now all participating in the archival process and performing artists are thinking too about how to sustain their work at the time of making rather than leaving it to others and at the time when the work is 'past'. This collapsing of making, performing, documenting and archiving is made even more visible in the recent desire by some performing artists to now make process the product. What was previously a private and unseen process is now made a spectacle in itself. Siobhan Davies' recent Side-by-Side project is one example. Described as 'an investigation into making' which had no finished product, two artists[8] were commissioned to collaborate and document their making/rehearsing/ discussion /resolving process by image, text, film and object, which was then presented to a live audience as well as online as a project to be spectated.

But these technical advancements in how we store and share cultural heritage have not yet fully grappled with how we support the capture of performance practices that tend to defy traditional modes, such as those by Gibson and Martelli and other artists who refuse to be defined by a single arts practice or art form. It may be that a partial documentation for preservation purposes is preferable to having no presence within our libraries and archives, but what these traces are, who decides what is to be preserved and how such varied events might generate new taxonomies to secure their own future is not yet clear. Finding agreement is going to be difficult so it may be that we continue to see a proliferation of online collections, particular to each artist. However, our contemporary/present-day artists are a precious resource, who can be active in the process by contributing creative solutions to the challenge of how we develop the tools and technology to document, circulate and share for the benefit of all.

Our artists are no longer relegated to mere interlocutors whilst memory institutions decide who and what is valid for preservation. As Barbara Borcic observes; "Performers often resist historization and the musealization of performance and we need to ask, if it is a document of something that is real duration – what does it lose and gain?" (2007).

Time will tell if the gains outweigh the losses but the traces that persist, however partial, are invaluable clues to the vivacious phenomena of contemporary cultural performance practice. It may be that the intersection between the dancing body and digital technology produces new kinds of performative events that only exist in their becoming but dance makes a significant contribution to our cultural heritage, in all its many manifestations, however intangible, by emphasising the vitality of the corporeal, expressive body in our performing arts cultural heritage.

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[8] The two artists are dance artist Laïla Diallo and craft artist Helen Carnac. See `http://www.siobhandavies.com/sidebyside/`

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MultiStage: Acting across Distance

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Abstract. We report on a prototype system helping actors on a stage to interact and perform with actors on other stages as if they were on the same stage. At each stage four 3D cameras tiled back to back for an almost 360 degree view, continuously record actors. The system processes the recorded data on-the-fly to discover actions by actors that it should react to, and it streams data about actors and their actions to remote stages where each actor is represented by a remote presence, a visualization of the actor. When the remote presences lag behind too much because of network and processing delays, the system applies various techniques to hide this, including switching rapidly to a pre-recorded video or animations of individual actors. The system amplifies actors' actions by adding text and animations to the remote presences to better carry the meaning of actions across distance. The system currently scales across the Internet with good performance to three stages, and comprises in total 15 computers, 12 cameras, and several projectors.

Keywords: Temporal Synchronization; Remote Interaction; Computer Mediated Collaboration.

1 Introduction

We envision computer mediated collaborative performances where actors at physically remote locations, as illustrated in Figure 1, interact and coordinate their actions as if they are next to each other on the same stage or in the same room. Through various means, including audio, video and animations, each actor has a remote presence at one or several remote stages. We are interested in how to mask the effects of delays and distance.

In this paper we describe a system doing this for the visual side of a remote presence: MultiStage collects state, like video, about each stage through various sensors, like cameras and microphones, and analyses the observed state to identify information like actor gestures. State data and information is streamed between stages to maintain a remote presence for each actor, and to monitor and control the system.

Each stage has several incoming data streams that are used to create a presence of remote actors. Actors in a room watch and react to the remote presence

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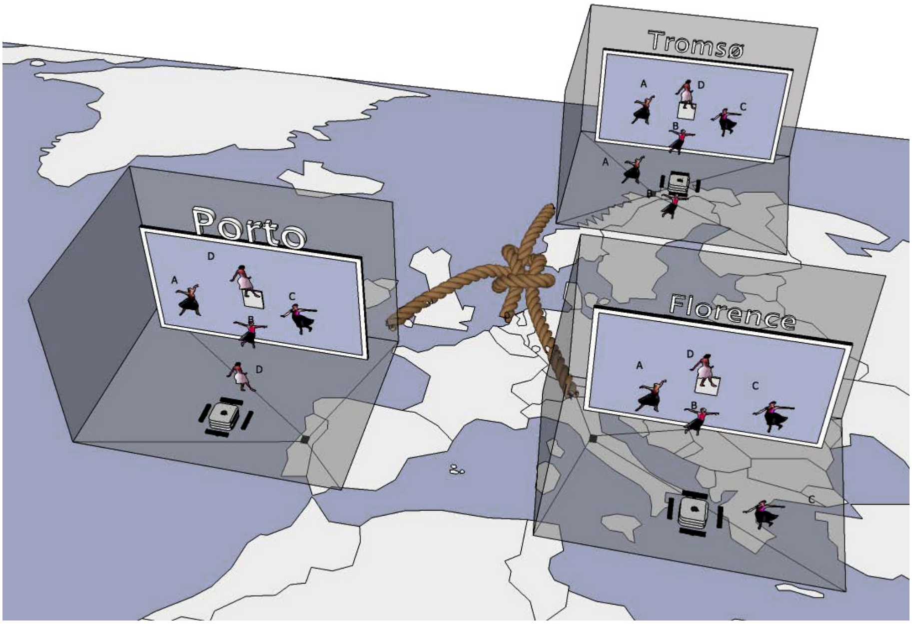

Fig. 1. Four dancers at three different stages dance together. Each stage is equipped with sensors to detect actors and a display to visualize the remote presence of all the performers. The rope and knot represent the global system binding together the stages.

of other actors. There can also be several third parties, audiences, just observing, and not directly participating. Audiences can be physically present at one of the stages, or be on the Internet. An audience local to a stage can watch the local physical events unfolding, and watch visualizations of both the local and remote events.

In principle, there will always be some delay from an event happens until it can be observed. Light alone needs 134ms to travel the length of Earth's equator. In practice, the total delay when observing a remote event includes delays coming from the sensors, transferal of data from sensors to computers, processing of the sensor input, network transmission, on-route processing, receiving and processing the received data, and preparing and visualizing the data locally. Even if the delays can be reduced, they can never be removed. Consequently, we have to live with the delays, and find ways of reducing the effect they have on the actors and the audiences. The effect of the delays can be reduced through different techniques including on-the-fly manipulation of the remote presence representation of actors. We must also mask the effect of distance. On a theater stage the actors use several techniques including costumes, makeup, and exaggerated movements to reach out to the audience. We propose to let a user instruct the system through gestures to add enhancements to the remote presence. For example, a given arm movement could be turned into a text bubble above the visualization of the user, or a glowing halo around the arm. We call this *amplified interaction*.

There are many commercial tele-conferencing and messaging systems where two or several persons interact through instant text, video and audio as well as file transfer. The latencies can be quite tolerable. However, teleconferencing systems are best when used in unstructured interaction without interactively fast synchronized movements of participants. Tele-conferencing systems are typically not flexible with regards to manipulating remote presences, and how they are arranged on, say, a display. They also lack functionalities for amplified interaction.

2 Related Literature

Several research systems for collaboration exist. In [1], [2] and [3] two room interaction systems are described with a focus on achieving audio synchrony. They compensate for the network latency by delaying local actions correspondingly, making both rooms experience the same delay. In [2] a series of experiments based on the DIP system is described with focus on the audio delay, and how the delay affects musician's cooperation. An artificial delay of 50ms to the remote room's audio stream was tolerable. With the same latency added at both rooms it became possible to play easily together with a delay of up to 65ms. This approach used by DIP for audio can also be used by MultiStage for video.

In [4] a remote camera system for teleconferencing supporting user cooperation between a local and a remote room is described. The system captures 360-degree images as well as supports pan/tilt/zoom of cameras. The audio and video can be recorded. Consumed network bandwidth is from 1.95 to 7.4MBytes/s.

In [5] a three-room distributed collaboration system is described, allowing three people to collaborate in a virtual environment. At each room there is a multi-touch table, camera, speaker, microphone, and two LCD monitors to display the two other rooms. The shadow of remote hand and arm gestures are captured by an infrared camera and displayed on the multi-touch table to show the remote person's behavior.

In [6] a remote presence system using a remote controlled android is described. The state of the android includes idle, speaking, listening, left-looking and right-looking. A teleoperator control android's behavior by choosing its state. They conclude that using an android gives a strong remote presence.

In [7] a system intended for informal meetings between rooms is described. The system merges the images from panorama cameras acquiring the background of a room, with a camera acquiring the users when they are close by the display. The system amplifies the remote presence of the users by allowing users to maintain eye contact during a conversation.

In [8] a multi-camera real-time 3D modeling system for tele-presence and remote collaboration is described. 3D models of users are computed from 2D images from multiple cameras, and the 3D models are streamed to remote rooms where users are visualized in a virtual 3D environment. Computing and visualizing collisions and reaction forces to virtual objects in the virtual space strengthen the remote presence. The system is built on top of a middleware that simplifies the use of a compute cluster to obtain 3D meshes and textures from the cameras.

In [9] a multi-modal corpus for research into human to human interaction through a virtual environment is presented. The virtual environment is defined as a virtual dance studio where a dance teacher can teach students choreographies. Both teacher and students are represented in the virtual studio by 3D avatars. The corpus consists of the recordings of the 3D avatars and outputs form other sensors, such as cameras, depth sensors, audio rigs and wearable inertial measurement devices. A dance instructor and a musician provided also some ground truth annotations for the corpus.

In [10] a study on hand gesture speed classification with the goal to improve the human-computer interaction is presented. The aim of the study is to train a virtual human to detect hand's movement in a noisy environment. The factors of the study are multiple body features like hand, wrist, elbow and shoulder, evaluated against different gesture speed such as slow, normal and fast.

3 Temporal Causal Synchrony between Actors

Some actions by actors are causally related. One actor does an action, and some time later another actor does an action because of the first action. A system must preserve the order of the actions when they are causally related.

Even if causality is preserved, there is a delay between an action and the corresponding reaction(s), and the system should ideally keep the delay low enough to make actors experience it as if they would when on the same physical stage. How large the delay is indicates how well actors are in temporal causal synchrony.

We define actors to be in *loose* temporal causal synchrony with each other when there are no special demands on delays. This is typically the case in unstructured interaction where it does not matter a great deal if actions by actors are slightly delayed or out of order with each other. This will typically be the case in teleconferencing with approaches like Skype.

However, for structured interaction with coordinated movements, as in synchronized dancing and in rapid action-reaction situations like, say, martial arts, correct causal ordering and short delays become critical to preserve the illusion that the actors are on the same stage. We define *interactive* temporal causal synchrony to be when actions by an actor is seen in causal order and as fast as actors are used to when being on the same stage.

Delays are unavoidable, and they can be large and even varying enough so that interactive temporal causal synchrony can not be achieved. In these cases we must mask the effects of the delays to create an illusion of synchrony. Some approaches are outlined in the following.

Actor Feedbacks: The actors reacts to the remote presence videos as if they were the actual other actors. Depending on how large the delays are and how much they vary, the interactions can become awkward. Only loose temporal causal synchrony can be expected to be achieved.

Shared Clock, Shared Performance Start-Time, Individual Actor Scripts: We synchronize the clocks of all computers, set a performance start-time and begin a count-down at each stage. When the count-down finishes each actor starts acting according to a script defining what the actor should do and when the actor should do it (for instance, two actors doing handshake). Assuming that the scripts are made correctly, even if the actors don't actually interact it will seem to an audience as if they do. In this approach the scripts have been made with knowledge about the delays, and each script tell the actor when, modified by the delay, to do an action.

Shared Clock, Individual Performance Start-Time, Individual or Shared Actor Scripts: We synchronize the clocks, and select a start-time for the performance. We select one stage to be the live stage. The other stages are secondary stages. We measure the delay from the live stage to all secondary stages and modify the start time of each stage's count-down according to the delay between it and the live stage. When the count-downs finishes, all remote presences will move at the same time and in synchrony with the actors present at the live stage. The actors and the audience at the live stage will see the other stages as if they are in interactive temporal synchrony with the live stage. Actors and the audiences at the secondary stages will experience the effects of delays.

Act-by-wire: We synchronize the clocks, and start the stages at the same time. The computers are continuously monitoring and measuring several metrics including delays between stages. If one or several videos are arriving late because of delays, the computers do on-demand manipulations and animations of the live video or substitute the live video with a pre-recorded video. If there are scripts available telling the system what each actor was meant to do, the system can create animations mimicking the expected movements. If there are no scripts telling the system what to do, it can try to predict the movements of an actor based on the most recent movements, or it can blur what is going on such that the audience not so easily notices the delays. In all cases, the goal is to create an illusion of interactive temporal causal synchrony.

4 Amplified Actor Interaction and Gestures

On a theater stage, with a significant physical distance between actors and the audience, bold makeup, clothes, and exaggerated movements are used to better project to the audience what the actors are doing.

In remote interactive performances there is a distance not only to an audience, but also between the actors. Consequently, the actors need their appearance, movement and gestures to be amplified such that they become easier to see and understand both for the other users and for the audience. In this way we extend the range of human interaction to remote locations and enrich the communication between them. We term this amplified interaction.

To be able to detect what an actor is doing, we must surround him with an interaction space [11]. An interaction space detects human movements, and analyzes them looking for gestures. A gesture represents a pre-defined command to the system to execute code to do some functionality.

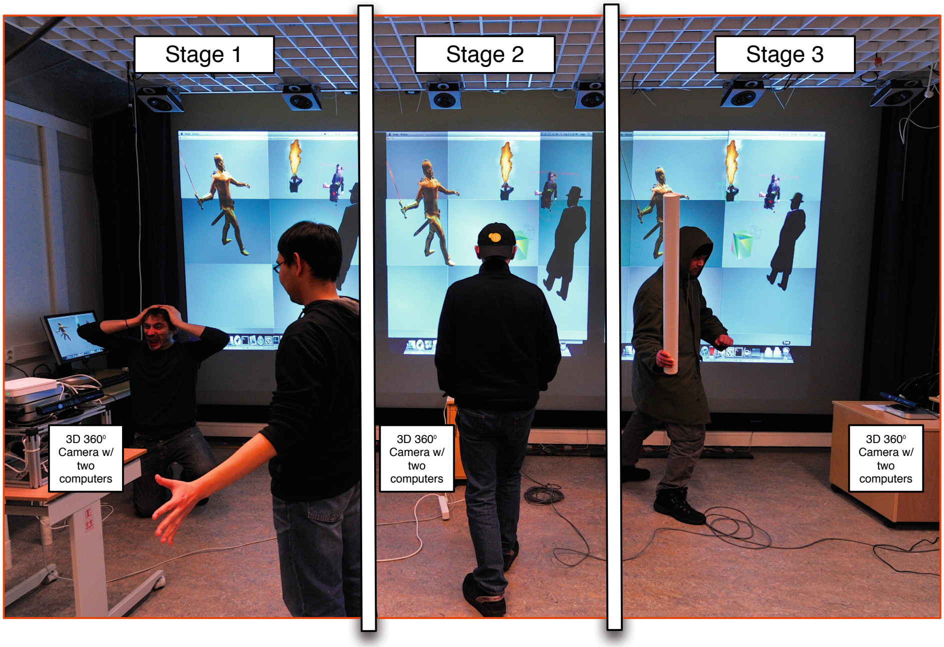

Fig. 2. To do experiments, MultiStage is set up with three stages and four actors in the same room. Each stage has its own camera rig. Each stage displays all actors. The global system binding together the stages are located either locally or on a remote computer across the Internet. Note: the flame animation has been enhanced in the figure for better visibility.

A gesture can be simple, like raising an arm, or complicated like doing two-arm movements. They can also be active like walking in a specific direction or passive as in standing still posturing. A collective (collaborative) gesture is a combination of the above kinds of gestures. Collective gestures can happen at the same stage, or be distributed, comprised of gestures from multiple stages. For example, when two actors at different stages, within some short timespan, raise their left arms above their head this can be interpreted as, say, a command to the system to animate a lightning between the two raised arms and display it on all the displays.

Based on the gestures we can create effects in the remote presence manifesting itself at remote rooms. A user's arm movement can in the remote presence be amplified by having a text bubble appear in the video, and by adding other visual effects to the representation of the user. The users remote presence can even be enhanced by executing a model of the user and using its output as the basis for the remote presence.

To experiment with the system, we set up three stages, named stage 1, 2 and 3, see figure 2, in a single room. There are two actors on stage 1, and one actor at each of the other two stages. Even if all three stages were co-located in

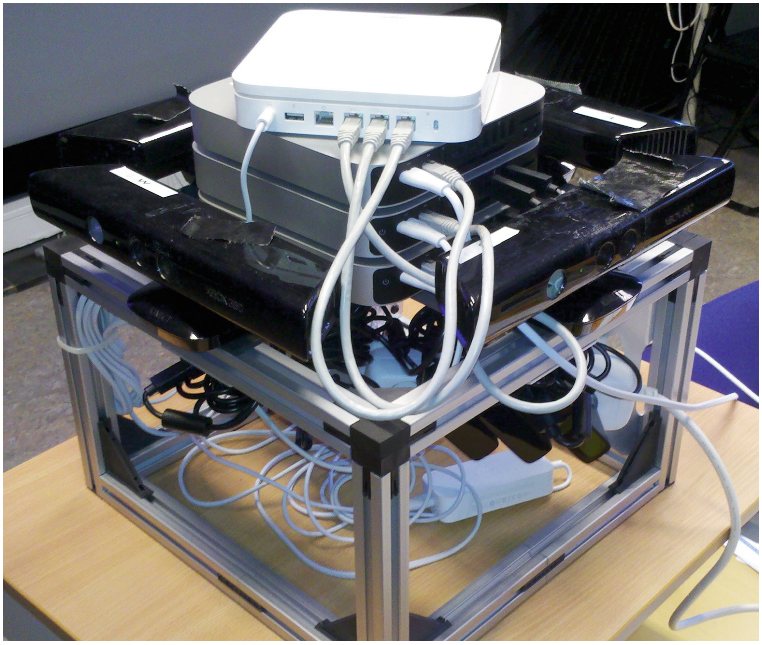

Fig. 3. The four 3D Kinect camera rig used at each stage for almost 360 degrees coverage

the same room they each occupied a different area of the room, and they each had their own interaction space and display. Each interaction space uses four Kinect 3D cameras, see figure 3. The cameras are arranged in a square with two computers receiving camera output and doing processing on the images. Four Kinects arranged in a square cover almost 360 degrees. We typically place the camera rig in the middle of a stage, and act around it. The room where the stages are located has a large 6m by 3m display wall. Each stage displays the remote presences of local and remote actors onto its assigned area of the display wall.

To simulate both the situation when all stages are on the same local network as well as when they are connected through a wide area network, the Internet, we locate the global side handling the distribution of data between the stages either locally at Tromsø or at a computer in Oslo or Copenhagen.

The images picked up by the cameras are analyzed and sent as data streams to all stages. This data represents the actors and to some degree what they are doing. The data is used to create a remote presence of each actors. This can take the form of a simple video, a manipulated video, or an animation of the actor as illustrated in the figure. Each stage has a display where the remote presence of each actors is displayed inside the same virtual stage.

On the virtual stage three of the actors have been amplified. At Stage 1 the kneeling actor with hands on his head is interpreted by the system as showing agitation, and the system has added an animated fire above his remote presence.

The other actor at Stage 1 does nothing the system recognizes, and a low resolution video of him is displayed at all stages. The actor at Stage 2 knows that if he keeps his hands in the pocket, has a hat on, and emulates walking, his remote presence will be that of an animated figure of a walking man with long dark coat and a hat. The actor at Stage 3 knows that if he has something looking like a sword in his right hand his remote presence will be that of a knight with a sword.

Presently, the prototype system cannot do all of the described functionality. The actual dynamic gesture and posture recognition is not yet in place. Consequently, the three amplified remote presences in Figure 2 were predetermined to be what they are.

5 Design and Implementation of Prototype

The design of the prototype, please see Figure 4, comprises several systems including the collaboration system, the human interaction system, the administrator interaction system, and an internal state & performance monitoring system.

The MultiStage system has a local side and a global side. The local side primarily focuses on what is happening locally on a stage. The systems implementing the local side executes on computers local to a stage. These systems include:

(i) the local detection system doing local state monitoring (LSM) recording what the cameras see, and doing on-the-fly local analysis (LSA) of the data to find interesting objects and events in the videos. The data is streamed to the global side for further analysis and distribution to the other stages.

(ii) the remote presence system subscribing to data streams from the other stages, and creating a remote presence of remote actors. Presently the primary remote presence technique is to visualize remote actors on a very large display per stage. In the future we may add physical devices like robots to the remote presence.

(iii) the human interaction system inform actors on when they should start actions, like moving arms, according to a given script. It will also in the future enable an actor to give gesture input to control a remote physical presence, like a robot and manipulating how the actor is displayed.

(iv) the temporal causal synchrony system applies the techniques discussed previously in this paper to reduce the effects of delays.

The global side is the glue binding the stages together, taking care of distribution of data between stages, and doing analytics needing data from multiple stages. The global side includes these systems:

(i) the administrator (or director) interaction system lets an administrator/director manage the systems, and setting start times for performances.

(ii) the global state detection system doing global state monitoring (GSM) collecting data from all the stages, and making it available for on-the-fly global state analysis (GSA) to detect distributed state like collective gestures and col-

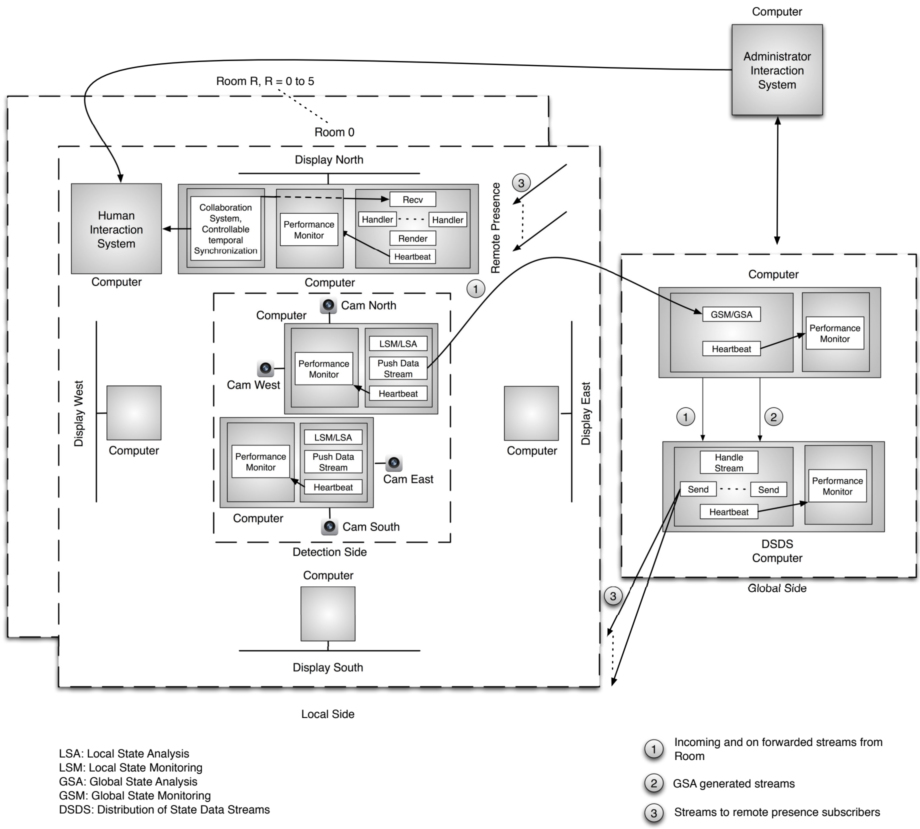

Fig. 4. The Design of MultiStage showing the systems at each stage and the global systems binding stages together

lisions when actors at different physical stages occupy the same volume on the virtual stage.

(iii) the distribution of state data streams (DSDS) system managing subscriptions from stages for data streams, and doing the actual transmitting of data to the remote presence computers locally to the stages.

Both the local and global side executes the internal state and performance monitoring system doing live performance measurements of several metrics including latency and bandwidth. These are made available to the global sides administrator interaction system. The performance measurements are also made available to the temporal causal synchrony system.

The systems were implemented on the operating systems Linux and Mac OS X and using several languages including C, Python and the Go programming language [12]. The animations and 3D models are rendered using the Horde3D graphical engine [13].

The prototype in Figure 2 can be configured to run on a variable number of computers. We typically have three to four computers per stage, two for the global side, and one computer for the administrator interaction system. With three stages the prototype comprises in total 12-15 computers. All computers can be connected through a combination of wireless network, switched gigabit Ethernet network and a wide area network (between Tromsø and Oslo (1500km)).

6 Evaluation

To characterize the performance of MultiStage a set of experiments were conducted. All computers used were modern Mac Minis at 2.7GHz. Each stage had three computers: two with two cameras each, and one with a large display. The global side had two computers: one for the global state monitoring and analysis, and one for the distribution of state data streams. Each stage and the global side had a network switch each. All switches were connected to a switch with access to the Internet.

For all experiments all stages were on the same 1Gbit/s switched Ethernet LAN inside the Department of Computer Science at the University of Tromsø. The DSDS, the system distributing data streams to the stages, was either on the same LAN as the stages, or located on a Planetlab [14] computer at the University of Oslo, 1500km away. In this case, all data sent between stages went from Tromsø to Oslo and back again. This separates the stages across the Internet.

Using the Python Psutil module [15], we measured the CPU utilization, amount of physical memory in use, and incoming and outgoing network traffic for all computers in use. We also measured three types of latencies: (i) the latency between the global side DSDS computer and the stages. We measured this by recording the time when we send a message from DSDS to a stage, and recording when a reply message comes back to DSDS; (ii) the end to end latency: the time it takes for a physical event happening on a stage to be picked up by the cameras and until a visualization of the actor is actually displayed on the same stage. We used a video camera with a high frame rate to record several videos of a user and the remote presence done on a display behind the user. We then counted frames to see how many frames it took from the user moved to the visualization caught up; (iii) the latency an actor can tolerate before the illusion of being on the same stage breaks. We subjectively decided this through two experiments. In the first we had an actor moving his arms while we observed him and his remote presence simultaneously. In software we artificially added a delay to the remote presence until we subjectively decided that the remote presence lagged too much behind to be mistaken for being on the same stage. In the second experiment an actor shaked hands with a remote actor. The delay between the actors was artificially increased until we subjectively decided that the handshake was not happening as fast as it would if the actors were physically on the same stage.

Factors in the experiments were the number of stages (1 to 3), the resolution of the images from the cameras (bounding box alone, 1000 to 5000 points per image), the number of cameras per stage (0 to 4), and the location of the DSDS subsystem distributing data between stages (LAN in Tromsø vs. WAN to Oslo).

The results show that the resource usage in all cases are either very low or low. The implication is that the system is not resource limited. There is practically no loss of data in the experiments with the DSDS on the same LAN as the stages. When we separate the stages with a WAN by locating the DSDS on a computer in Oslo 1500km away, we see just an insignificant increase in data not getting across to all stages. The implication is that we can expect that the system typically will have satisfactory bandwidth available even when the stages are separated by the Internet.

When all stages and the global side were on the same LAN, the round-trip latencies were between 1-2ms. When the DSDS system was on a computer in Oslo the round-trip latencies were around 32ms. This matches well with measurements reported by PingER [16] for Europe.

On a LAN the end to end latency was between 90-125ms. With the DSDS at the computer in Oslo, the end to end latency was between 100-158ms. Two times the end to end latency, 200-316ms, is the delay that actors will experience from they do an action until they see a visualization of another actor reacting. We term this the **actor to actor latency**.

We subjectively decided that movements being delayed less than 100ms maintains the illusion of being on the same stage. However, the objective measurements show that an actor to actor latency is at typically 300ms. Consequently, the system should apply its techniques to mask the effects of the too long delay.

In the handshake experiment, we decided that an actor to actor latency of about 600ms was just acceptable and could be mistaken for how people shake hands when both are present in the same room. Longer delays bordered on creating a feeling that the remote actor was being obnoxious by delaying just a bit too long before responding to a hand shake. This indicates that the prototype is able to maintain the illusion of being on the same stage for hand-shake type of interactions.

The variation in latency we measured is because of several factors, including the distributed architecture of the prototype and the frame rate of the projector, video camera (240 fps) and the Kinects (30 fps), and other traffic on the LANs and WAN.

7 Conclusions

The subsystems and bindings between them makes for a complex actor collaboration system. While good programming practices will reduce the number of failures, a simpler system will provide for a higher probability of avoiding failures right before and during a performance. We will simplify based on the lessons learned from the prototype.

We believe that the built-in on-line monitoring of the state of the individual components of the system is important to discover where problems happen, and to help in fixing them. The on-line performance monitoring is critical for discovering delays long enough so that the system can try to mask their effect.

Having stages across the Internet is a challenge for the system because traffic load, failures and outages are mostly unknown before they happen. We have documented that the system scales to at least three stages with a total of at least 12 outgoing and 36 incoming data streams. Based on the performance measurements we conclude that the location of the data stream distribution server binding together the stages is not critical for the end to end latency of the system when it is used to do natural interaction, like handshakes, where delays of even 600ms is tolerable. However, when movements are meant to happen simultaneously and synchronized, the distribution server should be located where it provides for the lowest latencies. Data available in services like PingER [16] can help to choose a location to minimize latency between stages.

With regards to bandwidth, the location of the distribution server is presently not critical. This may change if the data streams grow in size and number. However, if the global analyzer and distribution sub-systems are located on computers on the same local area network as one or more of the stages, the Internet traffic is significantly reduced. This will penalize the other stages but could be useful for a performance with local audiences or where synchronized interactions are mostly among actors on the local stages.

Even if the system can do temporal synchrony and mask away delays, it is not yet clear how practical the system is in actual use. While we have not done formal user study experiments exploring the system capabilities with actors needing to tightly coordinate their movements, we have documented the performance limits of the MultiStage system. This provides for a sound prototype platform for experiments in a context of distributed performances with real actors.

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Networked Performances and Natural Interaction via LOLA: Low Latency High Quality A/V Streaming System*

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Abstract. We present LOLA (LOw LAtency audio visual streaming system), a system for distributed performing arts interaction over advanced packet networks. It is intended to operate on high performance networking infrastructures, and is based on low latency audio/video acquisition hardware and on the integration and optimization of audio/video data acquisition, presentation and transmission. The extremely low round trip delay of the transmitted data makes the system suitable for remote musical education, real time distributed musical performance and performing arts activities, but in general also for any human-human interactive distributed activity in which timing and responsiveness are critical factors for the quality of the interaction. The experimentation conducted so far with professional music performers and skilled music students, on geographical distances up to 3500 Km, demonstrated its effectiveness and suitability for distance musical interaction, even when professional players are involved and very ”tempo sensitive” classical baroque music repertoire is concerned.

1 Introduction

Distributed collaborative environments have been recently the subject of considerable interest and investigations. In some specific cases, collaborative activities include tasks in which the speed of interaction plays a critical role, and the growing demands in terms of performance has highlighted the limits of the currently available multimedia data processing and transmission technology [1]. In particular, the field of interactive musical collaboration, referring to scenarios such as geographically distributed musical performance or distance music education, poses specific problems related to the management of high quality audio-video streaming, to the transmission speed and delays, and to the impact of transmission delays on musical performers accuracy [2,3,4,5].

Videoconferencing systems have always been the common answer to remote interaction among people in distant locations. However all of them were conceived for enabling people to hold a meeting where participants just talk and discuss. Until recent

* A project by Conservatorio di Musica G. Tartini and Consortium GARR.

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times, most of these systems did not even try to emulate the presence of the remote parties, and were designed with much higher delay (latency) tolerances then usually required for natual live interaction. Also the recent ”telepresence” immersive solutions (e.g., Polycom RealPresence or Cisco Telepresence System) only aim at a very fixed interaction scheme, such as a meeting where participants all sit together around a table, and talk.

Remote music education indeed tried to use and in some cases adapt existing videoconferecing tools, and adopted some of them as anyhow useful tools. Legacy H.323 systems usually offer poor qualiy audio codecs (80Hz-8KHz), put priority on video data over audio data in case of problems, use Automatic Echo Cancellation (AEC) mechanisms which are optimised for voice patterns, and cancel a wide range of audible frequencies. Some work has been done by some vendors [6] in collaboration with the music education community to obtain better results, but the codec latency remains still high (above 200ms), well beyond the possibility to play music together during the interaction. DVTS (Digital Video Transport System) [7] and ConferenceXP [8] have a much better audio codec quality and do not use AEC, but also have high latency (above 300 ms) which generates echo, and makes interaction complex and non-natural. Only ”walkie-talkie” style interaction was thus possible, wich required a highly structured human communication protocol, too.

The system we illustrate here was conceived for a completely different environment, where latency must be below what individuals can perceive, where people perform actions they normally do when they interact live (e.g., playing, singing, dancing), and where also remote sound fidelity must be the highest possible quality.

To specifically address this class of problems, an high-quality, low trasmission latency system aimed at distributed music performance over high-end packet networks, was designed and developed. Low transmission latency refers to a very specific feature of an Audio/Video communication system where the transmission delay among remote sites is very small and therefore negligible for the human eye and ear. Since its origin, the main goal of the LOLA project (the acronym stands for ”LOw LAtency”) was to create a system fulfilling this specific requirement, thus building an high quality tool for remote musical education and real time distance musical performance. To date, the system has been extensively tested and used in a wide number of demonstrative performances, and is ready to be used for production and musical education by institutions connected to academic networks.

LOLA was originally conceived and designed at the Tartini Music Conservatory of Trieste, and at present is being developed and tested with the collaboration of GARR (the Italian Education and Research Network organization). The Lola development team is composed of Massimo Parovel (conception and supervision), Paolo Pachini (general coordination), Nicola Buso (testing and musical advice), Carlo Drioli (system design and programming), Claudio Allocchio (testing and networking advice).

2 Architecture and Implementation

The LOLA A/V streaming system is conceptually an high quaility videoconferencing hardware/software system (see Fig. 1). However, the operating conditions that it was

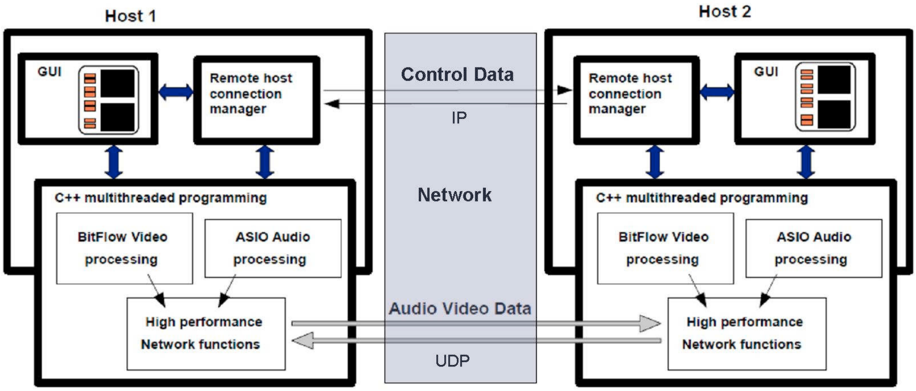

Fig. 1. System architecture overview

designed for, and the hardware and software design solutions adopted, makes it different from any other videoconference system available to date. It was designed to fulfill a number of fundamental requirements: 1. to be suitable for musical performances relying on both audio and visual communication, with the goal to provide a natural and transparent end-user interaction; 2. to be low cost and portable; 3. to exploit bandwidth and robustness of dedicated high performance networks (e.g., LightNet Project, GARR, GÉANT, Internet2).

2.1 System Engineering

In order to achieve a low transmission and presentation latency, LOLA relies on software optimization and on high performance audio and video devices. Fast video acquisition and streaming relies on a family of industrial video grabbers by BitFlow Inc., which provides high hardware performances and a versatile programming API for low-level video processing control, and on industrial class progressive video cameras. Low latency audio performance is achieved by relying on robust hardware and driver equipment (RME Hammerfall and ASIO drivers). Both audio and video streaming are optimized for speed by relying on accurate audio acquisition, transmission, and rendering threads synchronization, and the system supports multiple indipendent audio channels. Figure 2 illustrates the threads organization implemented in the software design: accurate synchronization of acquisition and transmission threads is required to transmit audio and video data as fast as possible, and similarly accurate synchronization of receiving and rendering threads is essential to receive, decode and render audio and video data as fast as possible. On the networking side, a low level network packets handling system has been created and used, to avoid hidden queueing provided often by common network software. Finally, to mitigate the effects of jitter that might arise in public network due to presence of irregular network traffic, a network jitter compensation mechanism is provided for both audio and video, through read/write ring buffers.

Current release supports audio at 44100 samples/sec, 16 bit, and 640x480 resolution video, at 60 or 30 fps, colour or black and white. Audio and video are non compressed,

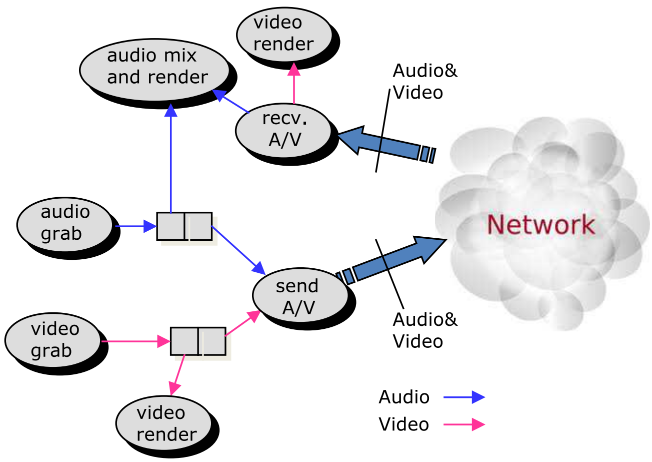

Fig. 2. Scheme of the threads involved in the audio and video streaming

to avoid introducing time delays in the encoding/decoding process. This allows to reach RTT delays (not considering network delay) as low as 5 msec for audio, and as low as less than 20 msec (estimated perceptually) for video. Network latency to be considered in the total RTT delay estimates is $<$1 ms on LANs, $\sim$1 ms per 100 Km on WANs. Jitter might become sensibly high when operating on network branches with public traffic, thus a buffering mechanism is provided to prevent data loss do to network delay oscillations. In terms of badwidth usage, LOLA requires at least 100 Mbps in minimal configuration (standard definition, b/w, 30 frames per second) up to 500 Mbps in full configuration (standard definition, color, 60 frames per second), and generates a very high Packet per Second (PPS) rate, as it uses 1 Kb data packets. Thus the minimal end-to-end connectivity must be at least 1 Gbps[1].

3 Distributed Performances

The LOLA project was conceived in 2005, and after a set of preliminary studies, the core system was developed between 2008 and 2010. LOLA first public showcase was in November 2010, with a live performance during the Network Performing Arts Production Workshop, by the piano duo Zaccaria-Trevisan (both professional performers and music teachers at the Tartini conservatory). The distributed piano concert was performed between the Music Conservatory ”G. Tartini” in Trieste and IRCAM in Paris, over a distance of 1300 Km, and featured some movements of Bach's Brandenburg Concertos (transcribed for piano 4 hands by Max Reger). During next year's Network Performing Arts Production Workshop, held in June 2011, the B. Bartok duets for violin were performed between the Conservatory of Trieste and the Gran Teatre del Liceu of Barcelona, at a distance of 2700 kilometers. The violin duo was made up of two brilliant

[1] The software and documentation is freely available for non commercial use at: `http://www.conservatorio.trieste.it/artistica/lola-project`

Fig. 3. Public networked live performances at four different moments of the LOLA system development. Top-Left: piano duo playing classical music repertoire (Bach, Reger) during 2010 Network Performing Arts Production Workshop at a distance of approx. 1300 Km (Trieste, Tartini Conservatory - Paris, IRCAM) ; Top-Right: violin-cello duo playing Haendel during 2011 Internet2 Fall Members Meeting at a distance of 1850 Km (Chicago, NIU - Raleigh, Congress Center); Bottom-Left: trumpet duo playing Bozza during 2012 Performing Arts Production Workshop, at a distance of approx. 2400 Km (Chicago, NIU - Miami, NWS); Bottom-Right: guitar-voice duo playng country tunes at a distance of 3500 Km (Chattanooga, TN - Los Angeles, CA) during 2012 Roots Riverside Country Music Festival.

students, Laura Agostinelli and Sebastiano Frattini, which have previously played together but still in their way to reach a complete technical maturity, proving that LOLA is also suitable to be used in the learning process and does not requires necessarily the experience of a mature concertist. A decisive test was then made in October 2011, during the ”Internet2 Fall Members Meeting”, between the NIU (Chicago, IL) and the Congress Center (Raleigh, NC), at a distance of 1200 Miles (1850 Km), featuring the execution of the Passacaglia for violin and cello by Handel by Marjorie Bagley (violin) and Cheng-Hou Lee (cello). In this case the two musicians had never played together before and had never met in life: after a one day rehearsal using LOLA (without a specific training), the day after they were able to successfully give a concert as if no distance nor technology was there. Since the first experimentations with LOLA, a number of successful performances have taken place during several other public events. In all these occasions, the system proved to be an effective transparent, non-invasive tool

Table 1. Some of the LOLA performances during public events in years 2010-2013

Event	Locations	Distance	Repertoire
Network Performing Arts Production Workshop, 2010	Tartini (Trieste)-IRCAM (Paris)	1300 Km	Piano Duo: Bach, Reger
Network Performing Arts Production Workshop, 2011	Tartini (Trieste) Gran Teatre del Liceu (Barcelona)	2700 Km	Violin Duo: Bartok
Internet2 Fall Members Meeting, 2011	NIU (Chicago, IL) Congress Center (Raleigh, NC)	1850 Km	Violin Cello: Haendel
Network Performing Arts Production Workshop, 2012	NIU (Chicago, IL) NWS (Miami, FL)	2400 Km	Trumpet Duo: Copland
JANET Performing Arts Networkshop, 2012	Royal College of Music (London) Napier Univ. (Edinburgh)	700 Km	Clarinet Piano: Mozart, Jazz
AEC Annual Meeting for International Coordinators, 2012	Tartini (Trieste) SS. Marcellino & Festo (Naples)	1200 Km	Trumpet Piano: Baroque, Romantic, Morricone, Dalla
Trieste Next International Festival, 2012	Tartini (Trieste) Ca Foscari (Venice) Academy of Music (Ljubljana)	750 Km (on GARR shared network) + 100 Km (on a 1Gbps Lambda)	Cello Quartett, Cello Duo Liute: Mozart, Vivaldi
Internet2 Fall Members Meeting, 2012	NIU (Chicago, IL) Sheraton Hall (Philadelphia, PA)	1700 km	Violin Cello: Haendel Halvorsen
Roots Riverside Country Music Festival, 2012	River Park (Chattanooga, TN) USC (Los Angeles, CA)	3500 Km	Guitars, Voice: Country
La Musica Viaggia Veloce, 2013	Tartini (Trieste) - Conservatorio (Frosinone)	1000 Km	Sax, Drums, Piano, Bass: Jazz Quartet

to remotely teach, rehearse and perform together. Table 1 gives an overview of the most relevant demonstrations to date.

If compared to inherent latencies introduced by standard videoconferencing systems (e.g. DVTS, Conference XP, Skype), usually not below 0.5 sec for both audio and video, the inherent low latency provided by LOLA was received very favourably by musicians who had former experiences related to distributed musical performances. In all cases in which the RTT was kept below the 75 msec threshold, performers reported to be able to play comfortably and to feel the system as transparent after a short while (this operating situation was met in all public events, see e.g. Fig. 3).

3.1 The Impact on Distance Music Education

Standard videoconferencing systems as the ones mentioned, also limit the effectiveness of distance teaching, since the teachers is not able to play along with students, because of the high transmission latencies, and the teaching action goes necessarily through verbal communication in deferred time: first the student plays, and then the teacher comments on his performance. The ability to play together guaranteed by LOLA allows to reintroduce a decisive factor in the praxis of distance music education, i.e. the non-verbal communication: a peculiar trait of music lessons, where the teacher accompanies the student by marking the rhythm, the phrasing articulation, and checking and suggesting the performing gestures. With this respect, other systems for distance learning, characterized by higher latencies, do not allow the purely musical interaction between the teacher and the student, forcing to resort to the mediation of speech for the most part.

The high quality audio rendering also allows to accurately deal with timbre aspects. The ability to intervene in real time on the timbric nuances of touch, on the gestures and with gestures, significantly expands the horizon of the distance musical education.

Last but not least, the significant reduction of the traveling and accommodation costs has a relevant impact on the opportunities for increasing cultural and technical skills, both from the teaching and from the professional point of view.

3.2 Considerations on Delay Impact and on Remote Acoustic Scene Rendering

During laboratory test sessions, in which latencies were artificially rised or lowered on request, a number of observations were collected concerning the different factors participating to the perception of interaction delay and on their impact on performance quality: the musical repertoire, the timbre and dynamic characteristics of the musical instruments, the reverberation and remote instrument rendering, among others.

To further discuss the importance of audiovisual communication delay in distributed interaction, let us refer to the following scenario: two musicians in different locations, connected through the network, must play together a sequence of four notes, lasting one second each, so that the notes played from the first musician are synchronous to those performed by the second musician. If the transmission channel and the signal encoding/decoding system introduce a noticeable delay, the second musician has to wait for the note from the first musician to arrive. When the first note of the musician arrives and is rendered, the second player can finally start playing his note. The execution of the second musician, in turn, is sent through the network to the first musician, who will receive it with the inherent delay of the transmission and reproduction system, plus the delay introduced by the second musicians. Only then the first musician will be allowd to play his second note, and so on, note after note. The delays due to technology sums up to the delays introduced by musician's due to their reaction time, and the concatenation of waiting and transmission delays gives rise to a rallentando, eventually leading to the loss of musical coordination bewtween the two. The overall delay is determined by the human-machine-human interaction. To be able to play together, the latency of the system should not be perceptible, i.e. should not exceed the order of magnitude of the thresholds of perception for temporal segregation (approx. 30 ms). To give an approximate indication, the round trip delay introduced should be no more than 75 ms (which is however an indicative value, which is subject to many variables: the class of musical instruments involved, the music repertorie and, last but not least, the musical skill of musicians). If the delay is kept below the threshold of perception, the human factor exits the dynamics of the growing delay loop, and the round trip delay reaches a stable value determined for the most part by the signal encoding/decoding, transmission timings, and network performance.

The microphones and sound diffusion setup may vary consistently, depending on the instruments involved and the acoustic characteristics of the rooms where the performers and the public are located. In principle, the use of small diaphragm condenser microphones, with cardioid polar figure and located fairly close to the acoustic source, is a good choice for a punctual recovery of the acoustic source nature and to minimize the electroacoustic feedback. To render the sound of the remote acoustic sources, a cluster of loudspeakers is used, directed radially with respect to the position of the virtual

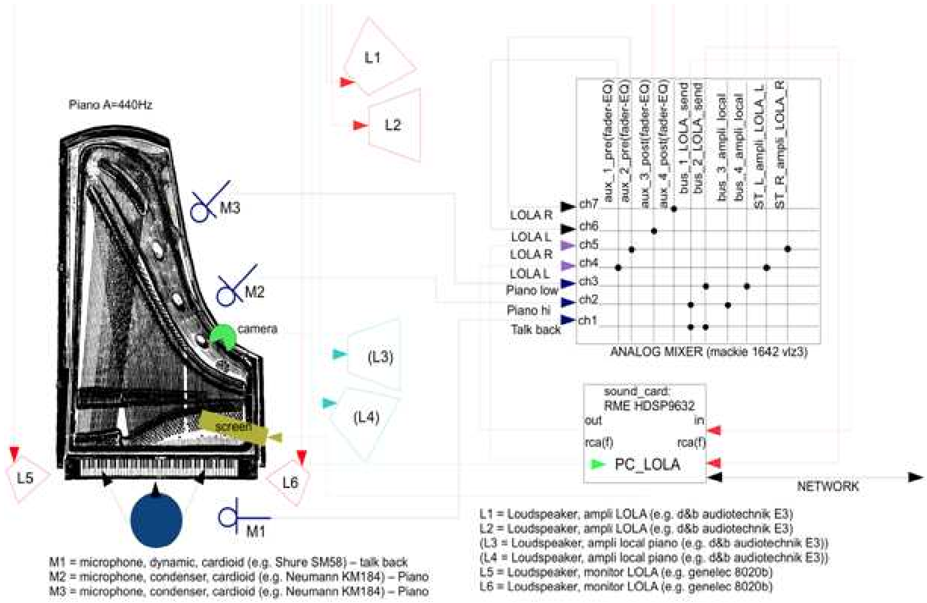

Fig. 4. The LOLA setup used for the distributed piano due performaces

remote instrument to simulate its sound radiation. Figure 4 illustrates the typical setup used so far for distributed performances involving two grand pianos.

Finally, another important element of the performance is the eye contact between the actors, in order to strengthen the understanding, as well as a comfortable environment in terms of reverberation, sound immersion and concentration.

All these factors will be sistematically investigated in future research concerning the musical applications of LOLA.

4 Considerations on Network Traffic

Since the beginning of LOLA design we assumed that the network was able to deliver in a timely and reliable way the audio and video data. This has proven to be true on all the long distance academic networks used (GARR, GANT, RENATER, Red.Es, JANET, Internet2, etc.) (see Fig. 5), but issues were discovered in some Local Area Network (LAN) setups: indeed, the quite high Packet Per Second rate generated by LOLA can put a non negligible stress on some LAN switches, when other application and services also compete with similar requirements (like Voice over IP services), and in a few cases the equipment is unable to perform correctly. However, this has always been solved bypassing the troubled equipment to access directly the network backbone, and most modern devices do not show the problem.

In order to ensure LOLA data traffic to be delivered, we also assumed that "overprovisioning" the network capacity is the best possible strategy: in fact we also successfully tested bandwidth resevation techniques, in situations where the situation could be critical (see Fig. 6, upper panel). But network latency also depends on network equipment

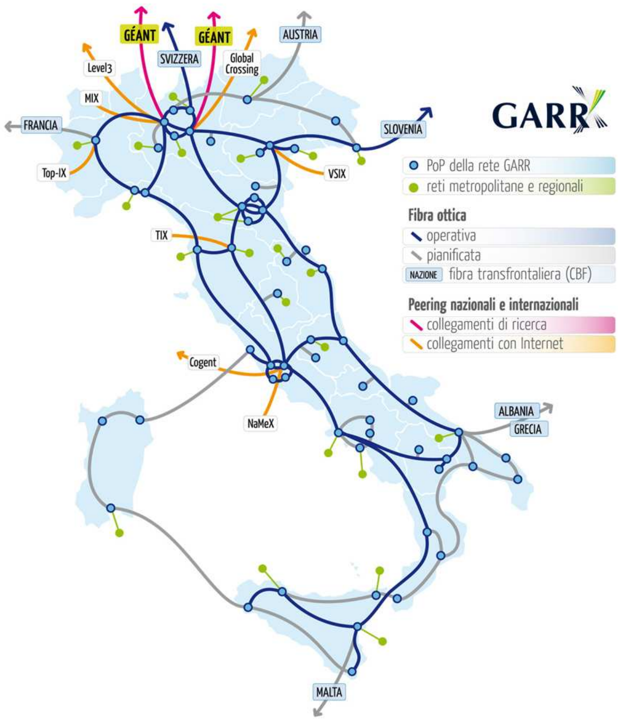

Fig. 5. The GARR-X dark fiber optical backbone

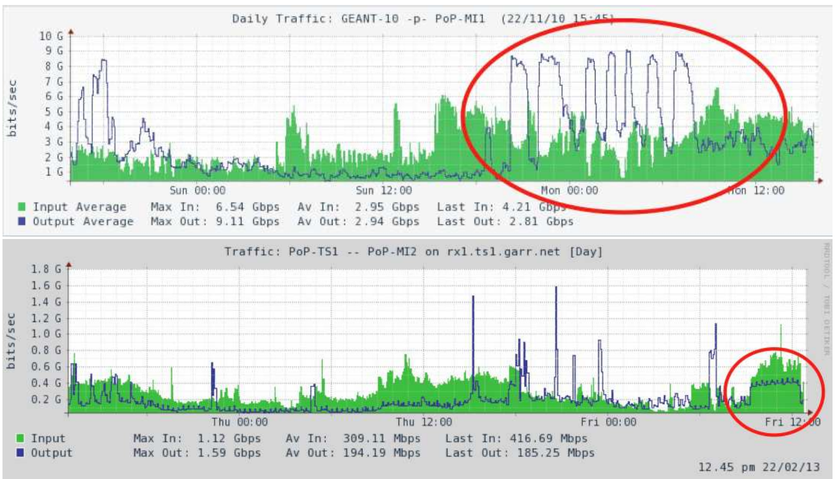

Fig. 6. Upper plot: network traffic close to backbone capacity (10 Gigabit at that time) close to the first public LOLA showcase in November 2010, when bandiwidt control techniques were used to ensure the minimal capacity for LOLA. Lower plot: LOLA traffic (in the red circle) on one of the GARR-X 10 Gigabit backbone generated by a single LOLA session.

processing time, and the more processing is added to packets, the more network latency is increased, thus overprovisiong shall be the preferred method, as it also ensures a much lower network jitter, and limits the number of buffers needed to counteract possible jitter effects on audio/video data delivery. On the basis of laboratory measures, we established that a single jitter audio buffer introduces approximatey 0.75 msec of additional delay (one-way). Whenever a shared network circuit was used, without any specific protection for the LOLA traffic and in regular traffic conditions, we observed that avarage jitter is normally around 1.5 msec, and 3 to 5 audio buffers are necessary to ensure a perfect audio communication. When protected circuits (including virtual ones) are used, for which jitter is still present but usually below 1 msec, 2 to 3 audio buffers are usually required to avoid audio drop-outs. When jitter is below the observable threshold, e.g. when using lambda or ad-hoc circuits, it is possible to avoid the use of buffering.

Last, but not the least, LOLA can generate, just for a single node running in standard definition, a non neglegible data traffic, which can be still very well visible also on high speed backbones (fig. 6, lower panel) where shared traffic runs. This thus requires a careful network planning, to avoid transforming LOLA into a network ”killer application”.

5 Conclusions

A new audio visual streaming system, characterized by high quality audio/video rendering and by very low data acquisition, transmission and presentation delays, has been illustrated. It was designed to accomplish time-critical distributed interactive tasks such as distributed music performance. It was assessed with respect to this specific aim by involving professional music performers playing classical repertoire over wide geographical distances, and it proved suitable and effective for distance musical rehersal, performance and production.

The remote musical interaction, either aimed at distributed public performances or at remote teaching purposes, is only one of the many possible applications of the LOLA system, which not only lends itself to experimentation in related fields such as dance theater, performing arts and teaching methods, but also in the more general range of disciplines concerning distributed interaction in the presence of hard time constraints, e.g immersive virtual reality and medical applications, for which there is an high interest in exploring the new fronteers of remote interaction offered by low delay audiovisual streaming technologies and high performance networks.

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Algorithmic Generation of Music Tunes for an iPhone® Game

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Abstract. This paper describes an algorithm employable in a game to automatically compose music tunes over a given chord progression. A key feature of our proposal is its efficiency in terms of computational power and resource occupation, which makes it usable in real time within mobile devices such as MP3 players and smart phones. Besides, music themes can be randomized, so that the cyclic repetition of the same chord sequence becomes the base for non-repetitive tunes, different as regards both their melodic contour and their rhythm. Furthermore, the complexity of the generated themes can be modified in real time by setting numeric parameters. A complete C++ implementation of the algorithm is provided.

Keywords: music, algorithms, automatic composition.

1 Introduction

A great number of algorithms are available to automate some processes typical of music composition. For instance, *ad hoc* algorithms can solve problems such as the harmonization of a music tune, the computation of an euphonical melody over a given chord progression, the creation of rhythmical pattern and loops, etc.

The adoption of formal instructions and processes to create music dates back to the ancient Greeks. In more recent times, W.A. Mozart used a simple technique in his *Musikalisches Würfelspiel*, in order to automatically create a menuet starting from music fragments [1]. The possibilities of automated composition had been predicted by Ada Lovelace, an early computer scientist, in the 19th century [2]. A pioneering use of the computer in algorithmic compostion is that of Iannis Xenakis, who created a program to produce data for his "stochastic" compositions, and described it in [3]. Some more recent approaches can be found in [4], [5], and [6].

The algorithm described in the following starts from a number of music parameters (e.g. meter, minimum rhythmic value, chord sequence, etc.) in order to automatically compose a tune to match the given harmonic and rhythmic

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background. The application field for this algorithm is a music game for Apple iPhone®. Section 2 will provide some details about the game play, so that the goals and the implementation choices will be clarified. Even if our proposal addresses a very specific application field, the proposed algorithm can be employed in a number of heterogeneous applications, ranging from the real-time composition of stochastic pieces of music to the on-the-fly creation of adaptable ring tones.

First, it is worth defining some terms used later in this paper to indicate specific concepts. For *music tune* we mean a succession of musical sounds forming a melody, without the harmony accompanying it. The concept of music tune embraces two complementary aspects: rhythm and melody. For *accompaniment* we consider the instrumental part that supports the solo part, thus constituting a background to the foreground tune. In the case we will discuss, the accompaniment is a loop that provides the harmonic background for the music piece, with a given rhythmic base. The harmonic background is realized through a progression of chords, called in the following chord sequence. Finally, let us define the concept of *music event*: it refers to the occurrence of a sound (note event) or to the absence of sound (rest event), as notated in a music score.

2 Game Play

The background of our work is the design of a music game for visually impaired people, available on iPhone® platform. The interface is intentionally very simple from a graphical point of view, due to the target of the game. The goal is repeating a given rhythm by finger-tapping the iPhone® touch screen. In detail, the player listens both to the leading part and to the accompaniment for a whole measure (say measure $2k-1$, with $k \in N$), and he/she tries to repeat the rhythmic pattern of the former during the following measure (numbered $2k$), when only the accompaniment is played by the system.

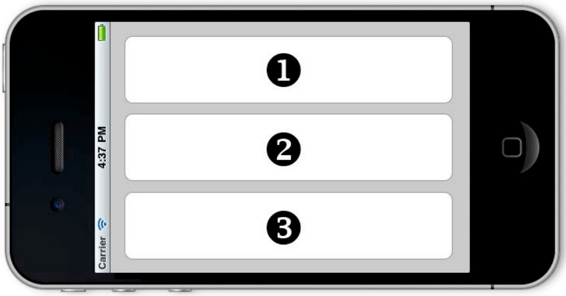


Fig. 1. The game interface

Please note that melody-related aspects are interesting only from an aesthetic perspective: the final result should sound euphonical, but the game play concentrates only on rhythm. Nevertheless, in order to give an idea of variety, it is desirable that the same rhythm is applied to different melodic contours, as well as the same harmonic background pattern (i.e. the selected chord sequence) at each iteration is used to support different tunes.

The interface, schematically shown in Figure 1, presents three buttons, corresponding to three different music instruments. The system selects an instrument to play measure m, and the user can choose - note by note - one of the available timbres to repeat the rhythmic sequence during measure $m + 1$.

The algorithm proposed in this paper aims at creating a random music tune which matches the underlying chord sequence. Since the generated tune has to be used in a game context, the musical complexity and the consequent current degree of difficulty should be either increased or decreased on the base of the player's performances. Consequently, the algorithm has to work in real time and measure by measure, in order to promptly react to user's behaviour. As explained before, our code provides a set of variables to influence the tune computation, e.g. the rhythmic density, the minimum rhythmic figure, the probability of tying notes, etc.

3 The Proposed Algorithm

In order to build an automatic music composition system that can simulate the abilities of a human composer, it will be necessary to incorporate knowledge of musical conventions into the systems. Music composition is made of many components. Its main aspects are: melody, rhythm, harmony, and orchestration. Let us consider them one by one to illustrate our approach.

In this context, only melody and rhythm must be automatically determined, and more in detail the melodic and rhythmic characteristics of the leading line, i.e. the music tune. All the other lines, which we have defined as the accompaniment, are given as the input. Consequently, the harmonic background for the music tune can be inferred from the accompaniment. For a number of applications the accompaniment could be available in digital audio format (like in the iPhone® game described above), but analysing its spectrum to extract a chord sequence would be a resource-consuming task, especially in a real-time environment. Thus, our implementation introduces some limitations: 1) chords must be expressed in a symbolic format, through the list of notes that form the chord itself, and 2) a unique chord is used to harmonize an entire measure. Finally, also orchestration-related aspects are not relevant, as the purpose of the algorithm is computing a sequence of notes, in terms of rhythmic figures and pitches, and not establishing a timbre to play them. For instance, the iPhone® application mentioned before uses pre-recorded loops for the accompaniment and samples for the leading part, extracted from a restricted set of available instruments.

This section contains not only a detailed explanation of our approach, but also some code snippets of a C++ implementation. The complete source code of the algorithm is available at the following address:
http://www.lim.di.unimi.it/download/musictune.zip.

C++ has been chosen in order to maximize the compatibility with available systems and environments. For example, ObjectiveC (the native language for iPhone® and iPad® applications) can be mixed with code written in C. Needless to say, a different choice such as Microsoft C♯ from .NET platform would simplify the management of dynamic data structures and would make the code more compact and easier to read.

In the following the algorithm will be described in detail, in particular as regards rhythmic and melodic aspects. The music tune is determined through a two-step process which takes into account the mentioned aspects in this order, by calling two ad hoc public methods: `generateRhythm()` and `generateMelody()`. After the explanation of the algorithm, Section 4 will present some clarifying examples, while Section 5 will provide information about computational complexity and performance analysis.

3.1 Classes and Basic Data Structures

Now we introduce the basic classes and data structures that have been implemented in the C++ library. The following snippets show how notes and rests are represented.

```
typedef struct{
   short num;
   short denExp;
} durationStruct;

typedef struct{
   short midiPitch;
   durationStruct duration;
} noteStruct;
```

The structure called `durationStruct` is employed to encode note values, e.g. crochets, quavers, etc. Since rhythmic figures typically have a denominator that is a power of two, not any positive integer value would be valid, at least according to Common Western Notation rules. In our implementation, the denominator can be inferred from an integer value $n \in N^0$ by raising the base 2 to the n-th power. For instance, $n = 2$ corresponds to quarter notes (since $1/2^2 = 1/4$) and $n = 3$ to eighth notes (as $1/2^3 = 1/8$).

In order to completely define a note event, pitch information is required too. This is the goal of `midiPitch`, an integer field inside `noteStruct`. For this field, admissible values are:

- -1, representing the initialization value, i.e. a note event with unspecified pitch;
- 0, meaning absence of sound and employed also for all the non-initial parts of a tied note. In the latter case, also the numerator of `durationStruct` is set to 0;
- Any value in the range [1..127], indicating a sound with a frequency fixed by the corresponding MIDI pitch.

In this context, a MIDI-like approach is sufficient to encode both notes and rests. Even if pitch description in a music score is more detailed (i.e. note name and accident), here the goal is creating a sequence of frequencies to be played, no matter which symbols have been originally written in the score: a MIDI-like representation is fit for such a purpose.

In tonal harmony, a chord is completely defined through a chord model (say major triad) on a fundamental degree (say the dominant) built on a scale model (say the major mode) applied to a given tonic note (say C). For example, the chord composed by [G, B, D] can be a (major) triad built on the dominant of C major, but also on the tonic of G major, as well as on the sub-dominant of D major. However, for our purposes, any harmony in the chord sequence can be simply defined through a choice of elements of a given scale. In this way, the previous chord becomes the set of indexes [4, 6, 1] on the C-major scale, defined by the MIDI-pitch array [60, 62, 64, 65, 67, 69, 71].

A more complex example is called for. A Neapolitan sixth chord is a major chord built on the lowered second scale degree (super-tonic) which occurs in first inversion. In C major, the chord is made of [F, A♭, D♭], and two of its components do not belong to the major scale model. In our representation, we adopt a model scale different from C major, namely the Neapolitan minor scale on C, whose MIDI-pitch array is [60, 61, 63, 65, 67, 68, 71]. In this case, the Neapolitan sixth chord simply becomes the set of indexes [3, 5, 1], as shown in Figure 2.

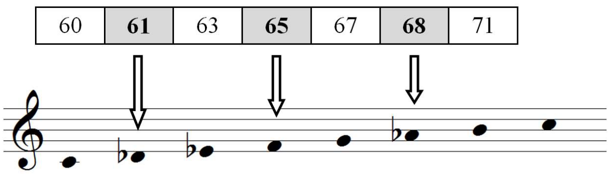


Fig. 2. The representation of a Neapolitan sixth chord in C major through *ad hoc* indexes on a Neapolitan minor scale

The information about the current scale could seem redundant. In fact, instead of focusing directly on the chord-related MIDI pitches, we are referring to an superabundant list of MIDI pitches (the scale) in order to filter it later. But this process offers an advantage: in this way the algorithm which calculates melody can pick also other "coherent" pitches, outside the chord but belonging to the current scale. Please note that scale information cannot be inferred from the chord, since the same chord (e.g. a G major triad) can belong to different tonalities (e.g. C major, G major and D major). Our library provides a unique class to pass all harmony-related information, i.e. the current chord and scale. Some methods make it easier to evince both the former and the latter from basic music information, instead of specifying data structures index by index: for instance, one of the constructor's overloads lets the user specify them through the tonic and the scale model. The class header is shown below.

```
class ScaleAndChord{
public:
   ScaleAndChord();
   ScaleAndChord(noteName tonic, scaleType type);
   ScaleAndChord(int _scale[], int _chord[]);
   ScaleAndChord(int _scale[], int _scaleLen, int _chord[],
    int _chordLen);
```

```
    void transpose(int k);
    int prevNote(int note);
    int nextNote(int note);
    bool belongsToChord(int note);
    int scaleIndex(int note);
    int* scale;
    int* chord;
    int scaleLength();
    int chordLength();
    char* scaleModel();
private:
    // omissis
};
```

The main class of our library is `Measure`, since the algorithm works measure by measure. The corresponding code snippet is shown below. When an object is instanced, a `durationStruct` parameter can be passed to specify the basic meter. The notes that form the tune are saved into an array data structure of `noteStructs`. The number of elements in the array can be obtained by calling the `length()` method. Finally, the integer variables whose name starts with `perc` prefix (standing for "percentage") are used to manually configure the characteristics of the music tune to generate. They represent the percentage of notes to tie and delete respectively. The latter case implies the generation of rests.

```
class Measure{
public:
    Measure();
    Measure(durationStruct timeSignature);
    short length();
    void generateRhythm(durationStruct subdivision);
    void generateMelody(durationStruct minAccentGranularity,
     int chord[]);
    static void copyRhythm(Measure* m1, Measure* m2);
    durationStruct timeSignature;
    durationStruct subdivision;
    noteStruct* notes;
    short percGroupNotes;
    short percDeleteNote;
private:
    // omissis
};
```

3.2 Rhythm-Related Aspects

The algorithm works on a single measure and first determines the sequence of rhythmic values. As it operates measure by measure, it would be virtually possible to have a different time signature and rhythm granularity for each of them. The latter aspect is important to allow scalability, and consequently to set music-tune complexity. For example, a pattern of sixteenth notes is potentially richer than a rhythm made of quarter-note beats, since:

– Notes are more numerous, shorter and less spaced in time;
– Thanks to the introduction of rests and ties, more rhythmic variations and music-accent combinations are available.

The very first step is creating an array of n cells to contain the music-tune's rhythm information for the measure. The array length depends both on meter and on the smaller rhythmic value a beat can be subdivided into. The former information is specified when the current measure is instanced, whereas the latter is a parameter passed when the `generateRhythm()` function is called.

The algorithm allows to choose both a time signature T and the minimum rhythmical value V to appear inside the measure. Given $T = n/2^d$ and $V = a/2^b$, the length of the V-values array is

$$l = \lceil (n/a) \cdot 2^{b-d} \rceil.$$

For instance, for $T = 4/4$ and $V = 1/8$, $l = \lceil (4/1) \cdot 2^{3-2} \rceil = 8$, which correspond to 8 fields containing eighth-note values. As a further example, consider $T = 6/8$ and $V = 3/4$, namely a dotted half-note. In this case $l = \lceil (6/3) \cdot 2^{2-3} \rceil = 1$, that is a single-cell array that contains one dotted-half value.

In order to dimension the basic array, apparently a problem arises when a given time signature is not compatible with the chosen subdivision value. In this case, the ceiling function solves the problem, and the last cell will not contain a whole subdivision value but the remainder of the measure. For example, given $T = 9/16$ and $V = 1/4$, then $l = \lceil (9/1) \cdot 2^{2-4} \rceil = \lceil 9/4 \rceil = \lceil 2.25 \rceil = 3$.

In this case the first 2 array fields contain one quarter-note each, and the last field the remainder, namely one sixteenth note $(1/4 + 1/4 + 1/16 = 9/16)$. As regards the complexity of the generated rhythm, a number of considerations emerge. Time signature is the first aspect that affects the overall complexity. Some meters such as 4/4 or 6/8 are very common, and they are perceived as easy to understand and reproduce in Western culture. On the contrary, irregular time signatures such as mixed meters (e.g. 5/4 + 6/4), additive meters (e.g. (3+2+3)/8), or even “irrational” meters (e.g. 3/10) are intrinsically more complex. However, the framework where the algorithm operates usually include a given harmonic grid over a predefined time signature, so the metric aspect is an input rather than a parameter to set inside the algorithm in order to change complexity.

On the contrary, with a given time signature, granularity can be chosen measure by measure. For instance, a “plain” meter such as 4/4 can originate an irregular-sounding rhythmic pattern when the measure is subdivided into dotted eighth notes.

After the creation of a grid of equal values - represented in our implementation by an array, as explained before - this data structure must be appropriately compiled. The initialization phase fills all array cells with default notes, having the duration field equal to the subdivision and the `midiPitch` field set to `-1`. Then, on the base of *ad hoc* percentage values, some cells of the array are deleted in order to create rests, whereas some consecutive cells are tied to create longer values. Please note that in both cases the `midiPitch` field is set to 0 for the cells involved. In music notation, a tie is a curved line connecting the heads of two notes of the same pitch, indicating that they are to be played as a single note with a duration equal to the sum of the individual notes’ values. In this case, pitch still has to be defined, so any pair of note events can be tied. As the values of the individual notes are identical, it is sufficient to empty the second cell and to double the duration coded inside the first one.

3.3 Melody-Related Aspects

After the creation of a rhythmical pattern, the algorithm has to assign pitches to note events in order to generate the final music tune. In terms of data structures, this implies changing `midiPitch` values previously set to -1, namely the default value for undefined pitches.

Pitches are computed by applying a simple set of rules involving both harmony and melodic-contour aspects. This set has been derived directly from music theory. In particular, the concepts of group boundaries and transitions exposed in [7] are applied to passing notes, namely those notes occurring on weak subdivisions. The code fragment containing the `generateMelody()` method is provided below. When `generateMelody()` is invoked, two parameters are passed.

1. The first parameter contains all the information about harmony: through a compound value, namely an instance of the `ScaleAndChord` class, both the current scale and chord are passed. The chord is used to harmonize the measure, and it is fixed through a list of indexes referring to the mentioned scale. A known limitation of the algorithm is using a unique chord for the harmonization of the whole measure. However, more complex cases can be easily managed by changing time signature. For example, if a 4/4 meter has to be harmonized through a 4-chords bass (like in many chorales by J.S. Bach), the algorithm can be instructed to operate in a 1/4 meter.
2. The second parameter contains the granularity G of "strong notes". This concept needs to be clarified: it indicates the subdivisions where notes should present pitches belonging to the current chord, provided that they are present in the data structure. In fact, in a given position there could be a rest, or the second part of a tied note. Please note that this parameter goes beyond the concept of beat, which is strictly related to time signature.

```
void Measure::generateMelody(ScaleAndChord* scaleAndChord,
    durationStruct minAccentGranularity){
    // the first pitch appearing in the measure must belong to the chord
    for (int i = 0; i < length(); i++)
        if (notes[i].midiPitch == -1){
            notes[i].midiPitch = _chooseChordNote(scaleAndChord);
            break;
        }
    // choice of notes in the chord
    int max =
        notes[length()-1].duration.denExp > minAccentGranularity.denExp ?
        notes[length()-1].duration.denExp : minAccentGranularity.denExp;
    int granScaled = minAccentGranularity.num * pow(2, max -
        minAccentGranularity.denExp);
    int subdScaled = subdivision.num * pow(2, max - subdivision.denExp);
    for (int i = 0; i < length(); i++)
        if (i * subdScaled % granScaled == 0 && notes[i].midiPitch == -1)
            notes[i].midiPitch = _chooseChordNote(scaleAndChord);
    // choice of the remaining notes
    for (int k = granScaled / 2; k > 0; k = k / 2)
        for (int i = 0; i < length(); i++)
            if (i * subdScaled % k == 0 && notes[i].midiPitch == -1)
                _computeMelody(scaleAndChord, i);
}
```

At this point, an example is called for. Let the time signature be $T = 3/4$ and the minimum granularity $V = 1/16$. By setting granularity $G = 1/8$, the algorithm is forced to choose a chord component for each eighth note, rather than using the default subdivision, namely $G = 1/4$. Figure 3 illustrates this case, where each quaver (if present) has a pitch that belongs to the current chord.

On the contrary, $T = 4/4$, $V = 1/4$, and $G = 1/2$ would force the presence of a pitch belonging to the chord only on the first and on the third subdivision of the measure, as shown in Figure 4. The other pitches can be determined on the base of the rules explained below. For example, one of these rules states that the first and the last note-event in any measure has to belong to the current chord.

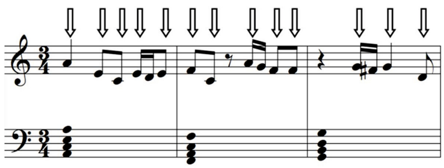


Fig. 3. Granularity $G = 1/8$

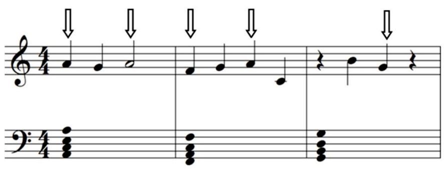


Fig. 4. Granularity $G = 1/2$

The rules to assign pitches to the previously computed rhythmic values can be viewed as a two-step process. The algorithm first takes into account "strong" notes, namely those note events occurring on strong beats, as defined by parameter G. For them, a pitch is randomly chosen among the current chord's ones. Here and in the following, the term "random" indicates an event in which all outcomes are equally likely. Needless to say, the algorithm to produce a sequence of random (or rather pseudo-random) numbers depends on the implementation.

All remaining notes are virtually managed in a recursive manner. For the sake of clarity, first we will state in which order note pitches are evaluated, and then we will enunciate the rules to produce the final pitch value.

Weak notes' pitches are fixed by taking into consideration their position inside the measure, ranging from the greater to the smaller subdivision. The greater subdivision corresponds to the maximum rhythmic value that has not been considered "strong", whereas the minimum value is the one defined by V. For example, given $T = 4/4$, $V = 1/16$, and $G = 1/4$, the algorithm for weak notes starts from one-quaver (1/8) subdivisions, and then considers one-semiquaver (1/16) subdivisions. When a pitch has already been set by a previous step, it is not redefined. In other case, for the cited example the first music event (provided it is a note) would be redefined many times, as it occurs on a semibreve, minim, crotchet, quaver and semiquaver subdivision. This *divide et impera* technique adjusts pitches progressively, until the smallest values defined by V are taken into account.

After explaining the order note events are evaluated, let us illustrate the rules for determining pitches. Weak notes are managed as follows:

1. The pitch of the first and last note event in a measure is always randomly extracted from the current chord. This guarantees that - apart from rests - a measure starts and ends with a note belonging to the harmony;
2. For a note which is not surrounded by two pitches already set, a random value of the current scale is chosen;
3. For a note surrounded by two known pitches:
   (a) If the previous and the following pitches are equal, a random choice is made among a one-step higher grade of the scale (upper mordent), a one-step lower grade (lower mordent), and the pitch itself (ribattuta);
   (b) If the previous and the following pitches differ by two steps (e.g. they form either an ascending or a descending third interval on the current scale), the current pitch "fills" the interval through the intermediate scale grade;
   (c) In all the other cases, a random choice is made among the current-scale grades.

Please note that the `computeMelody()` function tries to make a choice depending both on the previous and on the next note event. This is always possible for the smallest rhythmic values, since the previous steps (adjustment of strong notes and longer values) have already set the pitch of both surrounding note events. The complete process will become clear thanks to the examples shown in Section 4.

The mentioned measure-by-measure approach presents some known drawbacks. First, the music tune may appear to be discontinuous over measures, above all from a melodic perspective. In fact, rhythm can be copied from a measure to another by calling the `copyRhythm()` method, as required by the game play passing from measure $2k-1$ to measure $2k$; on the contrary, the algorithm performs independent calculations as regards melody. This approach is perfectly coherent with our goals, but it could represent a limit for other applications.

Needless to say, the set of rules could be modified and expanded, for instance in order to create variations of the original melodic line such as ornaments. Another improvements could be addressing a specific music genre and its own peculiarities: for example, Renaissance, Baroque, Romanticism and twelve-tone music apply very different composition rules and approaches. However, in this context the relatively small set of rules enunciated before has demonstrated to be effective.

4 Examples

In this section we will illustrate a step-by-step example that covers the whole process, from the determination of rhythm (part 1) to melody (part 2) for the music tune. All the figures present both a table containing some data-structure fields and the corresponding music notation. As regards the former, the upper row of the table contains current values for note pitches, whereas the lower row gives a numeric representation of rhythmic figures. Cells are vertically aligned to music notation. In this example, let the time signature be $T = 3/4$ and the minimum granularity $V = 1/16$. Consequently, the array is made of $l = 12$ elements. Its initial settings can be represented as follows.

−1	−1	−1	−1	−1	−1	−1	−1	−1	−1	−1	−1
1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16

Now the first part of the algorithm can be launched. As explained in Section 3.2, the rhythm of the music tune is determined through a two-step procedure. First, some notes are randomly deleted. In the data structure, this means setting their pitch to 0, as shown below.

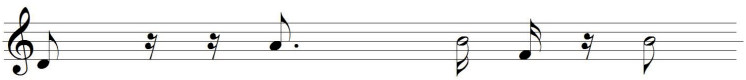
−1	−1	0	0	−1	−1	−1	−1	−1	0	−1	−1
1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16

Then, some of the remaining note events are grouped through ties, like in the following example.

−1	0	0	0	−1	0	0	−1	−1	0	−1	0
1/8	0/16	1/16	1/16	3/16	0/16	0/16	1/16	1/16	1/16	1/8	0/16

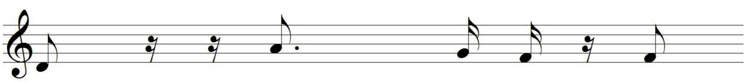
Now the second part of the algorithm can be invoked: it aims at the choice of a melody for the rhythmic pattern previously computed, on the base of the harmony-related information provided to the algorithm itself. As described in Section 3.3, also this process can be subdivided into two steps. First, the algorithm adjusts the pitch of strong notes. Let the granularity of such notes be $G = 1/4$ and the chord a triad on the tonic of D minor. A possible result is:

62	0	0	0	69	0	0	−1	65	0	−1	0
1/8	0/16	1/16	1/16	3/16	0/16	0/16	1/16	1/16	1/16	1/8	0/16



where a white note-head indicates unknown pitch. In fact, this step adjusts only the notes occurring on quarter subdivisions, coherently with the value of G. The pitch information of all the other notes is fixed by the second step of the algorithm. Applying the set of rules previously enunciated: i) the third note event "fills" a third interval by a descending movement, picking the intermediate pitch from the current scale, and ii) the last note event has to belong to the D-minor triad. An example is provided below.

62	0	0	0	69	0	0	67	65	0	65	0
1/8	0/16	1/16	1/16	3/16	0/16	0/16	1/16	1/16	1/16	1/8	0/16



Finally, Figure 5 present 5 different music tunes produced by the algorithm on the base of the following values: $T = 4/4$, $V = 1/8$, $G = 1/2$, delete percentage = 30% and tie percentage = 40%. Rhythm is copied from odd to even measures, as required by the iPhone® application. The 4-measure chord sequence is Gm - F - C - C.

Fig. 5. Examples of music tunes built on the same input parameters' values

5 Evaluation of the Generated Music

Providing an objective evaluation about the quality of computer-generated music is a difficult task, above all when a certain degree of randomization is required. In the following, we will supply some considerations to make an evaluation possible.

First, the adoption of a simple set of rules derived from music theory and from well-known generative processes guarantees that all music tunes are perceived as euphonical in a tonal context. Let us recall that the notions of current scale and chord are used to determine pitches, so that each note falls on an acceptable scale degree. The concept of "acceptable" is a subjective one, too: needless to say, what is acceptable in serial music was not in baroque music. Given the purpose of this work, the field could be limited to a simplification of traditional harmony, e.g. considering only major and minor scale models, and only triads, tetrads and their inversions. Nevertheless, the algorithm has been generalized: since both a chord and a scale can be specified, also "odd" results can be easily obtained. For instance, the commercial iPhone® application which adopts this algorithm employs a number of jazz scales.

Moreover, the algorithm keeps a distinction among strong and weak notes, depending on their position in a measure. The pitch of the formers always belongs to the current chord, and this adds a sense of euphony to the final result.

We conducted many experiments and made several subjective tests, concentrating both on musicians and on untrained people. The total amount of test users was about 100 people. In most cases the computer-generated music tune was evaluated as "good-sounding". However, an interesting result emerges as regards the adoption of unusual scales and chords. First, the average subjective evaluation of the generated tune gets worse and worse when scales and chords progressively deviate from tonal music and from its traditional major/minor models: most jazz scales still originate tunes perceived as acceptable, whole-note and pentatonic scales are harder, and finally many modes of limited transposition (see [8] for further details) generate bad-sounding tunes. Clearly, the subjective evaluation changes noticeably depending on the user's familiarity with music, and with contemporary repertoire in particular.

6 Performance Analysis

6.1 Run-Time Analysis

The purpose of this kind of analysis is estimating the running time of the proposed algorithm as its input parameters change. The ultimate goal is evaluating the efficiency of the algorithm in order to understand if it can really work in real time. In general terms, real-time programs must execute within strict constraints on response time. But in this context the real-time environment is not so hard: it is sufficient that the following measure can be completely computed while the current one is in execution. We have executed a number of tests on different iPhone® physical devices. The table below illustrates the results of our tests on a 3G model.

T	V	G	Time to calculate 10^5 measures
4/4	1/8	1/2	10456 ms
4/4	1/16	1/2	14611 ms
4/4	1/8	1/8	9814 ms
4/4	1/16	1/8	13524 ms

The duration of a measure expressed in seconds depends both on the meter and on the bpm. If we consider $T = 4/4$ and $bpm = 200$ (prestissimo), the duration of a measure is $t = 1200$ ms. Consequently, during time t (namely the time required to play "prestissimo" a single 4/4 measure) our algorithm is able to compute about the next 10000 measures.

Performance measurement tools highlight that the most time-consuming step is the determination of a new seed for random sequences. Unfortunately, this process is required to guarantee variety for the music tune.

6.2 Memory Occupation

Memory occupation can be a challenging matter on a mobile system, where resources are limited and often shared among various processes.

The algorithm employs very simple data structures to encode only those aspects of music information which are strictly required by the algorithm itself. Under many points of view, our approach represents a simplification of music structures and notation. For instance, the way to represent chords over scales is not a traditional one, but it is functional for our purposes.

In our C++ implementation, music events are encoded through 3 short integers (see Figure 3.1). In most C++ compilers, `shortint` requires 2 bytes. Memory occupation could be further improved by using 1-byte data types.

Any measure, as illustrated in the code snippet, has both a fixed part and a variable part. The latter depends on the minimum granularity V chosen for the measure itself. The array structure representing music events is made of l values (l has been defined in Section 3.2), where each value in our implementation requires 6 bytes. The aggregated amount of memory required for the fixed part is $m = 22$ bytes. For instance, a measure having $T = 4/4$ and $V = 1/16$ (thus $l = 16$), memory occupation is $m = 118$ bytes.

7 Conclusions

The algorithm shown in this paper generates a music tune over a chord sequence. From a rhythmic point of view, such an algorithm is able to manage regular as well as irregular meters, internal subdivisions related or completely unrelated to time signature, and aggregations of simpler rhythmic figures through ties. Melodies are computed by applying a simple set of harmonization rules, in order to obtain an euphonical result with a small impact over computational complexity.

The richness of the generated music tune can be configured via a number of settings accessible by external code or human interfaces, which alter in real time the outcome of the process.

In conclusion, the proposed algorithm has proved to be both effective and efficient in the specific context of real-time music tunes generation, also for systems where scarce resources are available.

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Feature Matching of Simultaneous Signals for Multimodal Synchronization

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Abstract. The process of synchronizing multimodal data is used within numerous applications, including musical improvisation, interactive multimedia systems such as gaming, and exercise/sport tools. This project focuses on techniques to detect and match patterns and features from signals captured from different modalities, with particular interests in time-invariant approaches and digital warping for synchronization. Through applying feature detection algorithms and segment matching, the project aims to identify associated components within each signal for comparison with features from other associated signal streams, in order to provide feature matching. This has resulted in a framework that can be used to aid the development of a broad range of multimodal and data fusion systems. The paper also discusses a virtual conducting application as a test case that has been developed with the framework. The application alters the tempo of music playback according to physical conducting gestures.

Keywords: Multimodal, Synchronization, Edutainment, Music, Audio, Games.

1 Introduction

This paper discusses a generic framework for feature matching of simultaneous multimodal signals for alignment, data fusion and synchronization. The application contexts for this technology are highly varied, and include interactive multimedia systems, games and sports.

Typically, such a system consists of several streams of data or measurements that relate to one another. For example, conducting gestures and audio data of the piece being conducted, or, within a game, the actions of the player and the game's soundscape. In each case the output of the system is controlled by a multimodal input designed to provide engaging interactive feedback.

Over the past few decades, sensor systems have become cheaper and more readily available, resulting in a growing interest in the use of sensor data within everything from computer music to sports sciences. This project investigated a number of innovative new applications of sensor data, in order to develop a framework with pedagogy and edutainment contexts in mind.

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This paper presents a framework which matches features from multiple simultaneous data sources so that they could be synchronized for use within multimodal systems. This was achieved through the application of signal segmentation, feature detection and signal warping.

2 Background

Developments within interactive multimedia systems have used different multimodal data to better understand certain interactions and controls for a wide range of applications including musical gestures such as conducting and instrumental playing techniques [1]. This provides instrumentalists with real-time analysis and feedback on their playing gestures through exercises which offer technology enhanced learning support to increase the effectiveness of practice and hence improve their performance and techniques (see Fig. 1). This can also be used to compare the consistency of playing gestures by high-lighting issues in their technique.

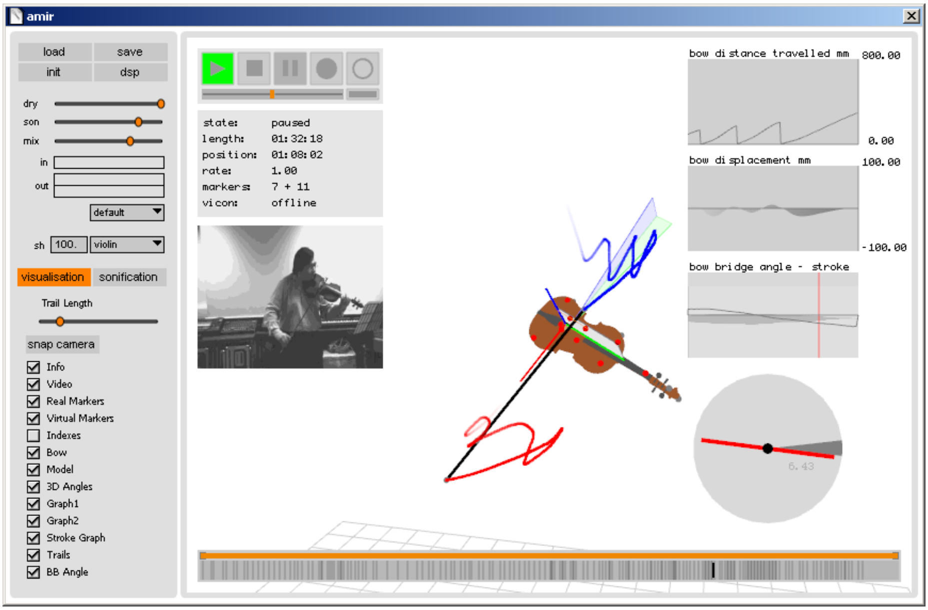

Fig. 1. i-Maestro 3D Augmented Mirror interface (see www.i-maestro.org)

The use of sensor systems within multimedia and interactive systems has become more common, particularly with the rise in available prototyping units and mobile platforms [2]. One such example is the Mobile Motion system [3], which comprises of a mobile device augmented with additional sensor units. This uses simultaneous sensor systems to control software instruments or virtual conducting; enabling the user to perform realistic physical gestures, rather than relying on touch-screen or keyboard interface.

Recent developments at SIEMPRE [4] have also utilized multi-modal systems to explore the relationship between conductors, performers and the audience in a range of musical scenarios. One more recent example of their work is ShEMP [5]: a mobile interface that uses a combination of hardware and software interfaces to explore networked musical interactions.

Multimodal music systems have also been used as a mechanism for exploring human interaction [6]. Such is the case with the experiments carried out by Varni *et al.*, whereby a multi-sensor system was used to perform real-time analysis of human interactions in order to detect the synchronization of affective behavior and the emergence of functional roles within a group of musicians.

Recent work in sports science has also given rise to the use of sensor-music synchronization to improve performance [7]. This has resulted in the development of sensor systems and mobile apps that automatically optimize the tempo of the music to aid running [8]. Similar approaches have also been implemented within gaming – with games featuring musical scores that speed up or slow down according to the player's actions [9].

There have also been a number of recent developments in the use of multimodal systems within human-robot interactions, such as Shimon [10] – a marimba playing robot. Shimon uses a multi-sensor system to synchronize its playing with musical sounds. In doing so, the robot is able to improvise with musicians in real-time through the use of improvisation algorithms, resulting in a highly meshed musical interaction.

Music has also become a regular component of sports and exercise regimes. This follows recent research in sports psychology that has revealed that the performance of athletes can be enhanced through the use of music [11, 19]. The results of these recent investigations suggest that this is due to the benefits exhibited by music; that it enhances performance through providing steady rhythm, improving mood and even reducing perceived fatigue. Due to these benefits, a number of systems have been developed to utilize music for the enhancement of physical performance. For example, Cruise Control [12], a mobile app that utilizes the device sensors to alter the tempo of music. Cruise Control synchronizes music to the device's onboard sensors as they estimate the runners' cadence. As such, the tempo is decreased or increased to match the running speed. In this way, the runner's speed is optimized, as they need to keep a steady pace in order to maintain the music's tempo.

Nike+ Fuelband [7] is a sensor band that can be conveniently worn around the wrist to record and monitor sports or exercise activity. The information from the Fuelband synchronizes with a specially developed iOS app [8], allowing the user access to a number of instant visualizations that represent their progress; including best times, calories and distance covered.

Music synchronization has also been exploited within gaming. Games such as Osmos [14] alter the musical components and tempo in accordance with the controller data. This provides a more immersive gaming experience – as the musical atmosphere changes with the player's actions. Spore [9] is another example of interactive game music. In this case, the game had a procedural score created by Brian Eno so that, as the user advances through the game, the musical pieces evolve according to the user's actions. Thus, the use of music synchronization within gaming demonstrates an exciting new area for user-interaction; paving the way for more engaging and immersive soundscapes.

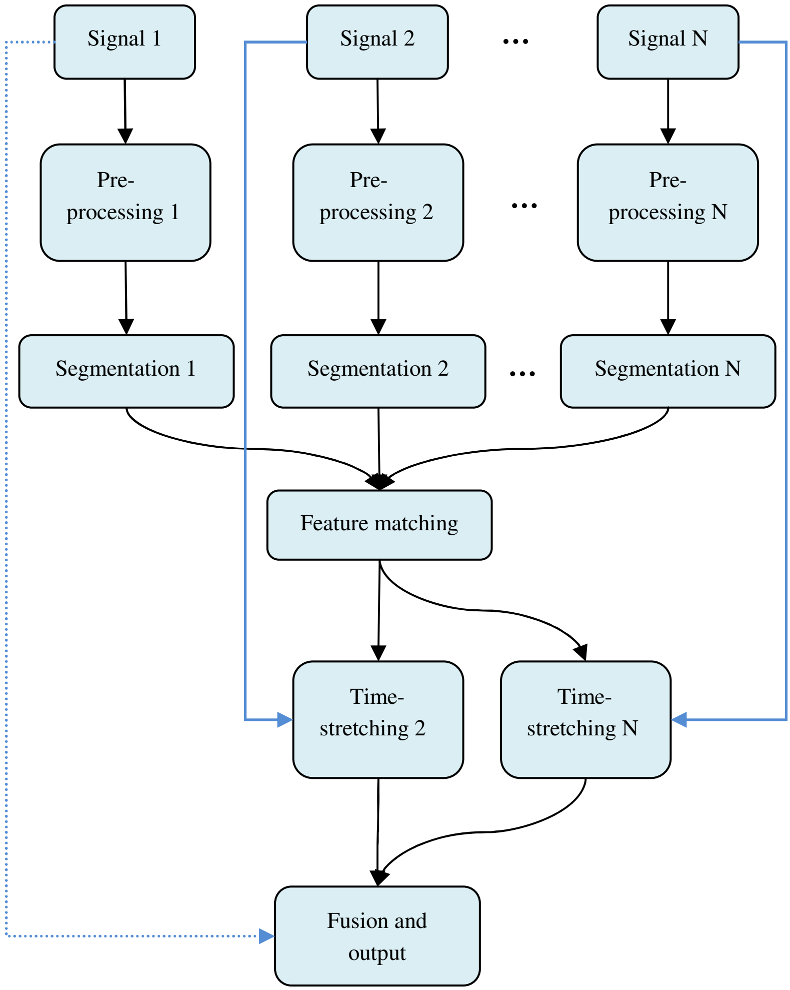

Fig. 2. An overview of the framework

3 Design

Fig. 2 illustrates an overall design of the framework. In this case, Signal 1 is the master signal – the signal to which the others are synchronized. Prior to synchronization, the pre-processing stage provides any necessary signal processing such as data-conditioning, smoothing and filtering. This reduces noise and thus the amount of processing required. Following this, a segmentation algorithm is applied to identify the distinct components of each signal. Segments and associated features are then analyzed to find matching features between the signals that can be used as anchor points for synchronization.

3.1 Segmentation

For this stage, one of the segmentation algorithms can be chosen as appropriate to break the signals into discrete meaningful sections. Techniques include extracting salient point detection using a set of configurable algorithms including cluster-based, feature-based and wavelet-based approaches to identify useful landmarks or control points in order to divide the signal in a logical and usable manner [15]. In this way, the incoming data streams can be broken up into meaningful sections for processing. Once segmented, the data from each steam can then be processed to find matching features and control/landmark points, providing the necessary information for synchronization.

3.2 Feature Matching

Once the signals were segmented into logical sets of data, further processing could take place to detect features within the segments and match these to features within the other data streams. To achieve this, a time-invariant algorithm would be required, as different data streams may have differing sampling rates and/or latencies.

At this stage, techniques such as Dynamic Time Warping (DTW) [16] can be used to identify and match features between multiple data sets, as shown in Fig. 3.

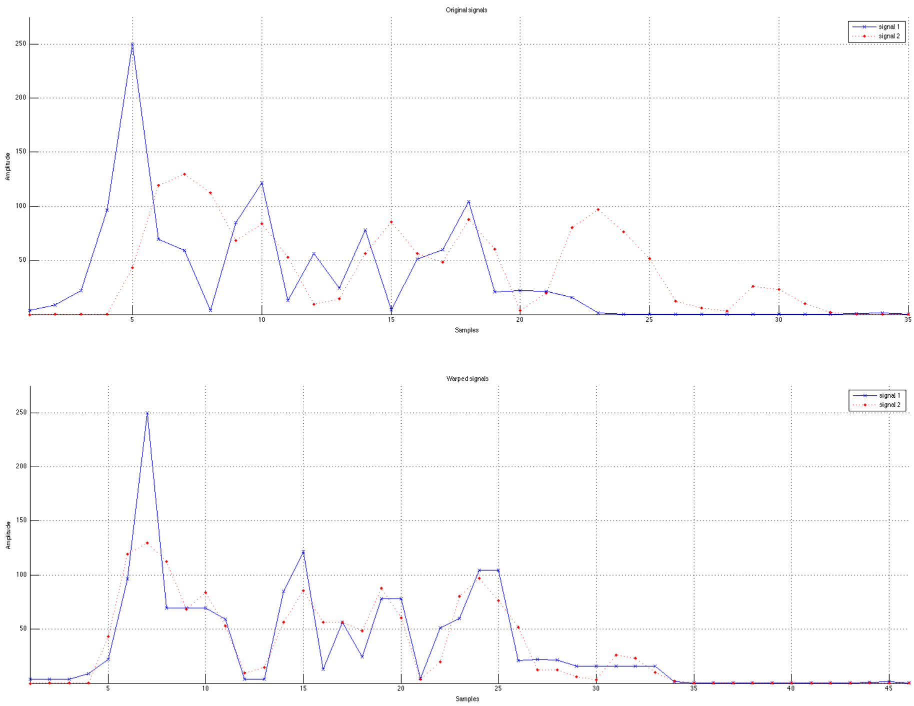

Fig. 3. Segment matching using Dynamic Time Warping (DTW) *Top*: Signals before DTW *Bottom*: Signals matched and warped after DTW

3.3 Time-Stretching

After the signal features have been identified and associated to one another, the information can be used to time stretch the signals so that they synchronize or optionally fuse with Signal 1 depending on the application context. This results in two time-altered signals whose features match to those of the master signal and thus to each other. As such, this is the final step in the process, resulting in a set of synchronized signals for use within music. Following its development, the framework was applied to a test application for validation as discussed in the following section.

4 Test Case

The framework is currently being applied within several specific test cases designed to control a musical output with sensor data. This section presents one of the cases implemented to enable a user to control a virtual orchestra via conducting gestures. To achieve this, a virtual conducting application was created in which the user is able to control a virtual orchestra via conducting gestures. The test case used a Microsoft Kinect to track a conductor's hand gesture to control pre-recorded audio data. The pre-recorded music has an associated data stream that indicated the beat of the track and hence can be used to synchronize with the conductor's gesture via the beat. The framework was then applied to synchronize the data streams and allow interactive control of playback using conducting gestures.

Fig. 4. Kinect depth map

The control signal within this system was the data from the Kinect sensor. This consisted of 3-dimensional positional data from the depth map, shown in Fig. 4. This was synchronized with the music – an audio stream. In order to identify how the music should respond to the conductor, the conducting beat point from the Kinect needed to be identified (Fig. 5). Prior research had found that conducting gestures were indicated by change points within the data [17, 20]. The segmentation portion of the framework focused on these: breaking the signal into useful segments accordingly. An audio beat detection was used to identify beat points within the audio [18].

For this test case, the two segmented data streams are analyzed using DTW. This was applied to find corresponding points within the audio and the conducting gestures through cross correlating the beat points within the audio signal to the change points within the gesture data; warping the signals to emphasize the points at which they most strongly converged.

The distance between each of these points (the 'warp distance' calculated by the DTW) could then be scaled to provide information on tempo changes. This was used to time-stretch the audio to match the new tempo indicated by the conductor.

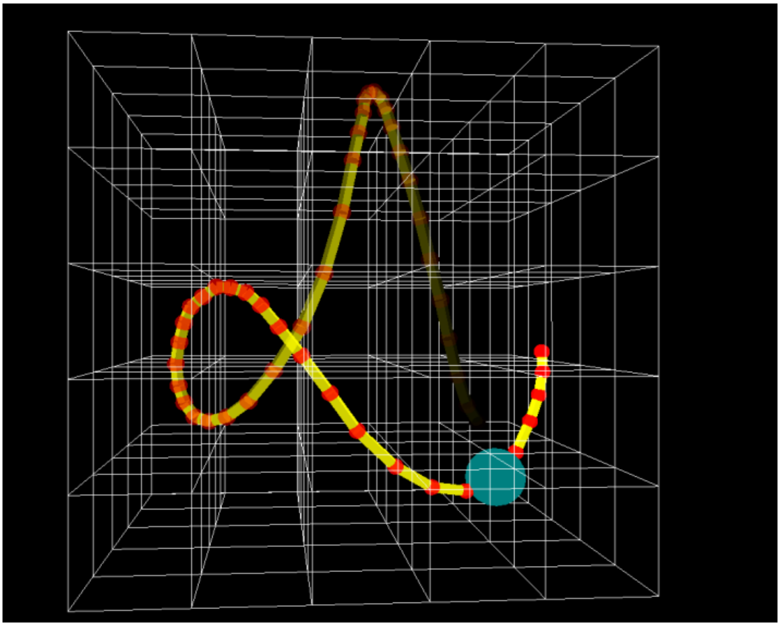

Fig. 5. Music via Motion (MvM) conducting interface [13] using Kinect

After matching the control and feature points for each of the conductor's beat points, it was possible to identify the most appropriate offset for the audio beat points, as shown in Fig. 6. Hence, at each gesture beat, the playback speed of the audio can be updated in order to sync to the gesture, thus exhibiting an interactive response to the conducting gesture through updating the tempo and movement of the music. The playback module also continues change of tempo such as *accelerando* or *ritardando* – simulating the real-life feedback and experience of a conducting session.

5 Application Contexts

A number of additional applications for this framework have been considered. One such application would be to synchronize multiple biosensors with musical output. This could thus be implemented within applications designed to aid physical rehabilitation or sports training.

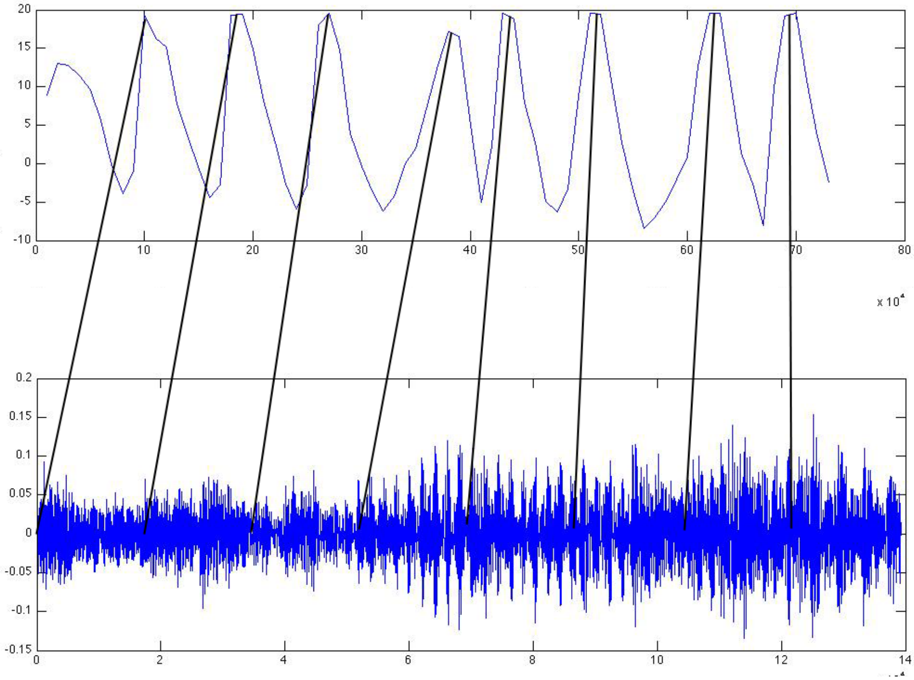

Fig. 6. Signal synchronization *Top*: Gesture signal *Bottom*: Audio signal *Black lines*: Matching change points in the sensor data to beat points in the audio

Applications within gaming are also being considered, as the framework could be used to monitor various forms of user input and use these to manipulate the in-game environment. This would be particularly advantageous given the recent rise of multimodal gaming systems (such as the Kinect, which supports both spoken and gestural input), as audio input and sensory input could be exploited to create a fully multimodal interactive gaming experience.

Finally, contexts within music, such as demonstrated with the test system, could be extended – with educational applications being of particular interest. One key direction is to combine gaming and musical components in order to create an educational form of entertainment that could be used to aid learning in music. In this way, users could learn real musical concepts through a highly interactive, engaging and fun application. This would be a particularly advantageous approach to educating younger children or as an introductory path to musical involvement.

6 Conclusion

The paper has discussed a framework that has been developed to synchronize multiple data sources for use in multimodal applications. This has been explained through a specific test case whereby the framework has been implemented within a virtual conducting application, allowing users to alter the tempo of a virtual orchestra through their conducting gestures which has been used as an edutainment tool for conducting beginners as well as a tool for technology-enhanced learning for conducting exercises. Many more applications are being explored, including utilization within physical training, rehabilitation, gaming, multimedia production and music education.

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Augmented Opera Performance

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Abstract. Operatic performance has a long and well-established history as a large-scale performance encompassing elements of music, theatre and design. Staging of such productions is an intricate process involving many parties both on the stage and behind the scenes. This paper discusses multimodal and multimedia technologies and techniques that can assist this practice. We look particularly at the conductor, as the controller of temporal progression, leading the various components as a cohesive unit. For this reason, a particular focus is upon the development of methods to communicate cues and information for lighting, visual stimuli and haptic feedback. Previous work that has informed the design of this system is also discussed. The paper concludes with the project's current status and impact.

Keywords: Stage, Performance, Augmentation, Music, Conducting, Communication.

1 Introduction

1.1 Context

A modern opera is considered a dramatized musical performance involving singers and a musical ensemble, combined with acting in a theatrical set or staging. The word 'opera' is the plural of the Italian *opus,* meaning 'work' or 'labour', and a shortened form of *opera in musica,* or 'works of music' [1]. Having been practiced for over 400 years, it is considered a tradition of Western art music. Over time the art form has evolved, influenced by a number of factors including technological development. This paper considers the impact that recent technological developments could have in opera from its composition to live performance.

An opera performance is a large-scale work, involving many parties both on and offstage. The primary onstage constituents are the operatic singers. Often beneath them, in the orchestral pit, are the conductor and instrumentalists. Working behind the scene are the stage crew, consisting of engineers controlling light and sound, and others assisting in arranging props and changing scenery. The success of the performance is dependent on the cohesion of these individuals. This is reliant on their ability to communicate and dynamically adapt to changes in the performance and environment; however, distances between individuals can reduce communication.

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Operatic audiences have an inter-artistic experience incorporating theatre, visual art and music. Multisensory performances allow audience members to engage with the work in different sensory domains, increasing the amount of expressive information that can be conveyed. Visual and auditory impairments can lead to accessibility issues in live performance. Enhancing information in alternative sensory dimensions can present a means through which all audience members' excitement can be enhanced.

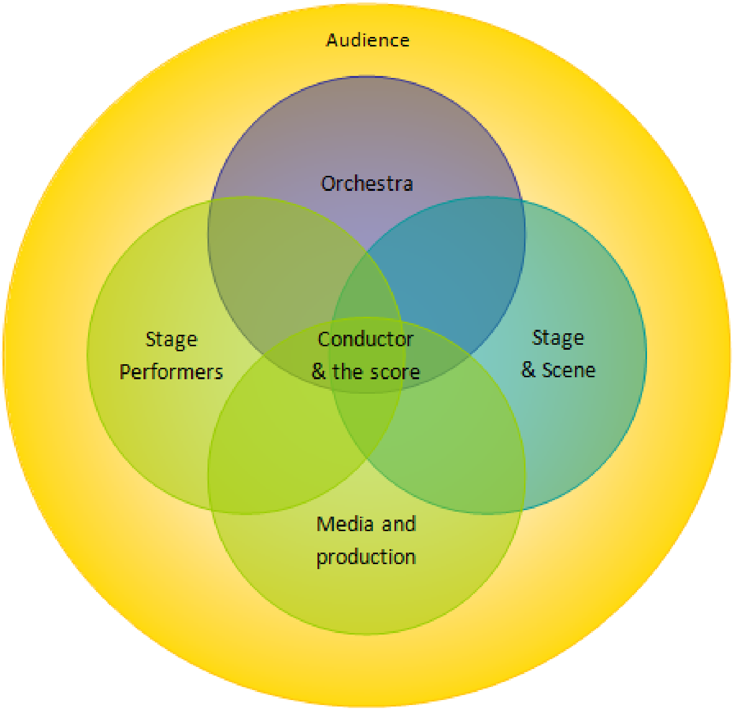

Fig. 1. High-level representation of the relationship between components of a live opera performance

Staging of an opera is a complex event comprised of many variables that challenge its success. Fig. 1 shows a high-level overview of the main components of a live opera performance. By isolating the primary subsections, we are able to configure the dependency relationships between them. The multidimensional nature of combining music, stage and media and production, requires each element to concurrently receive time-based cues. The centrality of the conductor within this visual representation reflects their role as director and controller of temporal progression through the score.

The Interdisciplinary Centre for Scientific Research in Music (ICSRiM), at the University of Leeds, has developed a number of new technologies that can be integrated into an operatic scenario, with a particular focus on communication. This paper focuses on the communication of time for cueing in live performance. A key logistical difficulty considered in this paper is the communication of beats and cues with other parties. Alongside live, online events, offline support is also considered through the distribution of multimodal opera recordings. This could be viewed as an extension of audio-visual media.

1.2 Aims and Objectives

The aim of this project is to develop a multimedia interface that offers augmented features to opera performances in real-time. Acoustic and gestural data are translated and mapped into different modalities, with a particular focus on visual and haptic feedback, including lighting control, scene changing and staging. Further to this, the project seeks to capture and represent performances beyond the usual audio-visual modality, allowing a multimodal experience of the performance to be recreated. Based upon this, the main objectives for this project are as follows:

1. Representation and media preparations – an extension of the score will be required to incorporate additional synchronisations for cues such as lighting, projections, supertitles and translations, and haptic;
2. Conductor interface – implementation of an interface to capture gestural data, analyse and communicate expressive and temporal information;
3. Synchronisation and mapping – methods of synchronising data streams and mapping data within specified parameters;
4. Reconstruction module – to translate mapped data to different domains, e.g. for rendering projections and haptic feedback for live and playback scenarios.

Relationships between the performers are considered particularly, the conductor, instrumental ensemble and opera singers on stage. Additionally, the enhancement of expressive and emotional communication will be explored through the audiences' response to visual and auditory stimuli. For this paper a high level overview of different application scenarios is given, with a particular focus on the control of visuals including projections, lighting and supertitles, and haptic feedback to both performers and audience members. The modular architecture of the project allows flexibility dependent on the performances requirements.

1.3 Paper Structure

This paper is structured as follows: Section 2 presents a background literature survey incorporating, an overview of related musical practices including conducting and instrumental performance, alongside multimodality and music, and systems utilising related techniques. Section 3 presents the design and development of the individual system components, and Section 4 concludes with a summary and current findings.

2 Background

With its rich history, it is easy to not consider traditional opera as an art form quick to embrace and adopt technological developments. Historically, operatic institutions have often been amongst the first to implement and benefit from new technologies.

An example of this is Siemens, in 1909, installing the first diesel-electric generator at the Opera House in Rio de Janeiro [2]. Envisaging a performance pre-electric lighting, it could be difficult to conceive a large opera hall lit only by gas burners, or worse, candles. Advancements in lighting techniques and media technology, such as audio and visual recording and distribution, have directly affected audiences both in and outside the opera house. How can new technologies be integrated into operatic performance to allow greater autonomy, without affecting authenticity?

This section presents an overview of musical practices that relate to the design of this system including opera, conducting and instrumental performance. Establishing the system's musical context is critical in understanding its potential impact in the proposed applications. After this, previous performance tracking and augmentation modules are discussed. The background section concludes with an analysis of feedback technologies such as haptics and visualisation in related applications.

2.1 Musical Performance

2.1.1 Conductor

The gestural precision, practice and techniques of modern conducting style have developed over approximately 300 years [3]. Whilst conductors employ many different techniques, there is a large amount of literature that describes its basic principles, including Green [4] and Boult [5]. This literature has established a common agreement; distinct gestures have specific interpretations and meanings for the performer. Thus, the conductor directs musical performance through visual gesture. While the performers look to the conductor for tempo, dynamics, and unified entrances and exits, audiences can look to the conductor for a summative representation of their auditory experience.

A number of earlier practices have influenced the role, technique and equipment of the conductor. The use of a hand gesture to coordinate musical ensembles can be traced back to cheironomy in Ancient Egypt [6, 7]. Cheironomy extended through to the Middle Ages, in Gregorian and Byzantine chant, as a means to relay pitch and rhythmic information [8, 9, 10]. With the rise of polyphony, music became more complex, leading to the practice of cheironomy becoming redundant. Salomonis' '*Scientia artis musicae*', written in the 12th century, is the earliest account of the conductor gesturally indicating pulse. He describes how the conductor, "beat time […] with his hand and indicates cues and rests to the singers" [11: 13]. During the 15th century, it became common practice for the role of the conductor to be focused on timekeeping.

Through the first half of the 19th century, there was much experimentation within conducting practice. Formerly, the orchestral leader was rotated within ensembles, as a pianoforte or violin player. By the mid 19th century, it became common practice to have a dedicated conductor; an individual who did not play in the ensemble. Other more technical considerations included whether beats should be silent or audible, and with what implement to conduct. Another important refinement was the position of the conductor, or leader within increasingly large ensembles [12].

The role of the modern conductor involves several processes: Preparatory study of the piece, coordinating rehearsals and directing the final performance. There are a number of key skills a conductor must therefore possess; as a musician, stylist, orchestrator and historian. Performance is the most challenging stage for the conductor. They must objectively coordinate the music, whilst analysing the sound and adapting to compensate for moments of performer inattention and alterations to the acoustic environment [4]. Performance requires the conductor to communicate a vast amount of information through non-audible channels. The gestural language of the conductor has had to adapt to facilitate the communication of complex musical direction required for an accurate and balanced performance.

2.1.2 Instrument/Singer

In current musical practice, the score provides the instrumental performer with a set of instructions detailing how the composer intends a piece to sound. Parameters including pitch, rhythm and time signature are quantifiable directions that have a defined musical response. Expressive characteristics of the composition, such as dynamics and tempo, are interpretive and relative to the performance environment. These expressive factors can be influenced by the performers' internal preferences, musicality and experience. In a solo performance internal factors allow the performer to exert their own interpretation of a piece. However, in larger ensembles internal interpretations can conflict. In the context of an opera performance, the orchestra is normally situated in a pit beneath the stage. Opera singers are situated on stage and required to act as well as perform the vocal line. Performers must coordinate through external auditory and visual cues [9, 13].

Auditory cues allow the performer to synchronise by responding to the music as it is produced. This method of coordination does not allow the anticipation of sudden changes in tempo, dynamic and dramatic entries. Visual cues are required to supplement this; musical changes can be anticipated through movement, facial expression and posture. In smaller ensembles, assuming idealised orientation, close seating arrangements mean that the performers can communicate visually with each other. However, in larger ensembles great separation can lead to communication difficulties. This is resolved through the implementation of a conductor; an individual who provides visual, external expressive cues to synchronise an ensemble. Through this implementation, the synchronisation challenge is now concentrated on a single point of communication, and constrained by the visibility between each instrumentalist/singer to the conductor. Light and space limitations in the orchestra pit further complicate this. This paper presents technologies to combat these challenges.

2.2 Auditory Stimuli and Multimodality

This project is interested in ways of enhancing communication during large-scale performance through multimodality. Particularly, enhancing audience engagement using additional sensory excitation through online and offline production. A particular focus is upon increasing performance efficiency for participants on and off stage.

For this section, the paper considers several transdomain mapping approaches for different visual accompaniment as well as haptic sensory expressions; exploring sound-visual association while listening to music with "feeling" physical attributes of sound through the body. The association between expressive communications are explored to enhance the expression in communication.

2.2.1 Synaesthesia

Synaesthesia is a neurological phenomenon where by stimulation of one sensory modality results in an extra sensory perceptual response in another. Common manifestations of this sensation include the perception of colour for music, phonemes, numerals and letters. In the context of this project, the sound-colour synaesthetic relationship is explored. There has been a range of research to study and quantify both the neurological and perceptual response of synaesthetes.

When measuring a subject's response to musical tones, Neufeld *et al.* [14], measured increased activity in a region of the brain involved in multimodal integration, for sound-colour synaesthetes. Paulesu *et al.* [15] derive similar results when analysing brain activity in sound-colour synaesthetes. An online standardised test, 'Synaesthesia Battery' is described by Eagleman *et al.* [16] as a method of identifying and analysing synaesthesia and its effect.

Sound-colour association has a rich history within both the sciences and arts. An early scientific association of the two domains is detailed by Newton (1704). Historically, visual and auditory artists have mutually served as each other's inspiration. A direct transposition of this is exemplified in the impressionist movement, particularly the work of Debussy.

Research into the sound-colour synaesthetes perception of stimulatory audio has produced varied responses, reflecting the subjectivity of the phenomenon. Individual's response. However, there are several features that exhibit more comment trends [17, 18]. These include: (i) pitch and brightness; (ii) loudness to size; (iii) colour and frequency. Many composers and artists, including Messiaen, Scriabin and Steen report synaesthetic responses that influence their work.

For this project, synaesthetic sound-colour associations present a range of possible mappings to translate between music and visual art. Utilising more general associations such as pitch to brightness, whilst allowing artistic interpretations and simulating reported mappings. This allows the user to experience an individual's sound perception.

2.2.2 Haptic

Haptic technology systems focus on relaying information to users via stimulation of the skin. These technologies are commonly used in both research and consumer environments. Research in the field explores issues such as accessibility and user experience enhancement. The integration of tactile stimulation into an entertainment environment is not a novel concept. In 1959, director William Castle introduced the 'Percepto' seat alongside his film *The Tingler*. The seats were built from vibrators salvaged from World War II aircraft and activated at random by the projectionist in certain scenes of the movie [19]. The concept endured through smaller scale productions in amusements parks. In the United Kingdom, there are plans to introduce '4D' vibrating chairs in thirty cinemas across the country [20].

Some haptic technology systems specifically focus upon increasing accessibility. Koslover *et al.* [21] developed a mobile navigation device that outputs visual, audio and vibrotactile cues. They found that navigation cues could be effectively reconstructed through multiple actuators placed on the torso. Similarly, Hao and Song [22] designed a system to present situation awareness information. Users interpret vibrotactile information from twelve different actuators around their torso. Nanayakkara's haptic chair explored the distinction between auditory, visual and the somatic sensory modalities [23]. Speakers are integrated into the chair to physically recreate the vibrations of the audio. Vibrotactile feedback, together with synchronised visuals, augments the music listening experience for the hearing-impaired.

Research has been conducted into the application of haptics in musical performance systems. Hayes and Michalakos proposed a system to aid improvised performance through the use of networked vibrating motors [24]. Berdahl *et al.* [25] designed a system, which uses a thimble to indicate correct fingering position through haptic feedback. The performers could individually adjust the strength of haptic output.

2.3 Performance Following

Performance augmentation has been explored in a number of different application contexts. Methods of augmenting the performance include real-time audio analysis, additional equipment on stage, and tracking techniques utilising sensors and cameras.

Some systems focus on beat tracking to allow human-computer interaction in performance. Musical beats or, tempo, can be tracked in several ways including conductor tracking. Morita, Hashimoto and Ohteru developed a conducting system to control a virtual orchestra in 1991 [26]. Their electronic orchestra responded to a conductor's gestures, tracked through a charge-coupled device (CCD) camera and a sensor glove. Another example of a conductor tracking system is Marrin's 'Digital Baton', designed as a multipurpose device to control electronic music using traditional conducting parameters. Gestures are tracked using accelerometers, infrared LED and piezo-resistive strips [27].

Another implementation of beat tracking is that proposed by Dannenberg [28] for use in human-computer music performance. A member of the ensemble taps their foot in time to the audio using a foot pedal interface to communicate beat points. Dannenberg cites the main advantages of this implementation as being its robustness and requirement for no extra performers.

3 Design and Development

This section outlines the design and development of the system with a particular focus on its implementation in enhancing and extending visual aspects of the performance.

Requirements of the system are overviewed, alongside hardware and software development and integration with the visual, lighting and haptic reconstructions.

3.1 Requirement

The design requirement of the system can be considered as four distinct modules: Media preparations, conductor interface, synchronisation and mapping, and reconstruction. In achieving this projects aim a method of incorporating additional information into the score is required. This will allow synchronisation of the musical line, with other media events. Providing an overview of all elements of the stage work including projections, scene changes, subtitles and translations, and lighting cues. A module is then required to track audio events with sufficient accuracy to allow alignment with score and triggering of other cues.

Once the acoustic and gestural data has been captured, the data streams must be synchronised. A set of mapping strategies is required in order to translate the data within the defined parameters of each feedback method. Software is then required to reconstruct the data. Specifically control signal to the lighting desk, and timings of projections including subtitles, translations and other visualisations.

3.2 Design

3.2.1 Representation

Augmentation of the musical score in this context requires it to be linked to audiovisual events, such as projections, lighting control and surround sound. This requires the information to be in a highly multimedia format. Optical music recognition techniques (OMR) can be applied to the score, converting it to a machine-readable representation with additional multimedia capabilities [29, 30]. At this stage, other events and cues can be added to the score including lighting controls using the MIDI Show Control (MSC) protocol [31]. The ISO MPEG Symbolic Music Representation (MPEG-SMR) is an exciting development that enables the realisation of the full system, offering better integration of musical scores with multimedia content and applications [32].

3.2.2 Conductor

Central to the performance, the conductor's gestures are used to direct all other elements as a cohesive unit. A performance can be 'followed' by tracking and analysing the conductor, or 'following' the resultant audio. There are a wide range of technology-enhanced scopes and existing research in this area including score following [33], beat tracking [28] and gesture following [34].

For our system, the conductor's gestural data is currently captured using the mConduct baton [34, 35, 36], a multisensory interface to capture the hand gestures of

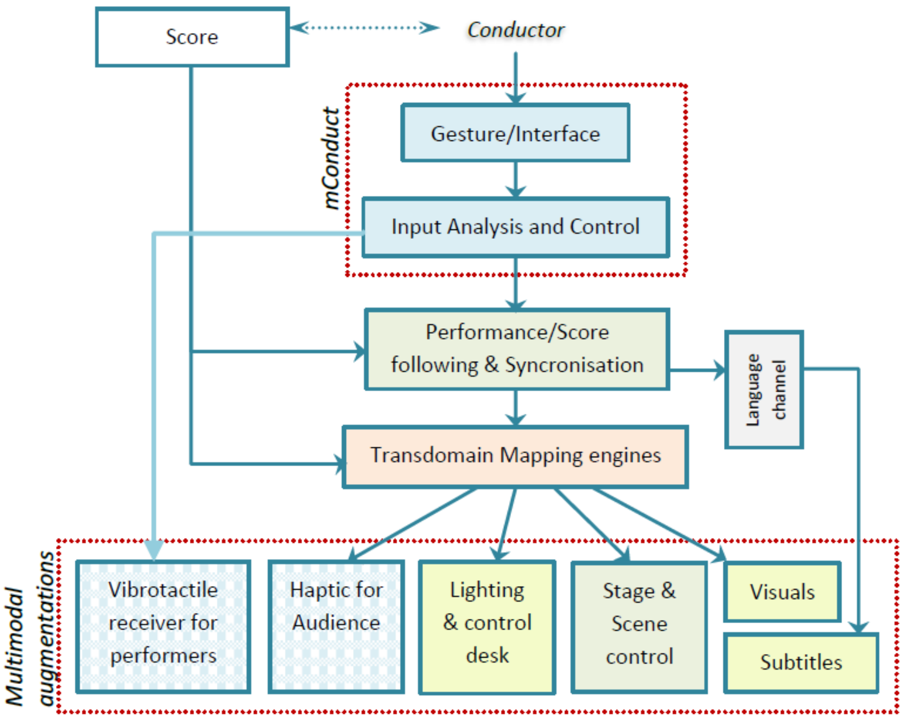

Fig. 2. An architecture design of the proposed framework

conducting. Integration of an inertial measurement unit (IMU) into the base of the baton captures three-dimensional accelerometer, gyroscope and magnetometer data. The IMU measures 3D vectors depending on its orientation. The effect of gravity on the accelerometer is calculated using quaternions, to find global movement [37].

The mConduct baton enables the conductor to communicate through means that do not require a direct visual connection. This is particularly useful due to the ergonomics of the performance environment space, and positioning of performers within it. Occlusion from visual communication, particularly between the conductor's hand gestures and performers, is commonplace in works of this scale, including operas, musicals and ballets. This can be further complicated with distributed performances, where choirs and instrumentalists are located offstage. Opera companies offer close-circuit video monitoring systems for performers who cannot view the conductor; these are bulky, requiring installation and careful positioning. The mConduct system is lightweight, wireless and wearable allowing the conductor and performers freedom of movement. Communication channels are further complicated through dim lighting in the orchestral pit. This results in the contrast between the conductor and the background being low. Some opera companies attempt to resolve this by painting the wall a contrasting colour, however, this can be counterproductive if the conductor does not conform to the dress code.

A separate design has been implemented for those who conduct without a baton using motion capture systems including the Kinect and Computer Vision techniques [38, 39]. This technology has also been integrated into the percussionists' drumsticks, providing a means of analysing the interaction time between the conductor and ensemble.

3.2.3 Synchronisation, Mapping and Reconstruction

Beside integration and synchronisation modules for the different data streams and mapping interfaces, a set of configurable and extensible transdomain mapping strategies are being developed. Allowing the performance to be translated from an audio-visual experience to other forms of representation. This augments the performance and widens accessibility for the appreciation and enjoyment of the art form. Conductor gesture data is used to control supertitles, change scene, and trigger additional multimedia content including backdrop projections and lighting.

Mapped data is translated into different domains for each application including: Rendering projections; haptic feedback for live and playback scenarios; sensor seats installed with vibrating actuators. Additionally, mConduct actuators can be used by stage and pit performers, removing the visual limitation of conducting gesture. This data can then be integrated into digital media of the performance, allowing the recording to reflect the original performance environment.

4 Conclusion

This paper considers components of large scale performance and opportunities for ICT augmentation to enhance operation efficiencies and to explore new musical expression and communications. Using opera as an example large-scale stage performance, the paper briefly described each of the main components and proposed several technologies to augment the performance. This occurs within the boundaries of its style and cultural heritage, with both real-time and playback scenario multimodal feedback. Particular focus was upon methods of communicating and automating beats and cues with a view to enhancing both the staging and audience experience. Validation processes are currently being planned for both the system as a whole and the individual components.

The paper reviewed performance techniques alongside other projects and concepts that have influenced the design of this system. Several implementations of the overall framework have been discussed including methods of augmenting the score to incorporate greater multimedia functionality. Methods of time keeping and beat tracking have been proposed, in particular, the mConduct system to capture and analyse the hand gestures of conducting. System synchronisation, mapping and reconstruction considerations have been conveyed. A particular focus has been on the execution of lighting, visual – projections and supertitles, scene changes and haptic feedback. Automating these aspects of the performance, allows greater flexibility and synchronisation. It also allows the performance environment to dynamically adapt to musical change.

Fundamental requirements considered include non-intrusive design to allow performers freedom of movement and position, and authenticity in performance to ensure opera goers to experience a performance within its traditional conventions. This expansion of the online (live performance) and offline (playback) multimodal playback experience presents a way in which opera could expand its musical possibilities, as well as widening its scope within digital consumer media.

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