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Global Thoughts, Local Designs

INTERACT 2017 IFIP TC 13 Workshops
Mumbai, India, September 25–27, 2017
Revised Selected Papers

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Foreword

This volume presents a series of revised papers selected from workshops organized by the IFIP TC 13 Working Groups during the 16th IFIP TC13 International Conference on Human–Computer Interaction, INTERACT 2017, which was held in September 2017 in Mumbai, India. INTERACT 2017 was hosted by the Industrial Design Centre (IDC) on the beautiful campus of the Indian Institute of Technology, Bombay (IIT Bombay). The conference was co-sponsored by the HCI Professionals Association of India and the Computer Society of India. It was held in cooperation with ACM and ACM SIGCHI.

The contents of this volume follows the main theme of INTERACT 2017: "Global Thoughts, Local Designs." In this new age of global connectivity, designers are often required to design products for users who are beyond their borders and belonging to distinctly different cultures. The process of designing products is becoming more multi disciplinary by the day. Solutions are now designed with a global perspective in mind, however local the solution might be. For those in the field of human–computer interaction (HCI), the phenomenon of global thoughts, local designs would have a direct impact. It encompasses the areas of HCI in the industries of emerging economies, HCI contributions in socio-economic development, HCI for products and services in emerging markets, including mobile systems, HCI and designs for low-literacy users, HCI and designs for bottom-of-the-pyramid users, and HCI for remote contexts, including issues related to international outsourcing/global software development. The IFIP TC 13 working groups reflect and develop on the spirit and theme of the IFIP INTERACT conferences and more generally of the TC 13 itself.

This volume presents the outcome of a thorough and competitive selection process, which started with the selection of workshops for INTERACT 2017. The IFIP TC13 working groups were challenged to propose workshops that match the main topics of the INTERACT conference. We welcomed workshops in diverse formats, including: (a) paper presentations followed by forum discussions with participants, (b) interactive events where participants work together on experimenting with or evaluating an artifact, (c) a design workshop focused on the construction of artifacts, and having as outcome a gallery/showroom exhibition during the conference, and, (d) any other innovative format that could have a scientific focus. The selection process of workshops was juried by workshop co-chairs and members of the international Program Committee of INTERACT 2017.

Workshops preceded the main conference, running from September 25–27, 2017. Only participants who submitted contributions were allowed to attend workshops. However, a dedicated session called "Workshops Summary" was held during the last day of INTERACT so that workshop organizers and contributors could report the outcomes of each workshop, receive comments, and interact with participants of the main conference.

Accepted workshops were allowed to establish their own reviewing process. However, to ensure the scientific quality of these proceedings, we asked that papers selected for this volume be peer reviewed by an international committee. After the workshop, authors were asked to revise their contributions including the comments and remarks they received during the event. Extended versions were then scrutinized again by the editors of the present volume.

The selected papers show advances in the field of HCI and they demonstrate the maturity of the work performed by the IFIP TC13 working groups. We selected 15 papers that are organized in four sections corresponding to IFIP TC13 workshops at INTERACT 2017. This is the very first time that workshops organized by IFIP TC13 working groups are compiled in a single proceedings volume. While contributions are connected to a particular workshop, they contribute globally to the IFIP TC13 aims in the development the HCI field.

It is important to mention that IFIP TC13 working groups are open to welcoming new members. The full list of IFIP TC13 working groups is available at http://ifip-tc13.org/working-groups/ and we invite interested readers to contact the officers for further information on how to enrol in working group activities such as the workshops organized at the INTERACT conference.

April 2018

Torkil Clemmensen
Venkatesh Rajamanickam
Peter Dannenmann
Helen Petrie
Marco Winckler

IFIP TC13 - http://ifip-tc13.org/

Established in 1989, the International Federation for Information Processing Technical Committee on Human–Computer Interaction (IFIP TC 13) is an international committee of 35 member national societies and 10 Working Groups, representing specialists of the various disciplines contributing to the field of human–computer interaction (HCI). This includes (among others) human factors, ergonomics, cognitive science, computer science, and design. INTERACT is the flagship conference of IFIP TC 13, staged biennially in different countries in the world. The first INTERACT conference was held in 1984 running triennially and became a biennial event in 1993.

IFIP TC 13 aims to develop the science, technology, and societal aspects of HCI by encouraging empirical research, promoting the use of knowledge and methods from the human sciences in design and evaluation of computer systems; promoting better understanding of the relation between formal design methods and system usability and acceptability; developing guidelines, models and methods by which designers may provide better human-oriented computer systems; and, cooperating with other groups, inside and outside IFIP, to promote user-orientation and humanization in system design. Thus, TC 13 seeks to improve interactions between people and computers, to encourage the growth of HCI research and its practice in industry, and to disseminate these benefits worldwide.

The main focus is to place the users at the center of the development process. Areas of study include: the problems people face when interacting with computers; the impact of technology deployment on people in individual and organizational contexts; the determinants of utility, usability, acceptability, and user experience; the appropriate allocation of tasks between computers and users especially in the case of automation; modelling the user, their tasks, and the interactive system to aid better system design; and harmonizing the computer to user characteristics and needs.

While the scope is thus set wide, with a tendency toward general principles rather than particular systems, it is recognized that progress will only be achieved through both general studies to advance theoretical understanding and specific studies on practical issues (e.g., interface design standards, software system resilience, documentation, training material, appropriateness of alternative interaction technologies, guidelines, the problems of integrating multimedia systems to match system needs and organizational practices, etc.).

In 2015, TC 13 approved the creation of a Steering Committee (SC) for the INTERACT conference. The SC is responsible for:

- Promoting and maintaining the INTERACT conference as the premie venue for researchers and practitioners interested in the topics of the conference (this requires a refinement of the aforementioned topics)
- Ensuring the highest quality for the contents of the event

- Setting up the bidding process to handle the future INTERACT conferences (decision is made up at TC 13 level)
- Providing advice to the current and future chairs and organizers of the INTERACT conference
- Providing data, tools, and documents about previous conferences to the future conference organizers
- Selecting the reviewing system to be used throughout the conference (as this impacts the entire set of reviewers)
- Resolving general issues involved with the INTERACT conference
- Capitalizing history (good and bad practices)

In 1999, TC 13 initiated a special IFIP Award, the Brian Shackel Award, for the most outstanding contribution in the form of a refereed paper submitted to and delivered at each INTERACT. The award draws attention to the need for a comprehensive human-centered approach in the design and use of information technology in which the human and social implications have been taken into account. In 2007, IFIP TC 13 also launched an accessibility award to recognize an outstanding contribution in HCI with international impact dedicated to the field of accessibility for disabled users. In 2013, IFIP TC 13 launched the Interaction Design for International Development (IDID) Award that recognizes the most outstanding contribution to the application of interactive systems for social and economic development of people in developing countries. Since the process to decide the award takes place after papers are sent to the publisher for publication, the awards are not identified in the proceedings.

IFIP TC 13 also recognizes pioneers in the area of HCI. An IFIP TC 13 pioneer is one who, through active participation in IFIP Technical Committees or related IFIP groups, has made outstanding contributions to the educational, theoretical, technical, commercial, or professional aspects of analysis, design, construction, evaluation, and use of interactive systems. IFIP TC 13 pioneers are appointed annually and awards are handed over at the INTERACT conference.

IFIP TC 13 stimulates working events and activities through its working groups (WGs). WGs consist of HCI experts from many countries, who seek to expand knowledge and find solutions to HCI issues and concerns within their domains. New WGs are formed as areas of significance in HCI arise.

Further information is available from the IFIP TC13 website: http://ifip-tc13.org/

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IFIP TC13 Working Groups

WG 13.1 – Education in HCI and HCI Curricula

Working Group 13.1 aims to improve HCI education at all levels of higher education, to coordinate and unite efforts to develop HCI curricula, and to promote HCI teaching.

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WG 13.2 – Methodologies for User-Centered System Design

The Working Group 13.2 provides an umbrella for academic researchers, students, and industry practitioners, who have an interest in the fundamental theory, practices, and technology related to the user-centered design philosophy.

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WG 13.3 – Human–Computer Interaction and Disability

Working Group 13.3 aims to make designers of information and communications technologies and complementary tools aware of the needs of these groups in order to encourage the development of more appropriate tools for accessibility and usability. As a result, systems will become more universally accessible, and the market for them will increase.

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WG 13.4/2.7 – User Interface Engineering

Working Group 2.7/13.4 encompasses activities of the Technical Committees on Human–Computer Interaction (TC13) and Software: Theory and Practice (TC2). It aims to investigate the nature, concepts, and construction of interactive systems. Another aim is to advance the state of the art in user interface engineering and science through meetings and collaborations between researchers who are experts in the system and user aspects of the engineering design of interactive systems. Engineering emphasizes the application of scientific knowledge and rigorous structured design methods to predictably and reliably improve the consistency, usability, scalability, economy, and dependability of practical problem solutions.

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WG 13.5 – Resilience, Reliability, Safety, and Human Error in System Development

Working Group 13.5 aims to support practitioners, regulators, and researchers to develop leading-edge techniques in hazard analysis and the safety engineering of computer-based systems.

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WG13.6 – Human–Work Interaction Design (HWID)

Working Group 13.6 aims to encourage empirical studies and conceptualizations of the interaction among humans, their variegated social contexts and the technology they use both within and across these contexts. It also aims to promote the use of knowledge, concepts, methods, and techniques that enables user studies to procure a better apprehension of the complex interplay between individual, social, and organizational contexts and thereby a better understanding of how and why people work in the ways they do.

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WG 13.7 – Human–Computer Interaction and Visualization (HCIV)

Working Group 13.7 aims to provide a creative work environment for performing innovative research at the interface between human–computer interaction and visualization.

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WG 13.8 – Interaction Design and International Development

The aim of Working Group 13.8 is to support and develop the research, practice, and education capabilities of HCI in institutions and organizations based around the world, taking into account their diverse local needs and cultural perspectives.

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WG 13.9 – Interaction Design and Children

This working group aims to support practitioners, regulators, and researchers to develop the study of interaction design and children across international contexts.

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Matthew Horton — University of Central Lancashire, Computing and Technology Building, UK

WG 13.10 – Human-Centered Technology for Sustainability

Working Group 13.10 aims to promote research, design, development, evaluation, and deployment of human-centered technology to encourage the sustainable use of resources in various domains. These technologies include interaction techniques, interfaces, and visualizations for applications, tools, games, services, and devices.

Chair

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Workshops Organized by IFIP TC13 Working Groups at INTERACT 2017

Workshop Jointly Organized by Working Group 13.2 and Working Group 13.5

Workshop on Dealing with Conflicting User Interface Properties in User-Centered Development Processes

Organizers

Marco Winckler	Université Nice Sophia Antipolis (Polytech), France
Marta Larusdottir	Reykjavik University, Iceland
Cristian Bogdan	KTH Royal Institute of Technology, Stockholm, Sweden
Kati Kuusinen	University of Southern Denmark, Denmark
Philippe Palanque	Université Paul Sabatier, France

Website: http://ifip-tc13.org/wg-13-213-5-workshop-interact17-mumbai/

Workshop Organized by Working Group 13.3

Cross-Cultural Differences in Designing for Accessibility and Universal Design

Organizers

Helen Petrie	University of York, UK
Gerhard Weber	Technische Universität Dresden, Germany
Jenny Darzentas	University of York, UK
Charudatta Jadhav	Accessibility Center of Excellence at Tata Consultancy Services, Mumbai Area, India

Website: https://ifipwg133.wordpress.com/interact-2017-workshop-cross-cultural-differences-in-designing-for-accessibility-and-universal-design/

Workshop Organized by Working Group 13.6

Human–Work Interaction Design Meets International Development

Organizers

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Veerendra Veer Singh	ICAR – Central Marine Fisheries Research Institute, Mumbai Research Center

Website: http://hwid.m-iti.org/?p=155

Workshop Organized by Working Group 13.7

Beyond Computers: Wearables, Humans, and Things - WHAT!

Organizers

Nahum Gershon	The MITRE Corporation, USA
Achim Ebert	University of Kaiserslautern, Germany
Gerrit van der Veer	Association for Computing Machinery (ACM)
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Website: http://hciv.de/what17/

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HCI Professionals' Association of India

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Contents

Beyond Computers: Wearables, Humans, And Things – WHAT!

Design for Cultural Heritage – Developing Understanding in Teaching and Practice

Teresa Consiglio[1](✉) and Gerrit C. van der Veer[2]

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Abstract. This contribution shows how we discovered, by teaching and design, the need for ICT support in the domain of cultural heritage collections. We show examples of current situations with, both, workable solutions and logistic problems regarding the maintenance, documentation, and availability of precious artifacts to keep cultures alive. We point to currently available techniques to incorporate cultural heritage artifacts in a cloud based structure for knowledge and communication that might enable the continuation of cultures in an easy and safe way.

Keywords: Internet of things · Wearable devices · Cultural heritage

1 Culture Is Living Is Learning

1.1 How We Discovered the Opportunity for ICT Support for Cultural Things

We have been developing and teaching university level courses on Design for Cultural Heritage in different countries and in different academic cultures [1]: In Alghero (Italy) in a faculty or Architecture and Design; In Amsterdam (the Netherlands) in a consulting company to experts in designing for cultural institutes; In Dalian and in Liaoning (China) to students of Usability Engineering and students of Multimedia and Animation; in San Sebastian (Spain) to students in Human-Computer Interaction and to curators of museum collections in various domains of Cultural Heritage.

We have been designing ICT support for collections of cultural heritage and developed an ontology for systematic support of scholars in domains of living cultures [2].

We collaborated with curators of a variety of cultural heritage domains: Folk costumes and the history of local dress habits [2]; Folk music, including a collection of instruments, the history, maintenance, documentation, historic recordings, and teaching [3]; A museum institute on the conservation and history of 35 mm celluloid movies [4, 5]; A collection of 17^{th}–19^{th} century European Art Music Instruments [6].

We visited some large cultural heritage collections where we analyzed documentation and retrieval problems: e.g., a Dutch museum of Natural History that keeps 17^{th}–19^{th} century specimen of plants collected mainly in (former) Dutch territory and colonies [7]; a Spanish museum of Folk Musical Instruments around the world [8].

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Based on these experiences we developed an understanding of the opportunities that state of the art ICT can contribute to the preservation of cultures and the maintenance, documentation, and accessibility of cultural heritage.

1.2 Examples from Teaching

When we teach design for cultural heritage, our introduction always includes examples from our own house where we show artifacts we inherited from our grandparents. These examples represent local or family culture and traditions that support the memories and knowledge as transferred between generations of a community. Figure 1a is an example that represents, for a single family: coat of arms of family members and of cities where family members have been living, the religious environment of this family, a family tradition of celebrating anniversaries of weddings, and the date of the celebration event. After our introduction, the first exercise for our students always is to bring from their own (or their parents') home a comparable artifact that represented the family or community cultural heritage.

Fig. 1. a. Picture of a memory document designed and painted by 3 teen brothers to celebrate the wedding of their father and their stepmother, 1915. b. Picture of a student and her sister wearing a historic dress that has been used in the family for 4 generations.

In a course we taught in a University at Sardinia, department of Architecture and Design, one of our students, member of an international community on the history of folk dresses, brought pictures of a 19th century dress owned by her family, see Fig. 1b. During the course a team of students designed a tablet application to document the costume and to support the growing knowledge about its history and continuing use in a developing culture of celebrating heritage folk costumes, depicted in Fig. 2.

Figure 2a illustrates the main structure of the knowledge as used in this community: artifacts are described in 3 different points of view. The history is (for this type of

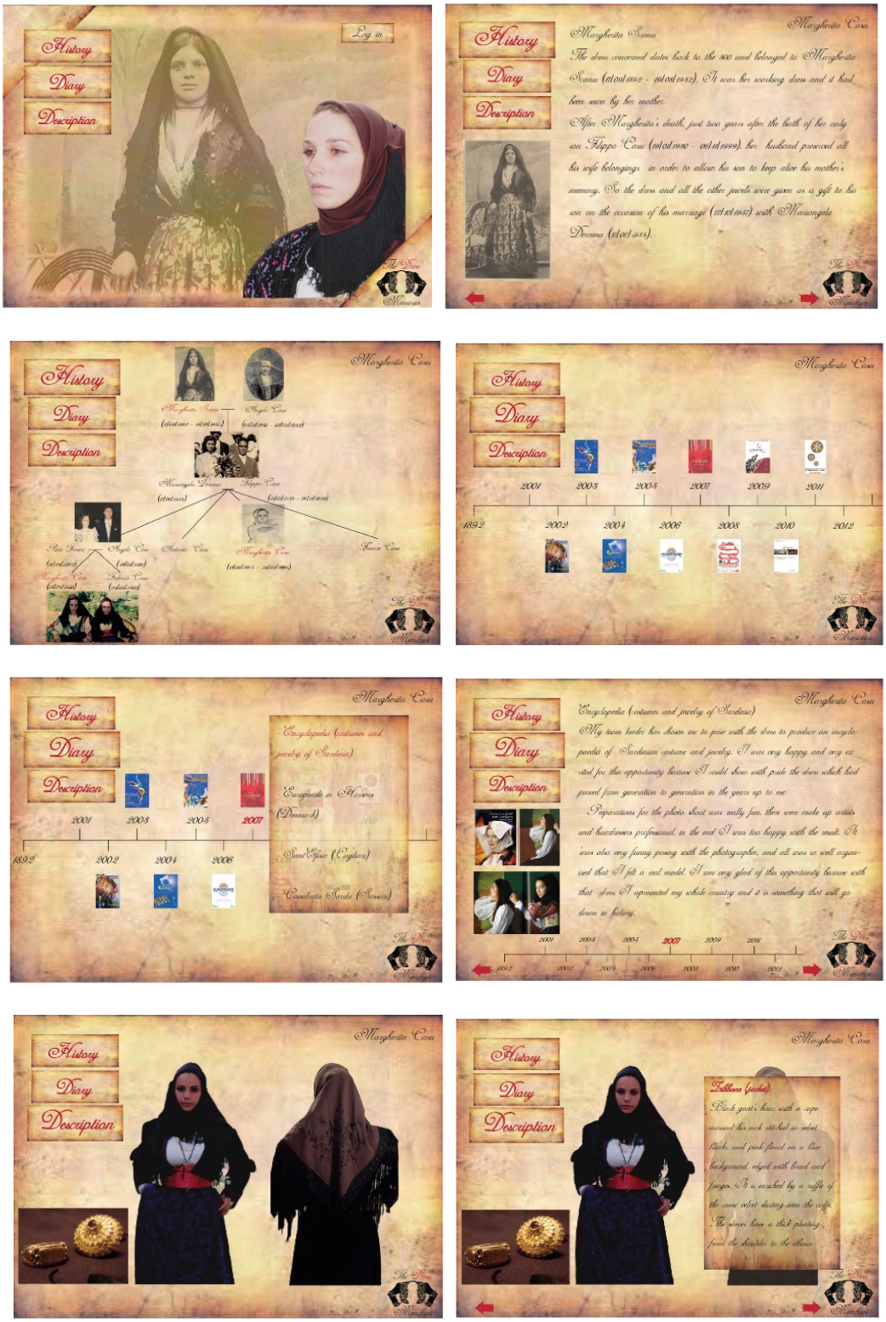

Fig. 2. Interactive tablet application that shows the viewpoints (2a) and their detail navigation on history (2b–2c); diary (2d–2f); and description (g–2h).

cultural heritage) described along the history of owners/users (Fig. 2b and c. The diary is a detailed account of what happened to the artifact during its use by the current owner (Fig. 2d – f), the interactive description part is shown in Fig. 2 g and h.

At a course we taught in Spain for group of computer students mixed with museum curators, one of the students contributed the case of a picture developing collection related to the town of Bilbao during the 60's, see Fig. 3. The student group designed a website for a community of citizens of Bilbao to integrate their collection of historic artifacts (mainly old photographs and documents) and related knowledge.

In this case some of the artifacts are in fact old paper documents, original photographs, or original photo negatives. However, sometimes the only artefacts left are electronic documents like PDFs.

Another student group in the same group focused on a collection of historic dances (where the primary artifacts are choreographies, songs, and melodies, with additional artifacts like video and audio recordings, sketches of steps and movements, transcribed scores, and other descriptions). This group (and other design teams that focused their design attempts on historic musical instruments or the performance of local traditional plays and games) elaborated the issue of differences between stakeholders regarding their contributions and their needs of access to the artifacts and to the growing knowledge of their culture. Figure 4 shows an example that they intend to put on.

1.3 Culture Is Learning Is Teaching

We adopt the definition of culture from [9], Sect. 5a: "*the integrated pattern of human knowledge, belief, and behavior that depends upon the capacity for learning and transmitting knowledge to succeeding generations*".

This definition from Merriam-Webster indicates that cultures are patterns of knowledge and behavior shared by a community that transfers the knowledge and behavior to new generations. People involved in such a culture we label in relation their role:

- Scholars: members of the community who are accepted to "know", and who may, consequently, act as teacher, researcher, restorer, copyist, historian, documenter. Examples in the domain of music: composer, performer, maker or maintainer of instruments, recorder of performances;
- Amateur: member of the community who participates in a meaning full way based on enough knowledge to experience the activities and to share the beliefs, and who aims at continuing to participate. Examples from the domain of music: people who choose the type of performance, the type of music played, the performers, they want to go to, who may keep souvenirs of events in the culture they want to remember.

In many cases these roles may be exchanged: a flute maker, may be happy to travel as an amateur to a performance where the artifact will be used by a performer.

- General pubic: In any type of culture as we define it, there may be people who do not (want to be) qualified as scholar or amateur. They may be labeled the "general public" or "tourists" – people who perceive a cultural event, performance, or an object of cultural heritage that they do not understand in relation to the knowledge, beliefs, or behavior of the culture.

Fig. 3. Sketch for a website on a picture collection, intended to grow a community that builds the combined historic knowledge that is currently still available, though mainly spread among individual older citizens of Bilbao.

Types of Stakeholders

STAKEHOLDERS	THEIR NEEDS	THEIR CONTRIBUTIONS
Dance and music teachers, as well as children's entertainment groups	· We provide them with practical learning material for both dancing schools and normal schools. The ideal target group would be students between the ages of 10-13. · The contents that are transmitted have a fun factor, which prevails over competition. · These games have the advantage of being atemporal and useful. · It also gives the opportunity to acquire cultural knowledge on the Basque Country (through music and dance); both to the monitors and teachers, so as to the students. · This dance is adequate to work on psychomotricity. · Participants could either work on the music (singing or playing) or on the dance (performing it).	· The main contribution is to transmit this dance game to the future generations, performing it and bringing it to life. · They could give us advice, based on their experiences during the practice of the dances (f.i. better ways to perform them, other music that could be used for this dance...). · They could also work as informants providing new information on our object.
Dance groups and associations (folklore)	· We enrich their repertoire and make it more diverse. · We offer them with a dance which makes their show livelier.	· They contribute to spread the dance and make people aware of its existence.
Town councils	· We fill their cultural agenda. · It also responds to culture and identity issues.	· Economical support. · Broadcasting.
Media	· Reports on local cultural events.	· Broadcasting and diffusion.

Fig. 4. Students' sketch for a structure of stakeholders of a local traditional dance collection, their needs, and their possibilities to contribute.

For this type of audience, the perceived culture as strange, incomprehensible, or surprising.

If the encounter triggers enough curiosity, however, they might be challenged to become an amateur. They might want to learn, and if they find teaching available, they may end up joining the culture and supporting its continuation and its staying alive.

Consequently, a culture that aims at staying alive will have to develop, keep, and provide, documentation and illustration in various levels of detail and depth, various types of representation and modalities, to accommodate both the scholars, the amateurs, and the general public.

And if the culture is alive, the knowledge and beliefs will continue to develop, and the tools of the culture will be used, adjusted, repaired or adapted to new situations and new members of the culture.

2 Cultural Heritage Is Things

UNESCO [10] defines Cultural heritage as follows:

- "*Tangible cultural heritage:*
  - *movable cultural heritage (paintings, sculptures, coins, manuscripts)*
  - *immovable cultural heritage (monuments, archaeological sites, and so on)*
  - *underwater cultural heritage (shipwrecks, underwater ruins and cities)*
- *Intangible cultural heritage: oral traditions, performing arts, rituals*"

In fact, the things, whether tangible or intangible, are the anchors for people to maintain participation in the culture, and, consequently, these things are essential to keep a culture alive. But the things alone cannot do this. The knowledge of their meaning related to the culture, and the skills needed to use them, are another part that should continually be kept, taught, and learned.

Things, in any culture, are from different types: tangible objects need to be maintained (and during the life of the culture often copied) by using (tangible) tools and (often intangible) prescriptions and standards. The actual use of the tangible objects will follow rules and customs (choreographies, scores, scripts, storylines) that are often itself intangible but may be recorded for memory, for teaching and learning in tangible ways (drawings, sketches, literature).

2.1 Collections of Things Need Structure

In the different types of cultural heritage collections that we analyzed during our teaching, we mostly found some type of ontology being used to be able to retrieve the objects and refer to them in documentation, in reaching, and in learning. Sometimes, a single cultural collection needs in fact several ontologies, depending on the viewpoint needed for retrieval. In the website of [3] we find what seem to be separate collections for:

- Music instruments (over 1400 artifacts, of which 400 are on display and visible at the virtual museum in the website), where the collection is structured along the standard description ontologies by Hornbostel and Sachs, as published in [10] and along categories of Basque traditional ensembles;
- Library (over 5800 documents);
- Sound library (over 4800 recordings) structures along locations (countries and regions in the Spanish and France bask area) and period of recording;
- Photographs, video, and films (hundreds);

where all these objects are described in documents in a single content management system, where single or multiple elements can be searched through the search page illustrated in Fig. 5. The result of a single search may be a single or a series of records, where each record is a description that may well refer to various objects, like a video recording, a sound recording, the instrument being played, a restoration report for the instrument, and a picture of the artist; all to be found in the museum premises, though stored on servers (for the digital recordings) or in different rooms and on different shelves related to the physical type of the artifact.

In [7] the ontology is still a challenge, since the 1000s of collected specimen have originally (often several centuries ago) been categorized according to different ontologies and taxonomies that have been overthrown, developed, or the category or species names translated. In addition, apart from the biological identification the location of origin (related to the Dutch Colonial history) is sometimes a main entry for search. The current labels often are being discussed, and the physical storage shows the characteristics of a collection that is in structural re-arrangement. The collection in [4] is structured along several dimensions: type of movie, location and studio, actors, authors, and date of creation. And the storage of the physical artifacts is related to the flammability of the material (the movies) and the size (of the projectors, which are both historic home projectors, and huge cinema machines).

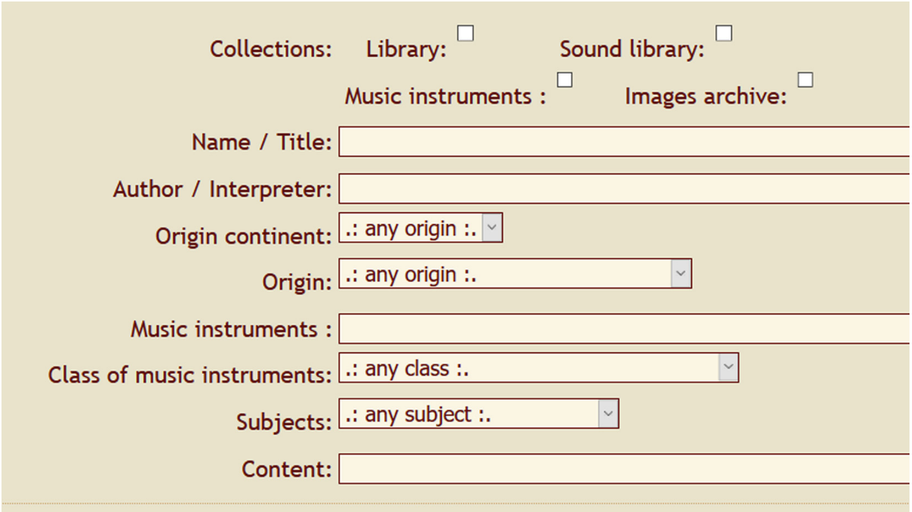

Fig. 5. Example search page, taken from [3], where for several types of cultural heritage a record may be found from the single content management system.

In [6] – a collection of musical instruments, the curators made the decision to label the physical instruments "*primary objects*" (to be searched according to [10], and to refer in their description to different types of "*secondary objects*":

- Sound and video recordings;
- Restoration reports;
- Other documents like validation reports, proof of purchase or donation;
- Publications referring to the individual primary object;
- Physical objects that were removed during maintenance and restoration;
- Physical objects that were related to playing the individual instrument (original bows or mouth pieces, original spare parts like strings, original cases, etc.)

Some of these secondary objects will not be stored with the primary object, but scholars, when allowed to study or manipulate the primary object, should be able to locate and inspect some of the secondary artifacts.

3 Where Are Our Things

Electronic records of elements in a collection may be nicely stored in a content management system and can be approached through a search facility that is based on a feasible ontology. The physical cultural heritage objects, however, each need their own space in the "real" world. In case of large, or complex, collections like [3, 4, 7, 8] locating the individual objects, and relating them to documentation or entries in the content management system is often a challenge.

The case of [8] shows how the structure and business model of the collection brings a challenge to the storage and handling of the artifacts. The collection is not available in a physical museum, the intention of the curators is to provide selections to specialized exhibitions in museums that are available and interested to do so [11–13], where the actual number of instruments displayed, related to the theme of the exhibition, is between 50 and 200. The total physical collection, comprising close to 5000 instruments, is kept in a large store room with cupboards, boxes, and shelves, see Fig. 6. Each individual instrument is labeled by paper sticker of 1 square centimeter containing a 5-digit number that refers to a paper card in a card box.

Fig. 6. Some pictures of the storage of the physical cultural heritage artifacts from [8]

The case referred to in [7] shows the same type of problem. The University website only provides an overview the collection and a few examples, the actual depot contains 1000s of artifacts, partly with descriptions in paper documents that are stored in other rooms. In all cases of [3, 4, 7, 8] retrieving a single artifact requires considerable time and the availability of a curator or an expert employee of the collection (Fig. 7).

4 Moving Our Things into the Cloud

To keep a culture alive, the cultural heritage objects need to be available and need to be related to the knowledge as described in Sect. 2. Current developments in tagging, mobile connectivity, and the internet of things allow us to find solutions for the question from Sect. 3.

The cloud and the internet of things may be conceived to provide locations for a knowledge resource as well as a knowledge storage location (a source and sink) for information related to individual physical cultural heritage artifacts, whether these artifacts are movable or immovable [10].

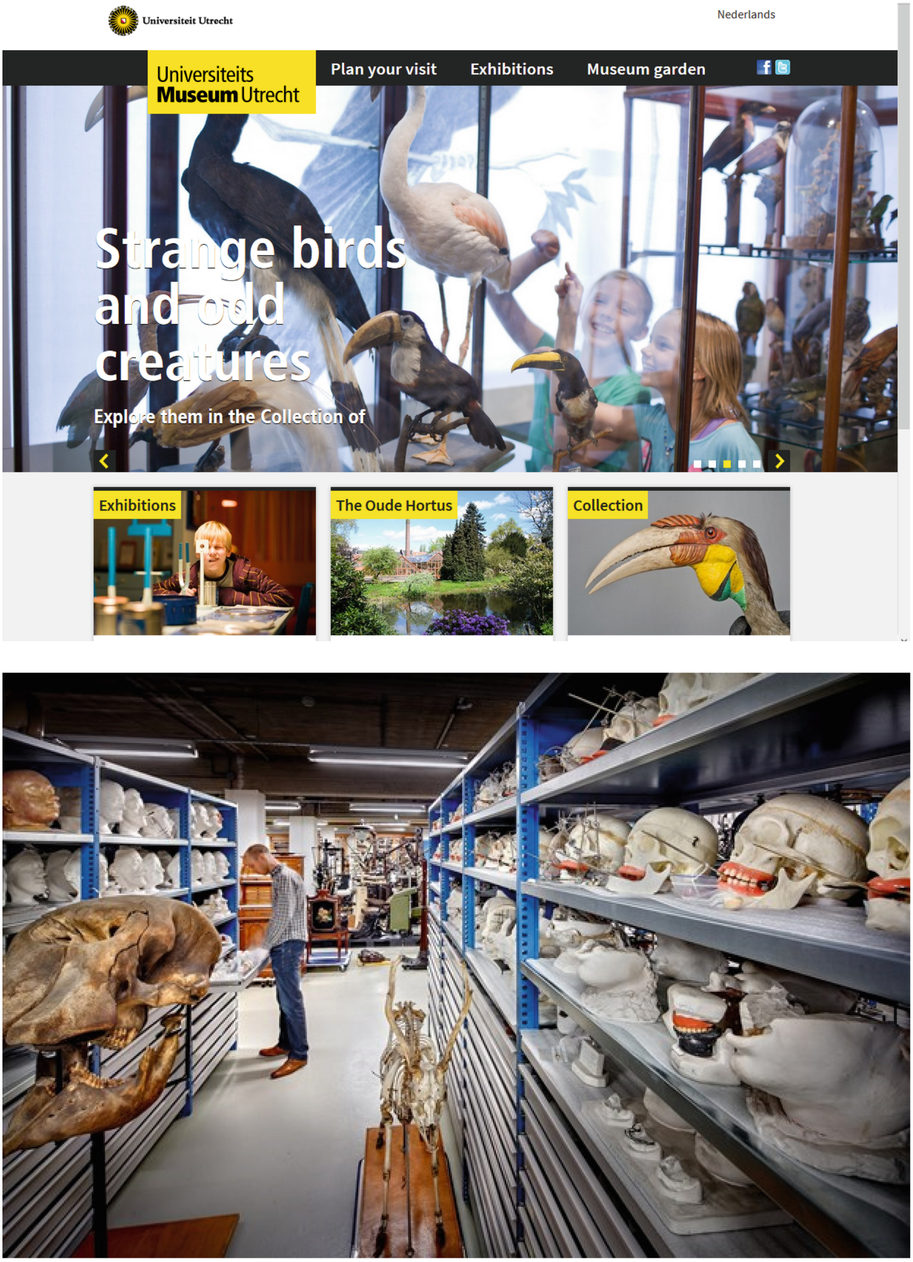

Fig. 7. Website related to collection [7]. And a view into one od = f the storages rooms.

4.1 Landmarks May Have a Virtual Location to Communicate with

Wearable devices like smart phones or their future successors, if they are enabled to identify precise location of the wearer as well as viewing direction (towards an immovable cultural heritage object like a building or a sculpture), can easily relate the artifact to information at the dedicated location for this artifact in the cloud, as well as allow the viewer to comment or upload multimedia recordings to the location (see [14] for an early prototype developed by one of our students).

4.2 Movable Cultural Heritage Can Be Monitored and Approached from the Cloud

If the number of physical artifacts in a collection gets large, housekeeping is a problem.

Objects may be moved around, be displayed temporarily at a foreign location, made available for research or inspection elsewhere. However, once we connect them to the internet of things, solutions seem available:

RFID based Identification and Authentication. RFID tags are available for this in a contactless and passive mode within a short range (current systems allow distances from 10 cm to 100 m).

And they may be attached to the object in a way that is not immediately visible (even worked into textile fabrics etc. This allows to:

- identify an artifact when encountered;
- authenticate the artifact or establish the status of copy or fake;

though forgeries might include cloning the RFID tag.

GPS Tracking. This will enable to locate an artifact within a 1 - 2-m range almost everywhere on the globe, by retrieving them on any web-connected device. It will work if the batteries are working, so some logistics need to be taken care of. This allows monitoring artifacts that are on the move, and retrieving lost or stolen artifacts. The latter functionality, obviously, will only work if the thief is not aware of the GOS tracker, or fails in removing it.

QR code Referencing to URL. QR codes can now be captured by wearable devices, and allow direct connection to web locations that provide access to multimedia information that is relevant and related to the artifact. In the same way, the code can provide access to comment on the artifact and to upload multimedia data that could be used to involve the audience in cultural events or allow them to enrich the connotations of the object.

5 Conclusion: How Safe Is Cultural Heritage in the Cloud

The techniques discussed in Sect. 4 each provide part of the functionality, and currently the size of the tags and tracker is shrinking to a level where unobtrusive application seems feasible. Still, in case of criminal intend locating a missing artifact, and in case of potential forgery fake authentication is still a problem. There are current attempts to, in some cases, overcome these dangers [15].

However, in case of the current large collections of tangible artifacts that are only loosely connected to the intangible knowledge and the relation structure of a living culture, current technical facilities promise a considerable improvement in supporting a living culture. On the other hand, it requires a change in the logistics of many current collections that seem based on traditional paper index cards and backroom storage. We will need to educate the scholars in our cultures as well as to provide IT solutions that are understandable and usable for them.

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Rethinking Wearables in the Realm of Architecture

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Abstract. The architectural built environments, which so ubiquitously, act as shelters and shape our daily personal and social experiences, can soon be envisioned as being interacted with and mediated through *wearables*. This conjecture is becoming salient with the increased interactivity of our built environments, and a sustained drive to render them energy efficient. This entails for the *upscaled* re-design, appropriation, and assessment of functions that are typically ascribed to wearable technologies, as well as the grounding of users' socio-technical interactions and experiences within the built environments.

In this position paper, we discuss this inevitable shift in the role of wearables and the expansion of its functional spectrum to include the built environments and the constituent social constructs, thus facilitating a comprehensive experience of inhabitants' well-being.

Keywords: Well-being · Human-Building Interaction · Sustainable HCI

1 Introduction

Le Corbusier, in his 1923 book *Vers une architecture*, has referred to a building as a machine to inhabit. This perspective is growing ever more relevant with the continued accelerated measures to increase the efficiency of built environments in terms of energy consumption and performance. Consequently, existing built environments are increasingly retrofitted with interactive elements (for example, NEST thermostat[1]) to optimize energy usage by *(a)* automating specific functions, *(b)* providing awareness about (the consequences of) inhabitants' actions, and *(c)* providing a platform (in a long term) to change one's behavior towards energy-efficient living. Additionally, in newly constructed buildings, more specifically the one certified by low-energy-consumption standards (for example, Minergie in Switzerland), automated heating and ventilation systems have mandated the removal of operational windows. While these developments have been reported to be advantageous in conserving energy, the lack of control over the environment (as a consequence of automation) has raised concerns about the inhabitants' perceived comfort [1, 2]. Furthermore, the furnishing of varied interactive and awareness devices calls for the design, appropriation, and assessment of new interaction paradigms and socio-technical practices. These evolving concerns and

[1] https://nest.com/thermostat/meet-nest-thermostat/.

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opportunities entail the monitoring of environmental parameters, knowledge about existing social constructs, and acute context awareness followed by recommendations for contextualized actions on the part of both the built environment and the inhabitants.

The functions of continued observance, diagnosis, and awareness of individuals' physical or physiological state are already ascribed to numerous wearable devices (for example fitness and activity trackers, medical implants, etc.). We believe that with the evolution of our built environments, these aforementioned functions are being expanded to include, beyond just the physiological state, the (spatio-temporal) knowledge about our physical environment and social contexts. Consequently, we can envision supplementing the role of wearables as a facilitator for our (two-way) interactions with the built environments and other inhabitants, in a way that our living/working experiences are grounded within an ecosystem of socio-technical systems comprising of sensors, actuators, ambient information, and data analyses. Furthermore, a (multi-modal) data-centric approach may manifest in the "quantified home (or office)" as an extension of the lifelogging movement.

In the following sections, we will illustrate this notion with the (developing) perspective of Human-Building Interaction (HBI) [3, 4], as well as our own participatory experiences within an interdisciplinary living lab project comprising of architects, building performance researchers, designers, and us (HCI researchers).

2 Human-Building Interaction (HBI)

Human-Building Interaction (HBI) is an emerging notion at the intersection of architecture, interaction design, and UbiComp that aims "*to provide interactive opportunities for the occupants to shape the physical, spatial, and social impacts of their built environments*" [3]. Interaction design and UbiComp have on numerous occasions drawn inspirations from the domains of architecture and urban design. However, the concrete possibilities for these domains to closely work together have been rare in the past [4]. HBI is (consequently) an attempt to bring together researchers from these contributing domains to share knowledge and work in close cooperation, in order to design for the sustainable living experiences while addressing the evolving living and working styles and habits of inhabitants. Smart Living Lab, as discussed in the next section, is a unique project which is the manifestation of principles at the core of HBI.

2.1 Smart Living Lab

Smart Living Lab[2] is an inter-disciplinary lab engaged in the envisioning of the built environments of the future by examining the research questions that concern sustainable living and working experiences, which are grounded in the evolving socio-cultural practices. A prototype building was constructed to study these aspects in central Switzerland, in the bilingual city of Fribourg. This building currently serves as a workspace for around 100 researchers from three academic institutions - Swiss Federal

[2] https://smartlivinglab.ch.

Institute of Technology (EPFL), University of Fribourg, and School of Engineering and Architecture in Fribourg (HEIA). The researchers come from different domains of Architecture, Building Physics and Performance, Design, Law, and HCI. Amongst multiple projects that are currently being pursued, inhabitants' well-being and the perception of comfort within the changing landscape of modern architecture, as well as the role of human factors in building design are the research topics which we are currently investigating.

Our contributions within the Smart Living Lab, so far have focused on the ecologically valid and multivariate building-data visualization, exploration and analysis, which may reveal varied aspects of occupants' behavior in different scenarios. This data-centered approach has implications for the comprehension of occupants' well-being, and simultaneously augment it through well-grounded socio-technical interactions and experiences. Here, we believe that the wearable technologies have a crucial part to play.

3 Beyond Quantified Self – Quantified Buildings

The potential expansion of wearables' functional spectrum to include our built environment may augment our self-awareness about our well-being by including aspects of comfort and its perception, as well as the contextualized negotiation of environmental state (temperature, air quality, etc.) with fellow inhabitants while maintaining a sustainable living practice. This entails design, appropriation, and evaluation of new interaction mechanisms with the built environment, either directly or indirectly through wearables by examining the dynamic socio-cultural practices through an amalgamation of ethnography, interaction design, and (sensor-) data analytics. In this section, we illustrate the varied dimensions and scenarios that may constitute this shift in our fine-grained awareness beyond ourselves to our environment. These dimensions correspond to the multiple sources of available physical and physiological data from sensors, which can facilitate the acquisition of knowledge about the context (number of inhabitants, ongoing activity, physiological history, etc.), and offer a quantitative platform to negotiate environmental state between a human and a building (for example POEM [1]), or amongst inhabitants themselves. In the following sections, we will especially focus on dimensions pertaining to the quality of indoor environment and mobility of its individuals, as these are the dimensions which can afford an extension to the conventional wearables.

3.1 Environmental Characteristics

Environmental characteristics concerning well-being can be grouped into four categories of thermal, respiratory, visual, and acoustic well-being [5, 6]. While significant amount of research has been conducted in different domains on the thermal and respiratory aspects, relatively less work accounts for the visual and acoustic aspects. This can be attributed to the immediately perceived effects of thermal environment (temperature, humidity, and air-flow) [7], and the adverse effects of inferior respiratory environment owing to the increased concentration of gases such as Carbon Dioxide, pollutants and particulate matter [8, 9]. The relevance of the respiratory environment is further heightened due to the adverse effects of poor air quality on human health, the lack of awareness about the air quality within buildings [10, 11], and especially crucial in metropolitan cities which experience increased levels of pollution.

Sensors recording different attributes of these dimensions can be distributed within the built environment, which in tandem with ambient and distributed awareness tools may prove to be informative to the inhabitants. Subsequently, these awareness (and visualization) tools can offer informed recommendations to the inhabitants about the set of possible actions (for example opening windows to allow for cross-ventilation). In addition, they can also provide an interactive platform for inhabitants to negotiate their comfort parameters (for example, in case of conflicts resulting from varying thermal perceptions). ComfortBox by Alavi et al. [12] is an example of such a tool that affords for awareness about these four dimensions, a possibility to inform the building (through interactions) about levels of acceptable comfort, and communicate one's perceived comfort to other inhabitants.

The perceived loss of control over different architectural elements such as windows and shades, with the increased automation of buildings and its environment, has also been observed by Brambilla et al. [2] to negatively influence the perceived well-being of inhabitants. This further exacerbates the need for tools and mechanisms that can mitigate this negative perception by providing awareness, empowering inhabitants to express their opinions about their well-being, and eventually enabling them to negotiate the desired environment. Furthermore, we envision that the living experience can be enriched by combining physiological information from conventional wearables (for example, body temperature, skin conductance), as it can facilitate the acquisition of precise knowledge about an inhabitant's health status, and enable the development of personalized and contextualized well-being models.

3.2 Presence and Proximity

Presence (or absence) of inhabitants within home, office, or a specific room, or proximity to certain artifacts and architectural elements within the building are vital resources to establish a precise context awareness for the built environment. Smart home technologies (for example, NEST thermostat, smart lighting) leverage this information to regulate the environmental state by controlling the HVAC (Heating, Ventilation, and Air Conditioning), or lighting systems, and consequently optimize the energy consumption. These systems often use the geo-location information of an inhabitant's smart phone to accomplish their goals.

Furthermore, at a finer level of granularity, the presence information can be used to precisely model the context such as the number of inhabitants and thus the likely activity the inhabitants are engaged in, or in specific cases to detect unexpected behavior for security reasons. Indoor localization techniques can be used to access this information. Besides allowing for finer control over the environmental attributes, the presence information can also be used to assess various building functions in the post-occupancy phase of a building. The study conducted by Verma et al. [13] employed presence information (specifically indoor mobility) to assess if the rooms within an office building were used to their full capacity, and how inhabitants with different professional profiles contributed to the utilization of office space. Such studies, in the short term, allow for the sustainable use of buildings and provide implications for design and appropriation. In the medium term, they can act as valuable knowledge resources for the next phase of building life-cycle, and in the long term they contribute to the repertoire of knowledge about human factors in built environment. Therefore, the presence and proximity information can be leveraged with the wearables to attain a comprehensive understanding of inhabitants' behavior, and this can be utilized extensively to expand wearables' functionality beyond health monitoring to design contextualized interactive services and tools.

3.3 Social Attributes

Environmental attributes and inhabitants' localized information can be easily accessed through a combination of distributed sensors, and can be simultaneously leveraged to interact with our built environments. In addition, social cues and signals (such as speech times, turn-taking, proximity to other inhabitants, etc.) which constitute an integral aspect of human communication, can further enrich the contextualized knowledge of the built environment. These social aspects which are investigated and designed for by researchers in the CSCW (Computer Supported Collaborative Work) community can be utilized, either directly or indirectly, by wearables to enable occupants to exercise fine control over buildings. Furthermore, the abundant knowledge within the CSCW community, which was acquired through the analysis of social interactions (verbal and non-verbal) may foster the design of collective awareness tools (about environmental factors – both indoor and outdoor). Such tools, in the short term may allow the occupants to negotiate their comfort levels, and in the long term can motivate occupants to regulate their behavior for a sustainable living experience.

4 Sketching the Research Landscape

Following the illustration of the broad constellation of variables (physical, physiological, social) that can - individually or in combination - influence our immersive experiences with or within our built environments, the next logical step would be to answer questions concerning inhabitants' needs, expectations, and mental models about the nature of interaction, interactivity, and immersiveness within our environments. In addition, discussions need to be organized around the role of wearables in mediating our interactions with the built environments, how this mediation will scale with the changing landscape of socio-cultural contexts, and where (within the broad spectrum of dynamic user experiences) will the wearables contribute significantly. This entails the establishment of an interdisciplinary knowledge about perception of environmental attributes, user experience, and inhabitant behavior through research efforts at the intersection of computer science, architecture, psychology, and sociology. In this section, we attempt to sketch the future research landscape by asking questions concerning the following themes, answers to which will concretely consolidate the role of wearable technologies in human-building interaction (HBI).

4.1 Agency or Control

The evolution of architecture through the incorporation of interactive and robotic elements (such as window blinds), is bringing to the forefront, the issues related to the inhabitants' agency or the sense of control over the built environment. This entails raising questions that are fundamental to the ascribed behaviors and afforded functions of wearables embodied within our interactive experiences with the built environments. For example, how do we bridge the gap between the individuality of wearables and the commonality of architecture? How can the coupling of wearables and adaptive/robotic environments provide for a seemingly integrative experience to the users? Or what features can be extracted from wearable sensing that could shed light on the points of inefficiency in the interaction between built environments and their occupants? Furthermore, how can our perception of environmental factors and our subjective experiences be leveraged and integrated by the wearables to enhance the overall user experience? In social scenarios, how can the agency be shared between co-habitants, or delegated to a specific inhabitant?

One of the HBI challenges is to reconcile inhabitants' agency with the efficiency of building automation systems. So, how can wearables help address this challenge? Also, how can the wearables be designed as persuasive platforms to encourage inhabitants to pursue sustainable and environmental friendly behaviors, for example, through the awareness about the consequences of their actions?

4.2 Health and Awareness

Consolidating the monitoring of inhabitants' health and well-being and their awareness can easily be regarded as the extension of wearables' capabilities to include the environment. However, this extended functionality has to be well-grounded within the context (location, activity, weather, etc.), physiological state, subjective preferences, and the social context of inhabitants. In addition, how can the wearables in-tandem with other environmental sensors contribute in the understanding of personalized comfort models/zones of the inhabitants? How do these personalized models differ in varying socio-cultural contexts? How can the wearables make inhabitants' more aware of their environmental attributes, especially about the health critical attributes such as air quality? When and how should the wearables intervene as the environmental attributes change (possibly from comfortable to relative discomfort), and what recommendations about the possible actions should they offer?

Next, framing the issue of health awareness within the notion of *biopower* and *biopolitics* [14, 15], which examines the "truth discourses" about human body, health, and life, and the "authorities which are competent enough to convey this truth" such as the wearable technologies and the role of data in assessing our health. Biopolitics, further examines the authority around the discourses related to life and health by questioning the role of authority itself and who can be considered as an authority. For example, does technology has an authority over our experiences related to health and well-being within the built environments, or the inhabitants themselves? These questions have to be grounded and studied within the architectural context while designing wearables to mediate/augment our experiences with our built environments.

4.3 Privacy and Data Protection

Owing to the *(a)* massive amount of data that is collected through the wearables and the ambient sensors within the built environment, *(b)* its storage and analysis on (cloud) servers, *(c)* extraction of health-related features, and *(d)* the potential inference of the state of the inhabitants' health and its relationship to the medical history and the personalized models of comfort as well as the context-sensitive information, render privacy and data protection a critical aspect of the design and application of wearables within architectural environments. These issues entail for the examination of privacy as a fundamental right since the beginning of the design process and not as a by-product, for example privacy by design [16, 17]. Who owns the data (inhabitants, building, or both), or has the authority over the actions resulting from data analysis and inference? In what circumstances or contexts, can the data be shared with external agents, and to what extent? How will the privacy and data protection policies evolve in varying social scenarios (for example, while hosting guests)? Going beyond the user consent, strategies and policies should be developed to evaluate the inherent risks and prevent the misuse of personal data without compromising the quality of service and the user experience.

5 Conclusion

In this position paper, we have argued that with the increased interactivity of our built environments and an enhanced need for sustainable living, the well-being (or comfort) of inhabitants is being rendered crucial. Here, we believe, that the wearable technologies can play a vital role in diluting the boundaries of *self* to (also) include our built environments. This extension in the functional spectrum of wearables is happening with the increased diffusion of different sensors (recording the thermal, respiratory, acoustic, and visual aspects of built environments), and the increasing interactivity of our living and working spaces. Furthermore, the physiological data that is being collected and analyzed by wearable devices can be combined and communicated with our built environments to *(a)* maintain a precise awareness of the context (inhabitants' health status and the ongoing activity), *(b)* increase the inhabitants' awareness about the environmental factors and their influence on health, *(c)* enable a fine grained control over our built environments while optimizing the energy consumption, *(d)* provide inhabitants with a platform to negotiate their comfort with others, and thus *(e)* foster an enhanced living and working experience. Finally, we have drawn out the emerging research landscape as a consequence of the diffusion of wearable devices within the interactive experiences with our built environments, by raising relevant questions concerning agency, well-being, awareness, and privacy.

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Tailored, Multimodal and Opportune Interactions on a Wearable Sport Coach: The WE-nner Framework

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Abstract. A growing body of evidence from Psychology and Sport Sciences shows that physical activity can be a cost-effective and safe intervention for the prevention and treatment of a wide range of mental and physical health problems. Research in domains such as the Internet of Things (IoT), wearables and persuasive technologies suggest that a coach intended to promote physical activities needs to provide personalized interaction. In this paper we introduce the WE-nner (pronounce "winner") framework for designing an automated coach promoting physical activity which supports interactions between the user and a smart wearable that are: (1) personalized to the user, (2) dynamic (e.g. occurring during a physical activity), and (3) multimodal (e.g. combine graphics, text, audio and touch). We explain how we implemented this framework on a commercial smartwatch and provide illustrative examples on how it provides dynamic personalized and multimodal interactions considering features from user's profile. Future directions are discussed in terms of how this framework can be used and adapted to consider theories and models from Psychology and Sport Sciences.

Keywords: Wearables · Embedded computing · Physical activity Personalization · Multimodal interaction · Sport coach

1 Introduction

Researchers are designing *automated exercise coaches* for health [6, 7] and sport experts or beginners [10]. A growing body of evidence from Psychology and Sport Sciences shows that physical activity can be a cost-effective and safe intervention for the prevention and treatment of a wide range of mental and physical health problems [1]. Yet, the design of virtual health agents faces multiple challenges such as [9]: (1) interpreting the situation and people's intentions, (2) intervention reasoning, (3) generating informative, educative, persuasive computer behavior, and (4) engineering generic solutions. Research in domains such as the Internet of Things (IoT), wearables and persuasive technologies [2] does suggest that a coach intended to promote physical activities needs to provide *tailored interaction* [8, 17], *personalized messages* and bring into play persuasive strategies that depend on gender and personality [3], and stage of behavior change [4]. The use of persuasive technologies and virtual coaches for promoting

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physical activity might help stress management [5], but adhesion might also depend on aspects of the self [15, 16].

Thus *tailoring information* is significantly more effective when it provides *specific* details on how to improve the performance, rather than when it just indicates whether the performance is correct or not [30]. When tailoring information involves emotional dimension, interaction becomes more attractive, increasing student engagement and motivation [29, 31]. Finally, when users manage the tailoring process, Kim et al. [32] observe in a positive attitude toward the conveyed information.

Although lots of people still use a phone for collecting data during a physical activity, *smartwatches* display several advantages over mobile phones: they are closer to the body, safer to use than the mobile phone when moving, and they are designed to have a longer battery life. Using smartwatches to support affective interaction nevertheless rises challenges in terms of human-computer interaction. Multiple commercial wearables for sport activities are available. We claim that in order to become smart, an automated coach requires to provide via a smartwatch: (1) interactions that are personalized to the user, (2) dynamic support occurring not only before and after a physical activity but also during a physical activity, and (3) multimodal interactions (including subtle and complementary use of embedded graphics, audio and touch).

In this paper, we introduce WE-nner, a framework for the design of a coach supporting personalized interaction for physical activities. We illustrate how we implemented this coach using a commercial platform for embedded programming. We discuss how this framework impacts the relation between users and computing devices (smartwatch, mobile phone, web site) and may improve the relationships between users and computing devices.

2 WE-nner Framework

Brinkman [9] proposes a research framework for behavior change support systems that brings into play situation interpretation, intervention reasoning (using personal and population data; possibly calling for remote assistance from human health professionals), and the generation of informative, educative and persuasive behaviors. In our framework we focus on this last step which requires that the system handles relevant features of user's profile and is able to use it dynamically during a physical activity to generate personalized and multimodal interactions.

2.1 Multimodal Interaction During Physical Activity

The WWHT framework [19] describes how to present multimodal information to users along several questions: What is the information to present? Which modalities should we use to present this information? How to present the information using these modalities? How to handle the evolution of the resulting presentation?

Few studies about multimodal interaction were conducted with smartwatches during physical activity. Lee et al. designed multimodal and mobile interaction between a user and a sport-watch while the user is walking on a treadmill [14].

Interaction with a sport-watch can be personalized along several dimensions:

- *Time:* interaction can take place with the user at different timescales around a physical activity, for example several days before an activity, just before the activity starts, during the activity, just after the end of the activity, and several hours or days after the activity. One might expect that interactions at these different times would have different goals and results
- *Modality:* information can be presented to the user on several channels and modalities: on the visual channel (graphics, text messages, text menus: displayed on the screen), touch (vibrations), and audio signals
- *Content:* technical messages, motivating message, warning messages,
- *Goal:* the task of coaching a user involves several components and use cases (e.g. weekly burnt calories)

Currently, user's profile include the user's name, gender, history of activities and weekly goal in terms of burnt calories.

2.2 Software Implementation

Few smartwatches provide a software Development Kit and a programming language that enables embedded computing on the smartwatch. This is nevertheless required to dynamically customize the interaction with users. This allows to design customized interactions that fit between minimal interactions available on other commercial wearables and full symbiosis that are investigated in research.

We implemented the WE-nner framework using the GARMIN Connect IQ environment and its MonkeyC object oriented programming language. GARMIN is one of the few smartwatch manufacturer that provides a Software Development Kit that enables to develop a program on a PC and to upload and embed the software on the watch itself. GARMIN offers a dedicated programming environment called Connect IQ[1] which enables to program and upload several kinds of applications on a smartwatch (face, widget, data field and apps). Different types of applications have different degrees of access to the sensors and actuators of the watch and allow for different types of interactive capabilities. GARMIN wearables support four types of interactions components:

- *WatchFaces* provide personalized "passive" displays of the main screen. Users are able to choose and download the watch face they prefer and add any information they like.
- *Widgets* provide at-a-glance information to the user that meets the individual customization. They are usually small practical tools like a compass or a weather report and are limited in terms of interaction capabilities.
- *DataFields* are fields displaying data which is computed or available at runtime (e.g. speed, time). The expert user can select the fields that she wants to be displayed and their order of presentation. DataFiels do not support any interaction.

1 https://developer.garmin.com/connect-iq/.

- *Apps* are the most interactive components that can be uploaded on the watch. They can contain menus, data, textual and graphical messages that can be selected and combined at runtime. An app is explicitly started from the main menu of the watch.

Interaction with advanced sport smartwatches such as a GARMIN watch can be quite tricky for the ordinary user. Furthermore, even apps available on the GARMIN store do not provide flexible and personalized multimodal interactions.

We implemented our WE-nner framework as a Connect IQ App in order to benefit from the maximum access to sensors and actuators. Figure 1 illustrates how the WE-nner software uploaded on the GARMIN Fenix 5 smartwatch provides interaction that is personalized at runtime before an activity starts. The smartwatch collects information from an .xml file detailing user's profile (e.g. user name, user birth date, activity history). The menus as well as the responses of the different physical buttons that surround the watch can be completely changed at runtime to cope with a given user.

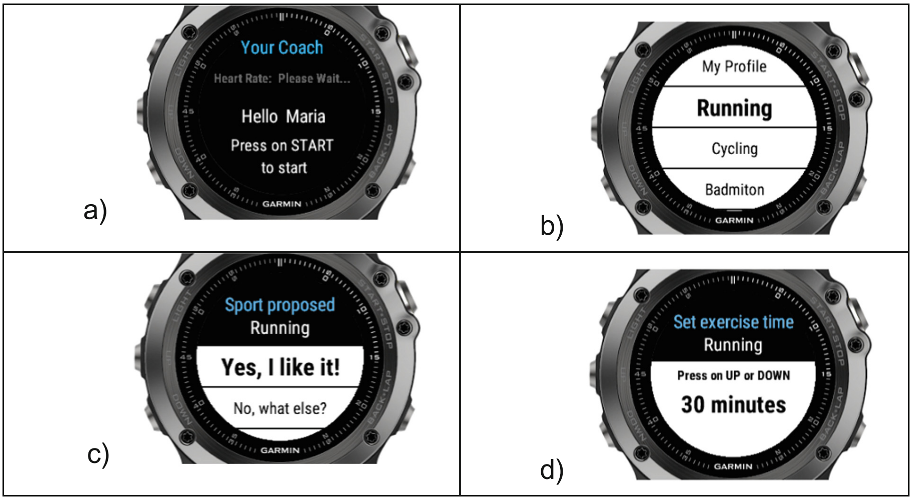

Fig. 1. Screendumps showing personalized interaction before an activity starts: (a) WE-nner displays a personalized message including user's name, (b) it suggests several activities (which can consider user's history of previous activities), (c) the user is able to select the activity she wants to do, and (d) the activity is ready to start.

Interaction can also be personalized *during* a physical activity. For example, a warning text, audio and tactile message (vibrations) can be generated dynamically by WE-nner when the heart rate frequency goes beyond a given percentage of the current user's maximum heart rate frequency (Fig. 2).

Finally, WE-nner also enables to personalize interaction after the end of the activity, and display for example a congratulation message that embeds user's name and information about the current achievements in terms of burnt calories (Fig. 3).

Figure 4 illustrates the displays on the watch during an outdoor test.

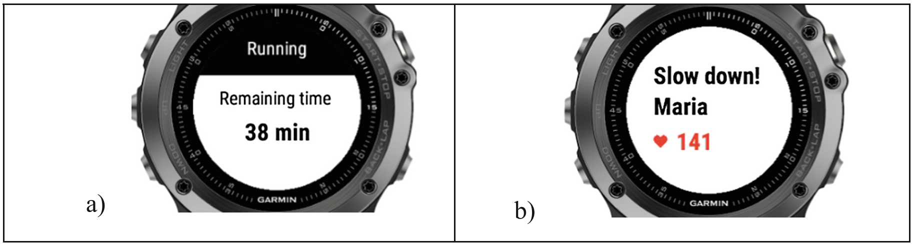

Fig. 2. Screendumps showing personalized interaction during an activity: (a) at some point during an activity, a multimodal (graphics, audio, vibrations) personalized message is dynamically computed and displayed including user's name and considering a threshold of heart rate frequency that is specific to this user.

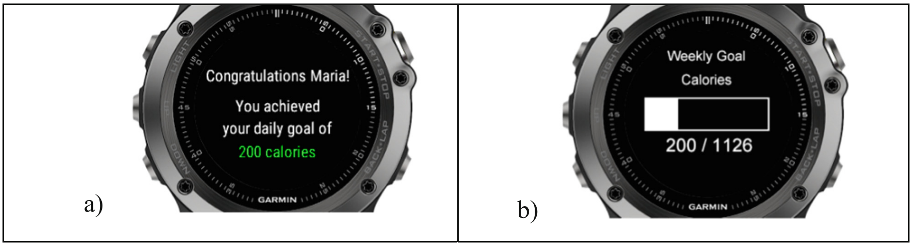

Fig. 3. Screendumps showing personalized interaction after an activity: (a) a personalized message is computed at runtime on the watch and includes user's name and the number of burnt calories during the activity, and (b) the percentage of this user's weekly calories goals can be graphically displayed.

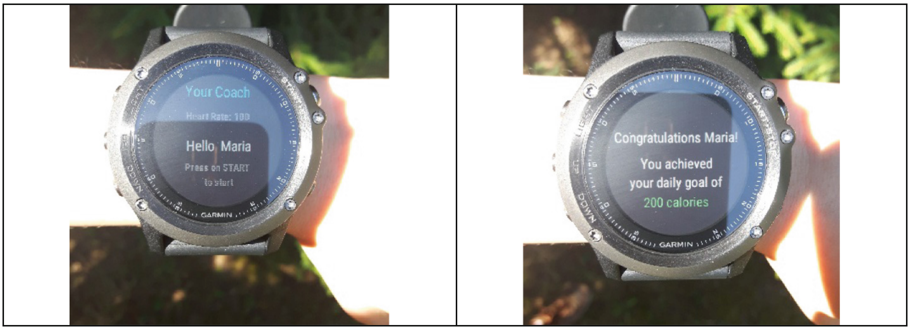

Fig. 4. Personalized messages displayed on the smartwatch during an outdoor test.

2.3 Software Architecture

The smartwatch provides sensors, screen and loudspeaker that enables a user to track her daily physical activities. The activity information that includes time, duration, speed, distance, calories burned and heart rate is mostly saved in .FIT binary files.

The GARMIN connect web site enables a user to login and visualize the data related to his/her recorded activities and health status. The GARMIN Connect Mobile Application is required to synchronize the data between the watch and the web site.

We have developed an Android application called WEnnerMobile. It enables a user to view his activity history, visualize his heart rate records by curve chart, and test his/her pressure level by a answering a questionnaire. It will also provide a virtual coach to give the user personal advice on exercises. The user can choose a FIT or CSV fitness file stored in the phone memory. When a FIT file is chosen, it is be decoded into a CSV file, and the data can be processed and displayed in tables and charts.

Finally a website is used (WEnnerWeb) to store data collected with the watch and the mobile phone. The administrator of this web site can define the sport types, user's initial preferences of the sport and the target training time. Each time when an activity is finished, the WEnnerWatch app can collect Ecological Momentary Assessment and ask the user to self report on her mood (e.g. "Positive", "Negative" or "Neutral"). Such information can be exploited to tailor and adapt follow-up sessions (Fig. 5).

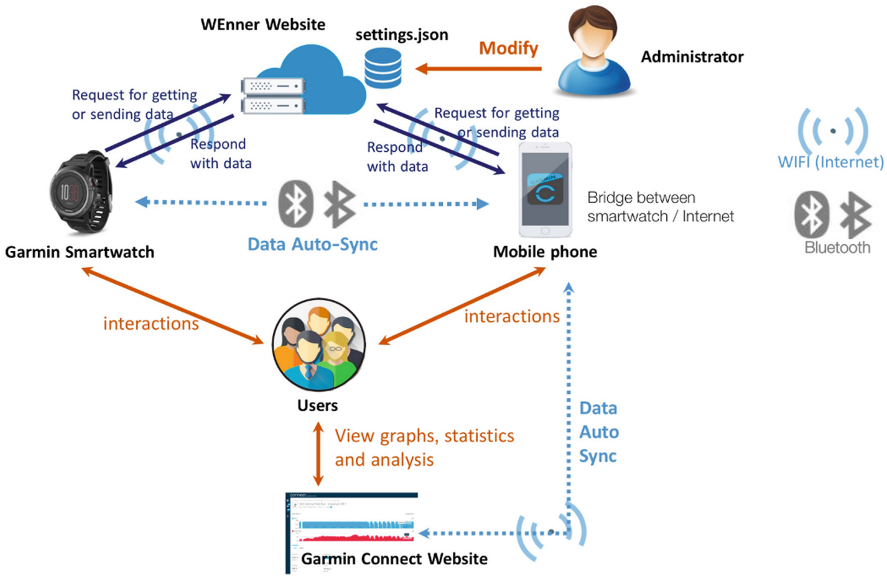

Fig. 5. Devices and software architecture of the WEnner framework.

3 Conclusions and Future Directions

We introduced the WE-nner technological framework for designing a coach that supports physical activity and enables personalized, multimodal and dynamic interactions between a user and a wearable. We explained and illustrated how this framework was implemented using a commercially available software development kit for smartwatches.

The next step is to define the specifications of the personalized multimodal coach. We will go through a requirement analysis involving users with different levels of physical activities practice. This requirement analysis will identify the desired functions of the coach as well as its multimodal interaction capacities. This includes the selection of opportune motivational interactions delivery timing [28].

Next steps include the modeling and implementation of relevant personality and inter-individual differences features in the WE-nner user's profile. We are considering two theories from Psychology: the OCEAN personality traits and the regulatory focus theory. These two theories because they have an impact either in terms of physical activity itself or in terms of persuasiveness. The OCEAN/Big Five personality traits, also known as the five factor model (FFM), is a model based on common language descriptors of personality [26]. The five factors have been defined as openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism, often represented by the acronym OCEAN. Relations have been found between the OCEAN personality traits and motivation to learn [27], but also with physical exercise (see [21] for a review). For example, Tolea et al. found [20] found some associations between personality traits and physical activity level. Saklofske et al. observed that self-report emotional intelligence mediated the relationship between personality and exercise behavior [22].

The second theory that we are considering is the regulatory focus [24]. Regulatory focus has been shown to influence how individuals make judgments and decisions [23]. We have already regulatory focus in our MARC virtual agent platform [12, 13]. Regulatory focus is also being used for the generation of persuasive messages [11]. Individuals are either gain-oriented ("promotion-focused") or loss-oriented ("prevention-focus"). Framing messages influence individuals' cognitive processing of messages [25].

In terms of interaction, we will extend our framework for supporting the dynamic selection of output modalities and their combinations (e.g. complementarity, redundancy) to achieve an appropriate integration of the senses by users. This requires considering contextual information (e.g. if the user is on the move, a vibration can be used to inform the user that she should stop and look at an important message on the watch). Frameworks for multimodal output generation will be considered [19]. We will also consider the design of consistent interactions between the smartwatch, the mobile phone and a web site in order to support the relation between the user and her personalized coach which is in fact dispatched over several devices (possibly including other sensors and wearables).

We are also considering on how an animated and expressive agent displayed on the smartphone (and simple representations of it on the watch) can motivate the user based on affective reasoning and data [18].

These dimensions of personality and multimodal interaction will be considered as input for the modelling and implementation of the coach using the WEnner technological framework introduced in this paper.

Long term user studies need to be conducted to test if this wearable and its personalized and multimodal interactions do induce engagement and behavior change, and to assess how much they are impacted by aspect of the self [15, 16]. Ethics and privacy are also considered since personal data is collected and can induce behavior change.

Finally, sport coaching will be articulated with another coach in charge of stress management so that both coaches can exchange information in order to fine-ture and tailor consistent interactions.

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The Evolution of Visual Art: From Painting to Interaction Design

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Abstract. This paper focuses on the application of interactive technology in contemporary visual art, showing that current development has traces in history. We sketch an evolution, from the creation of primitive visual art to interaction design and wearable art. We will discuss how the artist communicates through his creation with the intended audience, and how new technology enables the art work to interact autonomously.

Keywords: Interaction design · Wearables · Stakeholders · Visual art Co-creation of artistic experiences

1 Introduction

Goal of our research is to attract attention from different stakeholders in visual arts, so that they discover their changing roles and appreciate the potential for unknown mutual collaboration and cooperation. In this way, we may achieve an ecological art environment that supports survival, co-creation, and development. The current paper focuses on the application of interactive technology in contemporary visual art, showing that current development has traces in history. We sketch an evolution, from the creation of primitive visual art to interaction design and wearable art. In Sect. 2, we will show how visual art has always resulted in an artifact (a "thing") to communicate and to trigger understanding, experiences and behavior in an audience. In Sect. 3, we will discover how in the new world this "thing" can be created to interact: Visual art is getting a true life of its own.

2 A Short Account of a Long History

Interactive technology is developing rapidly. The Internet of things promotes interaction design for diverse audiences and many platforms, more practical, more interesting and more approachable than ever before. As Weiser points: "*The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it*" [1].

Early visual art works were intended to present images (drawings, sculptures) of important entities: gods, people, hunting. Such is prehistoric art: It is a mixed state of

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aesthetic and non-aesthetic factors, it does not only serve practical purposes but also shows aesthetic consciousness. Prehistoric art with its simple form and immature techniques attracts modern audiences and artists, partly because the content does not show too many ideas and values, which is also the goal of some streams in modern art [2].

2.1 Ancient Visitors of the Caves Understood and Experienced Their Art

Prehistoric cave- or rock paintings represent the earliest forms of painting that survived, traced back to 40 thousand years ago. We experience a hint of the spiritual life of our ancestors, and we may imagine the intended audience (members of the same tribe, gods), who were supposed to (actively) interpret and understand the message as depicted. Figure 1a shows how the artist triggers his audience to see a depicted hand, where "she" (According to archaeologists, these are feminine handprints.) in fact, paints the space around the (invisible) hand – the audience will "fill in" the invisible. The deer in Fig. 1b may well represent something related to hunt, and tribal relatives of the artist will have known much more about the values, activities, and emotions related to the scene than modern viewers will ever be able to understand.

(a) (b)

Fig. 1. Lascaux Cave Paintings, France, Lascaux, ca 17000 BC [3]

2.2 How Our Ancestors Understood Hierarchy and Holiness

Many early historic paintings refer to religious belief, to the existence of a soul. and to prayers: after death people hope to go to heaven or be reborn.

Ancient Egyptian murals are characterized by realism combined with deformation and decoration; hieroglyphs and images are used together, and the artist always maintains the readability (Fig. 2). The picture composition is arranged with characters in a line, with different sizes according to the status hierarchy and carefully represented distances to get the image size in order. Other than this, there is a stylized regularity and unity in the form of expression, and some artistic techniques have been used continuously over many centuries to form a unique style of Egyptian art. The intended audience, whether human or god, will have understood the emotional intentions and the esthetics in relation to their interpretation of the meaning.

Fig. 2. Egyptian mural. ca. 1100 B.C. [4].

Fig. 3. Painting of the ode of the River Goddess, Gu Kaizhi, A.D. 348–409 [5].

Chinese early paintings, like early Egyptian art, use exaggeration to highlight the main characters, to distinguish their status hierarchy, e.g., see the Lo River map (Fig. 3). In early Christian religious painting, the halo is used to distinguish between saint and man (Fig. 4a). The same technique can be found in Buddhist paintings (Fig. 4b) where the Buddha has a head halo and a back halo, which represents the highest level of this god. Some gods only feature a head light, indicating the difference in rank. This style shows many expressive techniques in painting and sculpture, representing the meaning as well as the specific style and workmanship, which is related to a specific period. These characteristics often are used as the basis for dating.

(a) (b)

Fig. 4. Halos of Christian gods (Giotto di Bondone: Ognissanti Madonna. Italy. c. 1310) and Buddhist gods (Dunhuang Mural. China. ca. 538 AD) [6, 7].

2.3 From Painting to Writing – New Understanding Needed from the Audience

In a next stage of civilizations, series of images were used to represent spoken language, where the individual imagines were supposed to be named and the string of names was supposed to (actively) be interpreted by the audience as a spoken sentence.

Fig. 5. Mayan text, Around the Christian era [8].

Examples may be found in Mayan texts (Fig. 5), Egyptian hieroglyphics (see left bottom corner of Fig. 2), and Sumerian cuneiform script. In each case, this type of script was used extensively for several centuries. However, in due time, the images lost pictorial details and developed into new type of "abstract" art styles, like Chinese calligraphy. Chinese characters are the only words in the oldest text that are still in use today. Figure 6 provides an impression of the development over time. Chinese calligraphy has independent aesthetic value, so it can be appreciated as a visual art. It is a technique which people learn by copying and creating their own style. The audience is supposed to appreciate the non-figural artistic qualities in relation to the meaning of the language.

Fig. 6. Examples of transformation of Chinese characters "Horse" over time [9]

2.4 Artists Challenge the Audience to Be Active

New developments in artistic techniques allowed, and triggered, active behavior of the audience: horizontal Chinese scrolls require the viewer to walk the painting from the start of a story to the end (Fig. 7a).

(a) (b)

Fig. 7. Han Xizai Evening Banquet, China, 937-975 AD [10]; John Gipkin, Bishop King Preaching at Paul's Cross before King James I. (1616) [13].

A different type of activity is triggered by the technique of panorama painting, displayed at a 360-degree angle, so that the audience can walk around and feel immersed in the visual representation of space. Like the Panorama Mesdag of Netherlands [11].

The development of perspective drawing provided the suggestion of 3D images as rendered on a 2D surface, an early type of virtual reality, that was originally sometimes considered to be what we now would label photo-realistic. For example, (Fig. 3) the perspective and composition of Chinese paintings are free and flexible. [12] Artists use this to break the limitation of time and space, aiming at a virtual reality in the viewer's mind. Later, artists took the liberty to play around and leave the interpretation of the suggested 3D work to the viewer (Fig. 7b). In due time, the photorealistic rendering was sometimes labeled "trompe-l'oeil" – showing that the intended interpretation of "normal" painting was already beyond photo realistic, and in this way the trompe-l'oeil requires the viewer to appreciate that this is not just a precise rendering but a successful attempt to confuse the experience of reality. This shows that appreciation and interpretation develop and changes with the development of (art) history. From early 3D glasses to virtual reality, augmented reality, and so on, the audience of visual art changes in understanding, experience, and active participation.

3 Modern Times

In addition to the evolution of painting style and techniques, there is the development of color, material and composition. Developments are the result of artists applying new techniques, and of artists triggering their audience to give meaning and be active viewers to appreciate new types of experiences.

3.1 Visual Art Becomes an Acting Agent

Today, people can interact, talk, and touch art works in real space or by wearing equipment. Information and communication technology allows visual artists to develop active pieces of art. The art work can, in principle, be provided with sensors to be aware of the presence, the movements, the facial emotion features, and even the identity of individuals or groups of spectators. The art work could be programmed to react to spectator behavior or to trigger spectator behavior.

Experiences in the Different Contexts. From our analysis of museums, galleries, and international conferences we detect an amazing jump in the impact of technology on art. We will discuss some examples from the art exhibition at CHI 2016, San Jose: 'Breaking Andy Wall' (Fig. 8) is an interactive installation. When participants smash the canvas with the hammer, they can gradually break down the art piece. Through the playful destruction and reconfiguration of iconic art pieces, this installation reconfigures relations between art objects and their audiences [14].

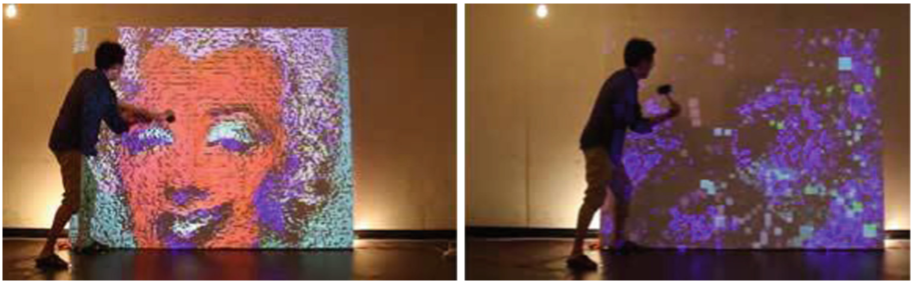

Fig. 8. Breaking Andy Wall, Interactive Art, Leo Kang

Pace Beijing Gallery is exhibiting works of Team lab from Japan: *Living Digital Forest: Lost, Immersed and Reborn* (May 20–Oct 10, 2017), e.g., Sketch Town (Fig. 9), a town that grows and evolves according the pictures drawn by children. The "town" in this work will be developed by all participants. After the 2-D drawings of the cars, buildings, UFOs, and spaceships are completed, they are scanned, become 3-D and enter a virtual 3-D townscape. Every component of the town has a role to play; for example, the fire trucks and cranes serve to protect the town. Children can interact with the final townscape by touching individual components to alter their behavior [15].

Fig. 9. Sketch Town, Co-Creation Art, Team lab, Japan, 2017 [15]

Chinese Artists Play with Their Audience. The work "Life · Hair" (Fig. 10) was created by students at China Central Academy of Fine Arts. The main material is embroidered women's hair on silk. Artist uses technology (the principle of static electricity) to let the audience feel the delicate emotion of women through their touch. For technical solutions, the artist collaborated with students majoring in nuclear physics at the Tsinghua University. So, the artist calls it a cross-border art.

Fig. 10. Life - two scenes from Hair, Interactive Art, Chen Yu, Beijing, 2016 [16]

The authors of work "Source" are Jiang Xiaoyan and Liu Hanlu, the Digital Media Art Institute, Shanghai Conservatory of Music (Fig. 11). In the picture, objects on the wall (simulated umbrella surface) can move with the music of the GuZheng. When the audience strikes the strings, the points on the umbrella surface are gradually converging into lines, and then covering the three sides of the umbrella, demonstrating that music can be relaxing.

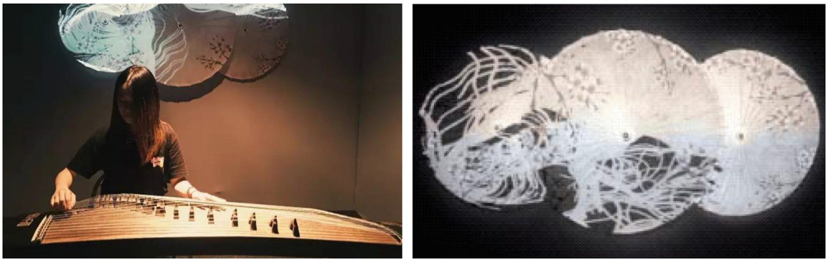

Fig. 11. Source, Co-Creation Art, Jiang Xiaoyan and Liu Hanlu, Shanghai, 2017 [17]

3.2 Art and Technology

As the great French literature master Gustave Flaubert predicted, "the more time goes by, the more art will become scientific and conversely, the more science will become artistic. Both will unite at a summit after having been separated at the base". The development of contemporary art has been closely related to science and technology. The exploration of the new art language was meant to be a combination of technology and science, interactive, and more intuitive. Thus, we see such as new media artists, audio-visual art, code artists and other new nouns of art have a significant attribute of this era.

Wearable Art - Interactive Textiles. Wearable devices are not just a hardware device supported through software, data exchange, and online interaction [18]. Wearable devices may have powerful effect on our perception of life. Smart fabric in wearable devices is a very representative case. The trend is to make core computing modules smaller (to nanoscale units), and they are increasingly being used by artists. Philips Design gave (in 2007!) a glimpse of how will fashion look in 2020 (Fig. 12a): The Bubelle Dress changes its look instantaneously according to wearer emotional state. It is made up of two layers, the inner layer contains biometric sensors that pick up a person's emotions and projects them in colors on the second layer, the outer textile, though limited to the sensor module and bulky looks [19].

(a) **(b)**

Fig. 12. Bubelle Emotion Sensing Dress. Design group at Royal Philips Electronics. Netherlands. 2007 [19]; Fabric Strain Sensor, AdvanPro. Hong Kong [20]

Fig. 13. Kino project of MIT media lab: Pattern Changing & Shape-changing jewelry. USA, 2017 [22]; MIT's Duo Skin, USA, 2016 [23]

In fact, both artists and scientists are aiming at a substance between visible and invisible. Sensors are become smaller, and smart fabric applications become more flexible and comfortable. The SOFTCEPTOR technology of fabric sensors is currently the world's softest smart sensor being developed by the Hong Kong Polytech University team. It's a piece of washable fabric as well as a strain gauge (Fig. 12b) [20]. In contact with human skin it senses physiological information and activity signals. Artists can develop more creative channels allowing the audience and different stakeholders to work together to co-creative [21]. Technology turns inspiration and creativity into reality. More and more artists focus on interaction mechanisms with wearable and implantable devices as well as integrating Internet-of-Things technology with new interaction art paradigms. They challenge traditional thinking and bring about an art revolution and even build a new world view. What is necessary is that this innovation requires collaboration with more interdisciplinary experts. And this cooperation and co-creation will generate a new cognitive system (a symbiotic relationship between human beings and everything, including machines, of course) (Fig. 13a) [22]. The work of MIT explores a dynamic future. Kino robots attached to garments, they generate shape-changing clothing and kinetic pattern designs—creating a new, dynamic fashion. MIT's DuoSkin turns temporary tattoos into on-skin interfaces. DuoSkin devices enable users to control their mobile devices and display information. In the future, on-skin electronics will converge towards the user friendliness, extensibility, and aesthetics of body decorations, forming a DuoSkin integrated to the extent that it has seemingly disappeared [23] (Fig. 13b).

Fig. 14. Mario Klingemann's Neurography, artificial intelligence creations, 2017 [24]

Beyond Wearables: Arts, Humans, and Things - New Cognitive Systems and Symbiotic Relationships

The early computer aided graphic art has rapidly developed into the Contemporary interactive art. And it occupies almost half of the contemporary art market. Both the artist and the audience are flocking to it. Technology enhances expressiveness and empowers the artist, and push some art pioneers unique in a short period. Some contemporary visual artists want to achieve interaction of art by means of wearables (VR glasses, sensor gloves, smart fabric, etc.) So where does art leads after that? As the different stakeholders of contemporary art constantly innovate, experiment and cooperate with new technology, the boundary between art and technology becomes increasingly blurred. The birth of AI gives many possibilities to art. Through deep learning and powerful and accurate algorithms, AI systems can be made to understand art, and even cultivate an artistic creativity. Figure 14b [24] shows AI art creations. Artist Mario Klingemann has a deep interest in human perception and aesthetic theory. He researches neural networks, code and algorithms. The advancements in artificial intelligence, deep learning and data analysis make him confident that in the near future "machine artists" will be able to create more interesting work than humans. From participation to independent creation, will AI eventually replace artists? For most artists, the question is whether AI is liberating or constraining them. The intervention of artificial intelligence is only a small part of the development of visual arts. It is difficult to replace human spontaneity and imagination and complex emotional systems. Artists are rich in inspiration and creativity. They try to co-create with audience. Artists have long experimented with the creation of multi-sensory experiences. In addition to the use of wearable devices, they also attract visitors' attention with smell, touch, and so on, to communicate a richer user experience. Like (Fig. 15), where the group of pictures was taken at a gallery of the modern museum in Stockholm: The artist used a large amount of lavender in the exhibition hall. When visitors came close to the space, they smelled fragrances. And senses feel directly to relaxation, harmony, and reminiscent of the symbiosis of human beings and nature.

Whether artificial intelligence or the integration of senses, it's a challenge to artists. Because of the influence of computers and the internet on visual art, art creation is popular. Resource sharing and usability of interfaces and tools allow everyone to be an artist. Even people who don't have programming skills and art foundation can use tools such as Processing and Arduino to play art (there are lots of online courses and lectures). Faced to the challenge, do artists insist on their pursuit of art or make a change? How to make the vitality of art work last for a long time? How to continue and inherit the traditional art and techniques in the contemporary environment? How does the artist adapt to the contemporary environment? This is a problem for all contemporary artists. This is also a problem for all stakeholders. Thereupon: what is going on in the domain of visual art is the development of a new symbiotic relationships between cognitive systems, art, and technology (Fig. 15).

Fig. 15. Most Ghosts Hold Grudges, Susanna Jablonski. Stockholm, 2017

4 New Techniques and Art Styles Need Understanding from All

We followed examples of historical steps in visual art to interaction design. From ancient times to the present, technology and science have played a fundamental role, and people's understanding and application has been closely followed.

Artists and their works will be more diverse, and the number of participants will increase. Stakeholders of current and future visual art should understand their new roles. Technology is still an alien domain for most artists. They should develop insight and learning ability for new techniques and paradigms, and consider blended creative patterns. It also requires stakeholders to study and develop components that are smaller, flexible and easy to use, so that more people will accept them. Universities should understand the importance of interdisciplinary collaboration and education. Galleries should be tolerant and encourage artists to innovate and experiment. Audiences should improve their understanding of contemporary art and become happy to co-create.

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WHERE – Physical Entries to the Internet

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Abstract. This contribution shows how the experienced location of data or information, and of computing, changed since the first general use of information and communication technology. We show how many current and future non-professional users will develop a view of locality for physical tagged entry points to resources that are in fact nodes in an, often global, network.

Keywords: Internet · Wearable devices · QR code · Cloud · Information

1 Once upon a Time

How did we ever manage without our smartphone? Well, we had computers, end before that we had books, and before that … Indeed, there has been life before:

People told each other stories and transferred **information** orally. If the information was complicated, people used rhyme to keep the knowledge reproducible, and started to carve information in sticks or clay. When books were still very expensive, one copy was enough to provide information to a community, e.g., a convent. Who was unable to read found someone able to read who could tell the story, to explain the law, or to evaluate the execution of a contract. The most important information for everyone was the location of the information: where to consult the expert or the document.

Information processing often required calculations. In due time experts developed tools like the slide rule. Figure 1 shows a recent one, still hand-made [1]. Another device is the abacus. Figure 2 shows a historic example from around from 1340, Upper Italy, currently in the German Historical Museum Berlin [2]. For complex calculations experts either made their own tool, owned one, or needed to know where to find one.

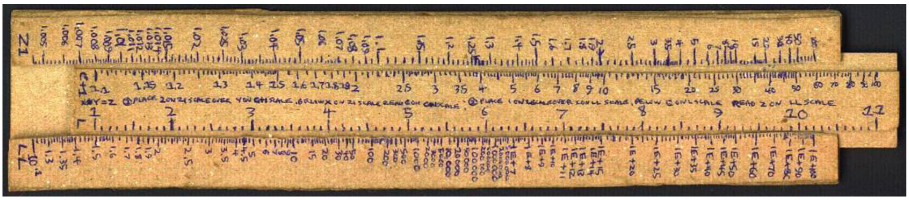

Fig. 1. Slide rule, hand-made made by Robert Munafo at the age of 14.

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https://doi.org/10.1007/978-3-319-92081-8_5

Fig. 2. Abacus from 1340 Upper Italy, German Historical Museum, Berlin.

In summary: both for information and information processing devices there has been clear physical locations to keep them and to use them.

2 Computers Expanded Our Possibilities – An Example

When we started our research in cognitive psychology in the early 60’s, one of our challenges was to develop models of individual differences in human information processing. The phenomena of individual difference in cognitive style was one of our key interests. Markov models seemed a promising way to characterize individual sequence preferences, so we choose a domain where sequences are an obvious relevant characteristic, melodies created by music composers. Based on a hand transcription of 46 melodies by Orlando di Lasso [3], we build Markov models to predict the most probable continuation(s) of melody fragments for this composer, intending to compare these to other volumes of this composer’s work, or to collections from contemporary other composers.

Keeping the information available was the first problem: working from the printed score was not (yet) feasible, working from a hand written or typewritten notation was rather clumsy. Luckily there were new tools available: machines like the Friden Flexowriter allowed us to input our data, to reproduce them, to correct errors, and to make multiple copies of the 7-hole paper tape that were the physical store of our data. A tape could always be read again and a human-readable document could be printed by this machine, see Fig. 3. We could read the printed document, but we mostly considered the paper tape to be the actual information: We would store it safely at a location of our own choice, we could hand over a copy to a colleague when needed, and we could easily transport it. In this way, we had our information or data on a set of paper tapes, and we wrote a program in ALGOL-60 to build the Markov models, typed it in the Flexowriter, producing a readable print as well as another tape that we considered our program.

In Amsterdam, a single computer was available for both universities and for the Mathematical Center (later renamed CWI), an Electrologica X-1 with 8K of memory words and, next to the binary console, a paper tape station, seer Fig. 4. To use it we had to go to the Mathematica Center, bringing our data and our programs on paper tape. We were allowed on night (9 h) each week, to consider this computer ours, which was enough to work on one matrix multiplication as part of our project.

Fig. 3. Friden Flexowriter [4].

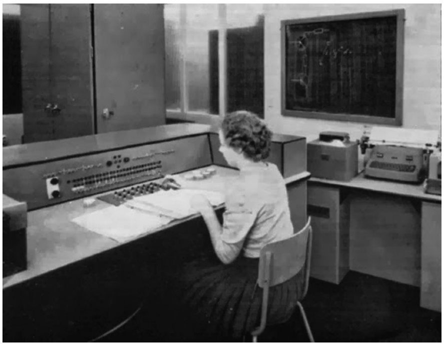

Fig. 4. Electrologica X-1 [5].

Around 1970 my department acquired its own "minicomputers", from DEC's PDP series, running UNIX. Now the location of the computer was next to the office and we just walked around with our programs and data tapes.

In the early 80s personal computers became available and we could buy one privately (see Fig. 5), a Commodore DX with a detachable keyboard and two 5.25″ floppy disk drives, running a disk operating system that was similar to UNIX, and, moreover, could be enlarged with UNIX-like editors etc. The machine could be carried and did fit in the overhead compartment of a plane so we were able to travel with our own machine, and with both our programs and data on disks. The computer, the programs, and the data or information resources were all in people's own hands and could all fit in the luggage of s single traveler.

Then mainframe computers got connected, and we could, both, send email to others, and to work on remote machines, where UNIX was the universal language as well as the hierarchical map structure of resources. Email addresses were in fact complete specifications of the chain of computers that our message should go to, e.g. "utzoo!utgpu!water!watmath!clyde!rutgers!seismo!mcvax!botter!gerrit" (1987), and the same network knowledge allowed us to go to remote machines and login. Figure 6 shows the network of European nodes. Because collaborated with colleagues in many European countries, we did set up an account at one of the available mainframes and we all used the same login name and password, so we could see who was working in our UNIX domain and we used one file to communicate. We knew the path and the location of the machine, and we knew where the programs and the data were that we were collaborating on.

Fig. 5. Commodore SX 64-1.

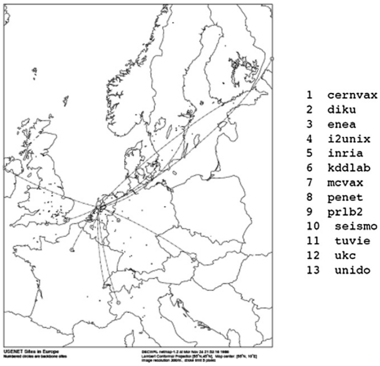

Fig. 6. European network in 1986.

Another possibility that existed for some time was (at least when using UNIX) to work between machines and connect the UNIX filesystems. When being employed by several universities this allowed us access to all programs and data stored at all sites, and even to operate peripherals to read or write at remote locations. This indeed provided strong opportunities, and required precise knowledge of the current state of the remote machines.

But the internet developed, paths were getting too complicated, and in fact multiple paths were used even in a single connection or transport.

3 Who Cares Where Our Things Are Anyhow

Email no longer requires the user to know the path or even the machine that hosts the mail server of the addressee. Addresses may refer to provider domains (Gmail), institutes (vu.nl), locations (.eu, .nl), type of business (.ed, .com, .org). Many of us will have multiple addresses, for which we may have to login to several systems. And some of our addresses are aliases (.@acm.org), that allow us to reroute the mail to whichever of our actual mail address.

We find our tools increasingly at websites. And if we download the tools or apps, we are used to get updates for which we sometimes pay and sometimes we are not even aware.

Our programs and information can be stored at machines that we know and that we trust. We store our data partly in local memories or hard drives, partly in the cloud, and we sometimes share with specific colleagues or friends, and sometimes with the world, and we might well forget we stored, or shared, or where we left them. In the case of the programs and the interactive websites we create, we will mostly be more carefully about in what system, and with whom we share certain rights. But we need to keep track of locations, names, and passwords. And sometimes we want certain access information to be easily available for a certain community or at a certain location.

4 Here Is What You Need at This Moment

Sometimes, people feel enabled if they find information or interactivity at specific physical locations.

4.1 Industrial Design Teams Work in Physical Spaces

Vyas did a field study in a design school [6] where he provided 2D color barcodes to the members of several design teams, showed them how they could stick these to any physical artifact like a sketch, a 3D mock-up etc., and how they could use their phone cameras to send tweets to the artifact and read the history of tweets to this artifact. Figures 7, 8, 9 and 10 show some examples. We found that as soon as an artifact was tagged and tweeted to, there was no need to scribble on the sketch anymore: all discussion and comments were tweeted. Somewhat surprisingly, in several (unrelated) projects designers invented an unexpected type of physical artifacts to tweed to, for discussing about other business: They took a clean sheet of paper, tagged it and put a single word on it like “vote” or “planning”, see Fig. 11.).

Fig. 7. Tagged sketch.

Fig. 8. Tagged 3D mock-up.

Fig. 9. Tweets.

Fig. 10. Reading tweets and commenting.

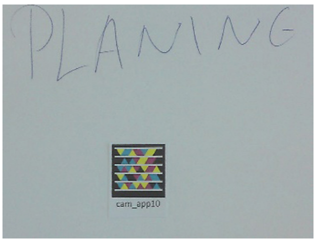

Fig. 11. Call for planning suggestions.

Whether sketches, 3-d mock-ups, or simple calls for ideas, in all cases the tagged artifacts were positioned at a location where team members would go to read, comment, and discuss. The tweet flow was the ongoing conversation, located wherever the tag was.

4.2 Pointing Is to a Location

We teach in multiple countries. In the case of China, we know that outside the Universities there is a language problem. Most people we need to talk to, like Cab drivers or waiters in restaurants, only communicate in Chinese and sometimes they cannot read complex phrases. We use our Lifescribe pen and notebook (Fig. 12) and ask our students to translate our written notes to written Chinese, at the same time pronouncing this translation (Fig. 13). Whenever we need to communicate we find the right page in our notebook, and point to the translation – if that does not work we point with our pen and the system will pronounce the sentence. Interestingly, anybody who has never seen or used this before considers the pen to be the resource of the sound. For the regular user, the location on the right page in the notebook is the location where the pronunciation is, see Fig. 14. And at the same time, the regular user will probably use the pen as input device for his regular computing devices like phone or laptop and network connections where the scribbles and the accompanying sound will be stored and often shared.

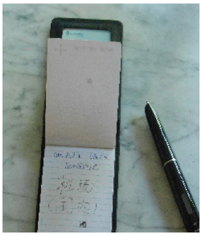

Fig. 12. Lifescribe Notebook and pen.

Fig. 13. English phrase and written and spoken translation.

Fig. 14. Pointing to the scribbles triggers the sound track.

4.3 Smartphones Open up the QR Code

QR codes are now arriving at many locations for very different purposes. Some public transport companies put them at stations to allow travelers access to actual traffic information. A QR code on a wine bottle provides information on production and content. Small businesses put them on their leaflets that people will find in their (physical) mailboxes, or pick up from the counter, see Fig. 15. At the time of writing, the smartphone is the common device for people to capture the code and find out about its meaning. Where the code is, there we will find the information.

Our students are experimenting with "interactive posters" to enhance the possibilities to engage their peers at conferences, see Fig. 16. In this case, the codes are intended to provide many types of experiences: interactive websites, videos of presentations, interactive PowerPoints, and strait forward text and pictures. The actual locations that the codes refer to are, consequently, websites, videos on YouTube or, in China, Youku. For the young researchers that crowed around the poster, phones in hand, the codes directly provide them the content of the discussion and the possibility to compare, e.g., the PowerPoint and the actual performance.

Fig. 15. Advertisement with QR code.

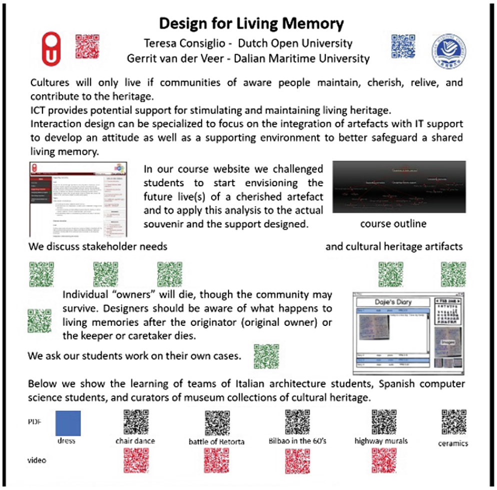

Fig. 16. Interactive conference poster.

5 Future Meanings of "Here"

Computing artifacts, increasingly, are connected, may be traced, and can be hacked. Professionals in computing should know, and should want to know, where things are: in their smart wearable device (for now their phone or their pen), in their laptop, in their pen drive, their company network, or in the cloud, and they should be concerned about ownership, changeability, safety and privacy.

The nonprofessional users of computing and of networked computing (at this moment these are already the majority) would need protection, by law and provided by ethical design and implementation. But at the same time, they cannot be bothered personally. RFD tags and GPS trackers seem to relate to things, not to the humans using them.

A special issue, and in fact the core concept of this paper, is the meaning of location for users of tagged entries to information. Currently the tags seem obvious (for devices like the Livescribe pen, however, they are invisible for the user, even if these needs to know and understand).

For most users of the tags that are increasingly being used to draw attention to information that may be relevant for the observer, for the agent that puts the tag, or for both, a tag is just location to point a wearable device on to find out if there is something relevant at the current moment in the current context. And even if the current common wearable is a smartphone, still growing, and decreasing in social acceptability of use in many contexts, new and more usable wearables will soon be available: think of camera-enhanced pointing device like pen, cameras in (simple or smart) glasses, in smart watches and in other types of smart jewelry.

The use, in all these cases, suggests that relevant information, fun, or interaction is "there" – something non-professionals seem to understand quickly and easily. They will relate to non-local information and interactivity, without telling too much about that and about the related aspects of safety and privacy. There certainly is a task for designers, for the law, and for providers here.

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Cross Cultural Differences in Designing for Accessibility and Universal Design

Issues of Culture in Designing for Accessibility

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Abstract. Cross cultural differences and cultural sensitivities have not yet received much attention in the areas of accessibility, assistive technologies, and inclusive design and methods for working with disabled and older users. However it is important to consider the challenges of developing accessible and usable technologies for people with disabilities and older people in different cultural contexts. This chapter presents the background to the topic and then considers three particular issues in relation to the topic: the accessibility of interactive systems in the home and implications for emerging markets; the accessibility problems in relation to a multilingual society such as India; and finally, the issues of the cultural biases of the methods used when working with users within a user centered design lifecycle or a "double diamond" methodology, whether they are mainstream users, disabled or older users.

Keywords: Cross cultural differences · Cultural sensitivities · Accessibility Universal design · Assistive technology · Users with disabilities Older users

1 Introduction

The population of older people and people with disabilities is growing rapidly throughout the world, due to many complex changes in societies from decreasing birth rates to increasing survival rates from accidents and chronic health conditions. According to the World Health Organization (WHO), there are currently between 110 and 190 million people with substantial disabilities [1] and approximately 901 million older adults (usually taken to be people aged 60 or older, although the definition itself varies from country to country and organization to organization), worldwide. The United Nations (UN) predicts that the population of older adults will increase to more than 2 billion by 2050 [2]. The UN also predicts that the number of older people will exceed the number of the young people, aged 15 or younger, for the first time in 2047.

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This change in the balance of older to younger people (known as the old age dependency ratio or the potential support ratio) has many consequences, one of them being that older adults and people with disabilities will need to live more independently, without as many people of working age to care for them. Many analysts and researchers [e.g. 3] believe that technology will provide at least a partial solution to this problem, allowing older adults to live in their own homes safely and independently for as long as possible and to give disabled people greater independence. While this may be a viable solution for some individuals in the wealthy, developed countries, for older and disabled people in many parts of the world, there are issues of affordability as well as accessibility and acceptability.

These demographic changes are worldwide phenomena, although different countries are experiencing them at different rates and in different ways. In addition, there are many cultural sensitivities and differences in attitudes to disability and old age, which have important implications for designing interactive systems for disabled and older people. However, designing for cultural diversity is an aspect of universal design and can increase the overall number of users and the usability of interactive systems for those users [4].

In this chapter we explore three particular issues in relation to the topic of cultural differences and accessibility: the accessibility of interactive systems in the home and implications for emerging markets; the accessibility problems in relation to a multilingual society such as India; and finally, the issues of the cultural biases of the methods used when working with users within a user centred design lifecycle or a "double diamond" methodology, whether they are mainstream users, disabled or older users.

2 Topic 1: Cultural Differences and Accessibility of Interactive Systems in the Home

Major drivers for the greater use of technology in the home include an interest in greater comfort and entertainment, a desire to reduce and simplify effortful and repetitious tasks, a desire to increase personal safety, interest in monitoring one's physiological state, and a desire to improve communication with family and friends. While this comes at the price of more complexity of the functionality of household technologies, there is now an abundance of products to support these functions. Many of them use a computer and serve multiple purposes through an interactive user interface. Understanding the needs of people using such interactive systems is crucial to detect both cultural and accessibility requirements in everyday activities.

Mismatches between the language and cultural assumptions of designers and those of users may lead to inappropriate functionality and hence a lack of acceptance of technologies. As pointed out by Chavan et al. [5], a very small error in the design of a washing machine for the emerging markets such as India, combined with a poor understanding of Indian clothing resulted in many items of clothing being destroyed and the loss of an important market for Whirlpool in India (this in spite of excellent washing system, serviced by men, which is available in India, see Fig. 1, below).

Fig. 1. Washing men at work in Mumbai (Photo © Gerhard Weber)

Whirlpool renamed the “delicate cycle” on their washing machine as “sari cycle” which probably seemed very culturally appropriate at the time. But unfortunately, the washing machine actually shredded the delicate fabrics of saris – Whirlpool had failed to research the cultural and linguistic conventions of this particular market.

Lack of accessibility relates to many facets of the use of computers by people with sensory, physical of cognitive needs in both developed and developing countries. In emerging countries such as China, some 73% of households already had a washing machine by 2010 [6]. To prevent accidental water flooding, it is mandatory to push a button to release an electromagnetic door lock before the washing machine door will open. Washing machines enter such a state at the end of the washing program and usually signal this only visually. Lack of sight makes it hard to know why the door will not open when this visual indicator is not present. Some machines do include an auditory signal, but there is only one auditory signal (a generic beep), which sounds when the washing program begins, when there is a problem and when the program ends. Although a visually impaired user can hear the signal, it is not sufficiently communicative to understand what state the washing machine is in.

At least three quarters of the world population now have mobile or smart phones [7]. In 2016, more than 98% had phones with either Android or iOS as the operating system [8]. Controlling a robot vacuum cleaner, such as the Roomba [9] by an app on a smart phone is convenient, and more importantly, the only way to change the robot’s operation. However, although a robot vacuum cleaner is very convenient for people with physical disabilities such as a tremor in their hands, adjusting its setting via the app can be very difficult. Designers of such apps need to understand the requirements for larger buttons and split the virtual keyboard to reflect sub-tasks on smaller screens, if more space is needed. The same approach allows enlargement of fonts for increased readability for people who are dyslexic.

In China, Brazil and India demand for web-connected smart TVs is considerably higher than it is in developed countries [10]. However, there are a number of accessibility issues in interacting with a smart TV. For example, smart TVs encourage interaction through gesture and voice commands. For people with physical disabilities interacting through gesture may not be possible. Voice commands may be a useful alternative, but creating voice command interaction that avoids accidental activation of commands when simply speaking is still not easy to design. In addition, voice command interaction has not currently addressed the needs of people with speech difficulties.

The examples discussed above make it clear that specific home technologies increase quality of life in many ways but may introduce new barriers, both cultural and in relation to accessibility. Providing a range of new modalities for interacting provide good solutions for the accessibility issues. Developing countries may sometimes utilize technology considered already out-dated in the developed world, but more often are now jumping straight to the very latest technologies and skipping what might be considered the intermediate steps. For example, in Cambodia smartphone use is very high, with over 95% of citizens having access to a mobile phone of some type [11]. This is largely because the landline infrastructure was badly damaged and became very outdated during the Khmer Rouge regime and subsequent war with Vietnam (1975–1992). At the end of that period, rather than invest in landline infrastructure, investment was made in mobile infrastructure. One consequence of this is that internet access is largely via smartphones, with 80% of those Cambodians using the internet doing so via a smartphone in 2017. This is far highly than in the United Kingdom, where in 2016, 66% of citizens reported accessing the internet from their smartphone [12]. Thus, Cambodia can be seen as more technologically advanced than the UK in terms of devices for internet access.

To some extent, addressing accessibility issues can also benefit cross cultural issues. For example, designers of medical devices have understood the need for high accessibility of their devices. Speaking thermometers, large print glucose meters, talking blood measure monitors are available at low to modest costs due to their widespread use. However, embedding them in homes alongside accessible home appliances requires a range of interdisciplinary skills involving architects, hardware builders, software and industrial designers. There is a need to establish appropriate services for living independently as none of these devices have a common approach to accessibility. Making the accessibility of devices compatible can be achieved most easily through personalization capabilities [13], which may be most beneficial to address the various cultural needs of people in emerging countries.

People with disabilities and older people have needs and wishes for technology that HCI designers and developers are often unaware of or fail to understand fully. In European countries, we have observed that designers and developers of interactive systems also often have difficulty establishing contact with disabled and older people and lack a good range of techniques to work with them in the development process, in spite of being eager to develop technologies to support these user groups. There are also many cultural and societal differences between countries which affect needs and attitudes towards technologies for disabled and older people. For example, the effects of demographic changes in China are comparable to European countries, but attitudes to family are typically somewhat different from European attitudes. Even between European and North American countries that are considerable differences in attitudes to disabled and older people. In the Nordic countries, there is a very strong philosophy that the whole of society has a responsibility to provide quality of life and opportunities for disabled people and to care for older people. In southern European countries, the philosophy is more that the responsibility lies with the individual family to care for their family members. In North America disabled people are strongly encouraged to be very independent whereas in European countries the philosophy if more of providing as much support as possible (e.g. financially, technically) for disabled people.

When designing an interactive device or localizing an existing design for a different culture, a number of critical needs of older and disabled users should be addressed: the need for communication with and through devices, the need for mobility, and the need for personal safety. We consider two approaches for designing home appliances to address such needs for users: simulation and standardization.

Simulations can be used to help designers and developers understand the needs of disabled and older users and possibly the needs of users from other cultures. For example, the effects of having a tremor in one's hands (a common problem for older people, essential tremor is experienced by at least 4% of people over 65 [14]) may be experienced by creating a randomly jittering touch point. This allows designers to get a personal insight into older users' need for larger buttons. Visual problems can be experienced by having designers and developers were spectacles which simulate different visual conditions [15] or by distorting the screen contents [16, 17]. The latter is particularly useful for understanding how people with color vision deficiencies experience the colors in displays [18–20]. Dyslexia may be simulated by reversing, inverting and transposing characters and creating inconsistent spellings of words [21]. Limitations in dexterity may be experienced by placing small buttons on the knuckles of the hands and wearing several layers of tight rubber gloves, this impedes both mobility and sensitivity of the fingers (see Fig. 2, below). Although the simulation approach is promising it has not yet been applied to cultural design features.

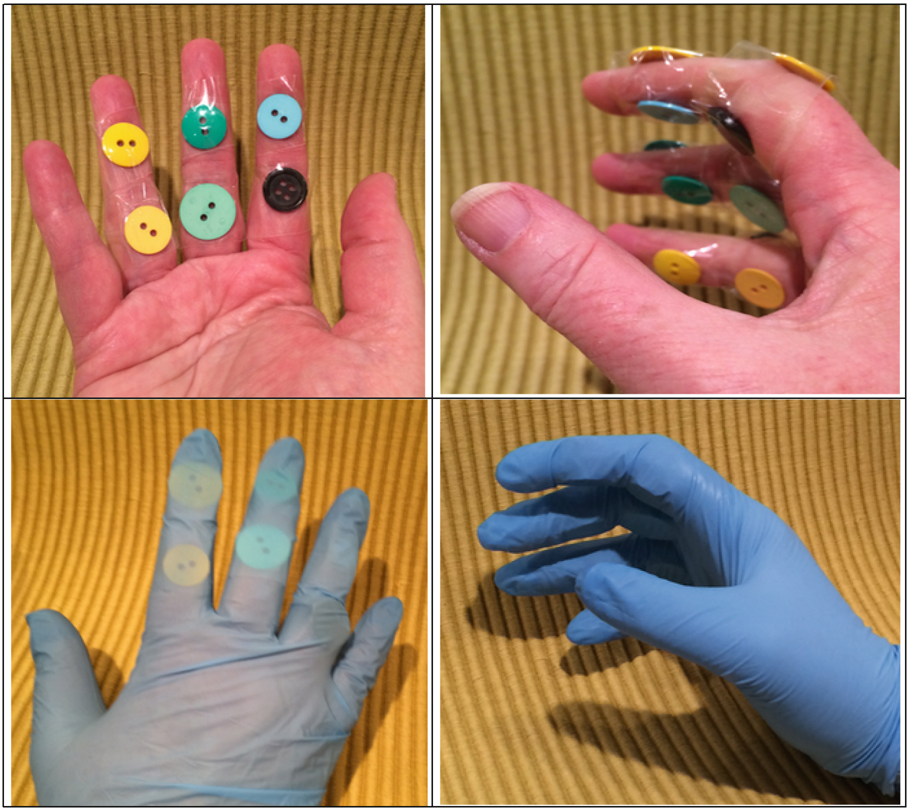

Fig. 2. Buttons and rubber gloves to simulate reduced dexterity (Photos © Helen Petrie and Jenny Darzentas)

Standardization of user interfaces is making good progress towards establishing the key concepts of accessibility. New work in Europe requires that those creating standards must consider whether accessibility is a concept is that is applicable to their technical committee work, and have a protocol to do this [22]. In addition, all standardization bodies revise standards periodically, meaning that theoretically, older standards will be reviewed in the light of accessibility. In particular, International Organization for Standardization (ISO) standards are subject to review and revision every five years. Thus, existing standards are updated if there are experts available to do the work. However, a problem for variations in accessibility due to cultural factors, is that even ISO, whose member countries vote for approval of standards, does not represent the cultural variations throughout the world, due to a lack of experts familiar with cultural and accessibility requirements. In addition, there normally need to be strong background economic reasons to be part of standards initiatives, that are traditionally dominated by trade and industry and less by consumer representatives. Thus, for instance in a country that does not manufacture home appliances, it is less likely to find manufacturers aware of cultural factors to do with accessibility. Similarly, consumer organizations with expert localized information about cultural factors impacting accessibility may not have an interest or the funding to participate in these standardization activities.

In the United States, the National Federation of the Blind [23] have repeatedly requested that the accessibility needs of blind users be taken into account especially in the design of home appliances and consumer electronics, and called for a Home Appliance Accessibility Act [24]. In Germany, an organization representing blind people [25] is campaigning directly to manufacturers to consider accessibility in the products they design. This is because accessibility for home appliances and consumer electronics has not yet been legally regulated, and the draft regulations about accessibility requirements for products and services in the European Accessibility Act (EAA) [26] exclude these two product groups, in spite of the recommendation from the expert group on standardization [22] to prioritize accessibility concerns including domestic appliances and consumer electronics.

3 Topic 2: Cross Cultural Accessibility Issues in India

Another set of issues relate to language differences and the provision of assistive technologies and accessibility of digital materials. People from cultures with languages which are not widely spoken current face many barriers in access to technologies, both mainstream and assistive, due to such language issues. For example, India has 22 official languages and 12 different scripts for writing them. But in total, India has over 780 languages and over 60 different scripts [27]. The core technologies of text-to-speech synthesis, automatic speech recognition and optical character recognition software are widely used in assistive technologies to make them accessible to people with print disabilities and older people. Such assistive technologies include screen readers, screen magnifiers, and electronic braille displays. But in India these core technologies are only available for a handful of the official languages, let alone the total range of languages. Thus, assistive technologies are not available to many disabled and older Indians at all, or only in their second or third language, and not their preferred native language.

A further aspect of the language issue and accessibility is the availability of digital content in Unicode. Unicode is a computing industry standard for the consistent encoding, representation, and handling of text expressed in most of the world's writing systems. In particular, Unicode allows websites to render text in different writing systems and assistive technologies to convert text to speech and vice versa. It is very important that these digital codes are universally used. The digital code for any specific character must be the same all over the world. To achieve this the Unicode Consortium has published a standard of all possible characters of all languages of the world along with their digital codes [28]. For example, all the Indian languages are part of this Unicode standard.

The problems start with the development of different fonts. Many companies and organizations which develop fonts do not follow the scheme proposed by the Unicode Consortium. For example, the digital code in the Unicode standard for the Hindi character "ka" is 0915 whereas the Kruti Dev font (widely used in northern India, particularly in official documents) assigns the digital code 0064 to the same character. In the Unicode standard, 0064 is assigned to the Roman alphabet lower case “d”. If we try to convert a Hindi document created in Kruti Dev font into braille, then the braille conversion software will convert this character into braille dots 145 (N.B. the correct set of braille dots for the Hindi character “ka” is 13, not 145). On the other hand, if you type a Roman alphabet lower case “d” into a digital device and apply the Kruti Dev font to it, then it will display the Hindi character “ka”. However, screen reading software will still read it as “d”. One important consequence of these issues is that when an organization in India wishes to create a braille version of a document for blind readers, the electronic version of the document cannot be used, instead the document first needs to be re-typed completely. Thus, one of the great advantages of electronic documents is lost.

The Unicode issues also affect optical character recognition (OCR) processes, one of the basic technologies used to create digital content, and one which has made a great difference to the accessibility of material for many people with print disabilities. A digital library cannot come into existence if there is no OCR software for a particular written language. The digital content gets its real power only when the characters of the content is stored as digital codes and not as an image of the printed paper. Only after digital coding of the characters do we get the flexibility of the digital content, such as representation in different media (e.g. audio, braille, even simple font changes such as large print). Creating digital content without OCR again means re-typing all the material and denies print disabled people a key component of their independence, the ability to OCR documents themselves. OCR is available for more that 100 languages across the world. Unfortunately, India languages largely lack this benefit. There is no OCR software for most Indian languages, barring a few which are very recent innovations.

As a measure of the situation in India with regard to problems with its multilingual culture, a number of articles about web accessibility have recently appeared which mention this issue. This is particularly important due to interest in India in transferring services to digital forms, most lately fuelled by the Indian Government’s Digital India [29] campaign launched in 2015.

In a case study looking at the accessibility of e-portals [30], Clemmensen and Katre collected data from state government web portals in India and examined across seven parameters, including accessibility, for which they used 18 criteria. Only two portals met the accessibility requirements, as judged as meeting at least half of the 18 criteria. However, the authors noted that since 20 of the 28 portals were in the English language, this in itself probably posed considerable accessibility barriers.

In a report that examined Indian Government websites [31], amongst 7,800 websites in total, only 3% were judged as accessible and the report commented that “websites which are not developed in accordance with the Web Content Accessibility Guidelines (WCAG) 2.0 will remain inaccessible to over 50% of India’s population comprising persons with disabilities, elderly and illiterate persons, linguistic minorities and persons using alternate platforms like mobile phones”. The report highlighted examples of accessibility errors common on the websites, one of which was the tendency to present important information written in a different language and script as an image, meaning it would be skipped over by screen readers.

A study of 48 Indian banking websites [32] was undertaken in 2014, testing the sites for accessibility using both WCAG 1.0 [33] and WCAG 2.0 [34]. Accessibility of the banking websites was low: only 25% conformed to the minimum conformance level with respect to WCAG 1.0 (Level A), and none conformed to the minimum conformance level with respect to WCAG 2.0. The authors explained that this is a problem, since although the internet banking sector in India is still new, the change from cash transfer to bank transfer of welfare payments, will mean a greater need to use internet banking. Amongst the accessibility problems found, the authors noted that a banking website should have content in appropriate regional languages. They concluded that there is a need to develop a multilingual model for the Indian context. The imperative for the banking services to be accessible is becoming a matter of urgency as the impact of the Indian government's digital push on the economy becomes reality. Kumar Srinivasan, a leading digital entrepreneur has noted that "since the government's push for a cashless economy with the announcement for demonetisation in India, we have seen a rapid transformation and growth in the digital payments segment. With an unbanked population of over 250 million Indians and the country moving towards 520 million smartphone users by 2020, it is a wise move by the government to incentivise digital payments to encourage consumers to shift to "cashless" and increase bandwidths to reach out to a larger populace" [35].

Ismail et al. [36] in investigating accessibility and readability features of the 20 most frequented websites in India, commented that as there were no tools and metrics for readability for languages spoken in India, they had used six different methods in their study, but these were all developed for the English language. They noted a serious gap in the availability of such tools and that there is a strong need to develop readability measures or tests that are language independent. If the language independent route is not possible, there need be efforts to build metrics which would harness the specific features of languages.

Even the official Digital India initiative is struggling with the issue of even the national languages in India as evidenced by the accessibility statement of Digital India, the following notice appears "Digital India is working towards making its portal accessible for persons with disabilities, however currently … information provided in Hindi language is … not accessible" [37].

Tackling the multilingual problem of India is an ongoing process: the Centre for Development of Advanced Computing (C-DAC) [38], the research and development organisation of the Ministry of Electronics and Information Technology has been working on this problem for over 25 years. The statement on their webpage about multilingual technology explains their motivations: "India is a unique country in the world having 22 scheduled languages besides heritage languages and over one hundred widely used languages with different scripts. Despite a very impressive growth of computers and the Internet over the past few decades, most of the content on the Internet and most of the ICT based solutions in India are still available only in English. This is in stark contrast to the ground reality as hardly 10% of Indians use English as a language for communication. C-DAC realized long ago that penetration of IT to masses is possible in India only if we develop tools and technologies to overcome this language barrier" [39].

4 Topic 3: Methods of Working with Disabled and Older Users in Different Cultures

A final problem to be considered is that of the methods that designers of new technologies use when working with potential users of those technologies who are from different cultures. Designers and HCI practitioners are typically taught to use a user-centred design lifecycle [40] or a "double diamond" design methodology [41]. Both these methodologies involve working closely with users with specific methods such as questionnaires, interviews, focus groups, card sort exercises and so on [42]. However, all these methods have been developed in North America and Europe and users from other cultures may interpret them differently. For example, presented with a prototype interactive system, potential users from some cultures may think it inappropriate to openly critique the design of the system, when it has been developed and presented by authoritative experts. Hofstede [43] would explain this by appealing to the "power distance" dimension of different cultures.

A particular case in point is the extensive use of Likert items in questionnaires about usability and user experience of interactive technologies, for both mainstream users as well as disabled and older users. On Likert items, respondents specify their level of agreement or disagreement on a symmetric agree-disagree scale for a series of statements. Thus, the range captures the intensity of their agreement or disagreement with a given item [44]. A well-known example of the use of Likert items is the System Usability Scale (SUS) [45] which asked respondents to indicate their agreement to a series of 10 statements about the interactive system they have just experienced on 5-point Likert items such as "I think that I would like to use this system frequently". Although the SUS is much criticized [46], it is still widely used and fulfils a clear need in the quick and simple evaluation of interactive systems [47]. The cultural specificity of the SUS has been considered, but only for people completing it in English, for whom some of the wording may be difficult [48].

A much more fundamental problem is how people from different cultures interpret the Likert system of varying agreement/disagreement. There is a considerable history of research on this problem in cross-cultural psychology, where it is sometimes known as the "extreme response style" (ERS), a phenomenon noted as long ago as 1946 [49]. ERS is the extent to which respondents will use the extremes of a rating scale, as opposed to tending towards the middle of the scale. Variations of the phenomenon are the tendency to answer positively as opposed to negatively in relation to items. Some examples of cultural differences in ERS which have been established include: greater ERS amongst respondents in the USA compared to Korea [50]; greater ERS amongst Hispanic respondents in the USA compared to non-Hispanic respondents [51]; greater ERS amongst North American (from the USA and Canada) respondents than amongst East Asian (from Japan and Taiwan) respondents [52]; and significant differences in ERS between Australian, French, Mexican and US respondents [53].

The cultural bias in the case of Likert items is fairly easy to detect, because it is a simple quantitative measure. The cultural biases in other methods used in working with older and disabled users may be more subtle and difficult to detect, but researchers and practitioners should at least be aware of the possibility that they exist and exercise caution in extending methods to different cultures.

5 Conclusions

In this chapter we have begun exploring a number of issues related to cross cultural differences and cultural sensitivities have not yet received much attention in the areas of accessibility, assistive technologies, and inclusive design and methods for working with disabled and older users. This is still a very unexplored area and warrants considerable further research and discussion. However, some interesting synergies have begun to emerge. In the same way that personalization and flexibility of interaction designs can assist users with different abilities, these same principles may also be deployed to address the needs of users from different cultures and from different language groups. We welcome further exploration of these issues in a wide range of cultural and language contexts in the future.

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Dealing with Conflicting User Interface Properties in User-Centered Development Processes

Conflict, Costs and Trade-Offs in User Interface Design

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Abstract. A framework for cost benefit analysis to inform design choices in configuration and customisation of user interfaces is presented. User costs of learning, UI complexity and operational usability are traded against benefits from better functional fit for the users needs. The design process is illustrated with case study experience from an eHealth application involving trade offs between conflicting requirements from two groups of users.

Keywords: Configuration · Customisation · Trade-offs · Cost-benefit analysis

1 Introduction

The conflict between goals, needs and requirements from different stakeholders has received considerable attention in the Requirements Engineering (RE) community, where the conventional response has been to negotiate the conflicts to arrive at a common viewpoint (Sommerville and Kotonya 1998; Robertson and Robertson 1999). Goal modelling (Mylopoulos et al. 1999; van Lamsweerede 2009) can make conflicts explicit, thereby supporting the negotiation process; however, resolution of conflicting requirements inevitably leads to compromises by some users. User interface (UI) properties, usually referred to as non-functional requirements in RE are a sub-set of the more general problem; for instance, the clash between usability, privacy and security in passwords is a well known design dilemma (Braz et al. 2007).

In HCI the requirements conflict-resolution process is an essential component of user-centred design (UCD) (Sutcliffe 2002a). However, different user needs might be accommodated by different versions of the user interface, via a process of configuration or personalisation. While surface personalisation of UI features such as menu toolbars, display colours and layouts, and message terseness/verbosity, are standard components of all major operating systems, resolution of deeper functional differences between users is more problematic. Offering users choice of UI/application versions by configuration facilities imposes a cost on users when operating the configuration user interface, and most users accept the default version. The design dilemma is how to fit the requirements of diverse user groups while minimising the configuration cost and maximising the functional fit of the application to users' needs.

This paper reports experiences in resolving requirements conflicts in user interfaces, approached through examining users' needs at a more fundamental level in the

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form of their values. Values have been explored in value-sensitive design (Friedman 2008) and the related concept of worth can help to frame users' viewpoints as worth maps (Cockton et al. 2009). In Value-Based Requirements Engineering VBRE (Thew and Sutcliffe 2017), users' values are made explicit by analysis with a reference taxonomy of values, motivations and potential emotional reactions. Making users' values explicit provides a richer context for negotiation and resolution of conflicts. The VBRE method has been applied to two case studies in health informatics. This paper first presents a framework for considering design trade offs for conflicting requirements and then describes the experience and lessons learned from the ADVISES and SAMS projects; which contribute to a discussion about different approaches and implications for conflicting requirements. UI design responses to conflicting requirements has been described by a variety of terms, e.g. personalization, customization, localization, configuration, adaptation. In this paper I use the term 'configuration' to refer to choice between alternative functions, which is close to the sense of adaptation of the user interface (Fischer 2001b). Design of user interface features, such a colour, font size, menu options, which are more commonly referred to as personalization/customization are not with my remit.

2 A Trade-Off Framework for Assessing Conflict

The design response to conflicting requirements will depend on the number of user roles and the conflicting requirements demanded by those roles. As more requirements are added to the design, complexity increases, consequently the first design trade off is to consider a graded response from a single, complex product including a variety of functionality to meet each user's requirements, to separate product versions matched to each user role. A supplementary consideration is whether to provide configuration/customization facilities to enable the user to tailor a complex product to their own needs or to design separate product versions. These choices impose different costs on users and developers, summarized in Fig. 1. User costs are composed of learning to use the product and the configuration interface (if present), and then operating the configuration. Developer costs are the consequence of additional software development for versions and configuration facilities.

Benefits accrue when the product exactly fits the user's requirements while minimizing developer and user costs. Clearly many product versions tailored exactly to individual users is the ideal, but this usually imposes prohibitive costs. The UI designer has to strive for a 'sweet spot' where development costs are constrained, while maximizing the user- system task fit, and minimizing user costs from learning and operating the UI. A further trade off emerges between increasing product complexity, which imposes learning and operating costs for the user to search and find the functions they require, in contrast to configuration facilities which enable users to select their required functions and hence reduce complexity of the operational UI. However learning and operating the configuration UI is an imposed cost.

There are further complexities the design trade off space that arise from the progression from simple configuration (i.e. by a selection menu at product set up time) to complex End User Development facilities that maximize user choice with increasing

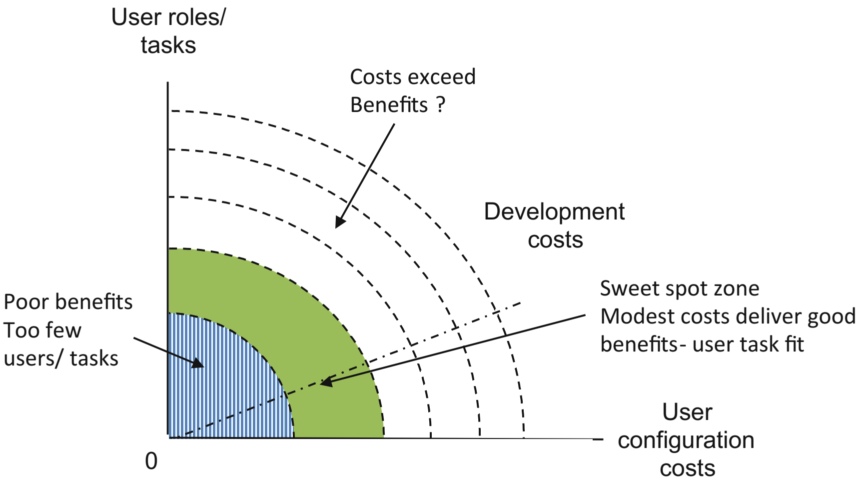

Fig. 1. A trade off framework for considering user and developer costs with potential benefits.

learning and operating costs. I have explored these questions in previous papers (Sutcliffe 2002b; Fischer et al. 2004); in this paper I will only consider simple configuration, since this part of the trade off space relates to the forthcoming project experience.

3 ADVISES Experience

ADVISES is a decision-support system for academic researchers and National Health Service public health analysts who investigate epidemiology problems (Sutcliffe et al. 2011). The two distinct stakeholder communities had different goals. For academic researchers, understanding the generic causes of childhood obesity by statistical analysis of health records was a high-level goal. In contrast, the goal of public health analysts was local health management; for example, identifying where best to target interventions, such as promotion of healthy eating campaigns. Two academic research epidemiologists (both male, age 31, 52) and seven public health analysts (four male, three female, age range 27–41) were interviewed and participated in requirements workshops. VBRE augmented UCD techniques to investigate the users' workflows to explore how new decision-support tools might be used by academic epidemiologists as well as by public health professionals.

The key issues identified were the apparent contradiction between expected and actual collaboration among the stakeholders, which suggested requirements for better collaborative tools with trust-building measures, e.g. visualisation of workflows and research activities. Security and privacy of data emerged as an important value, in particular the addition of security features to customise data access to particular stakeholder roles. Collaboration, security and trust were shared values, but differences

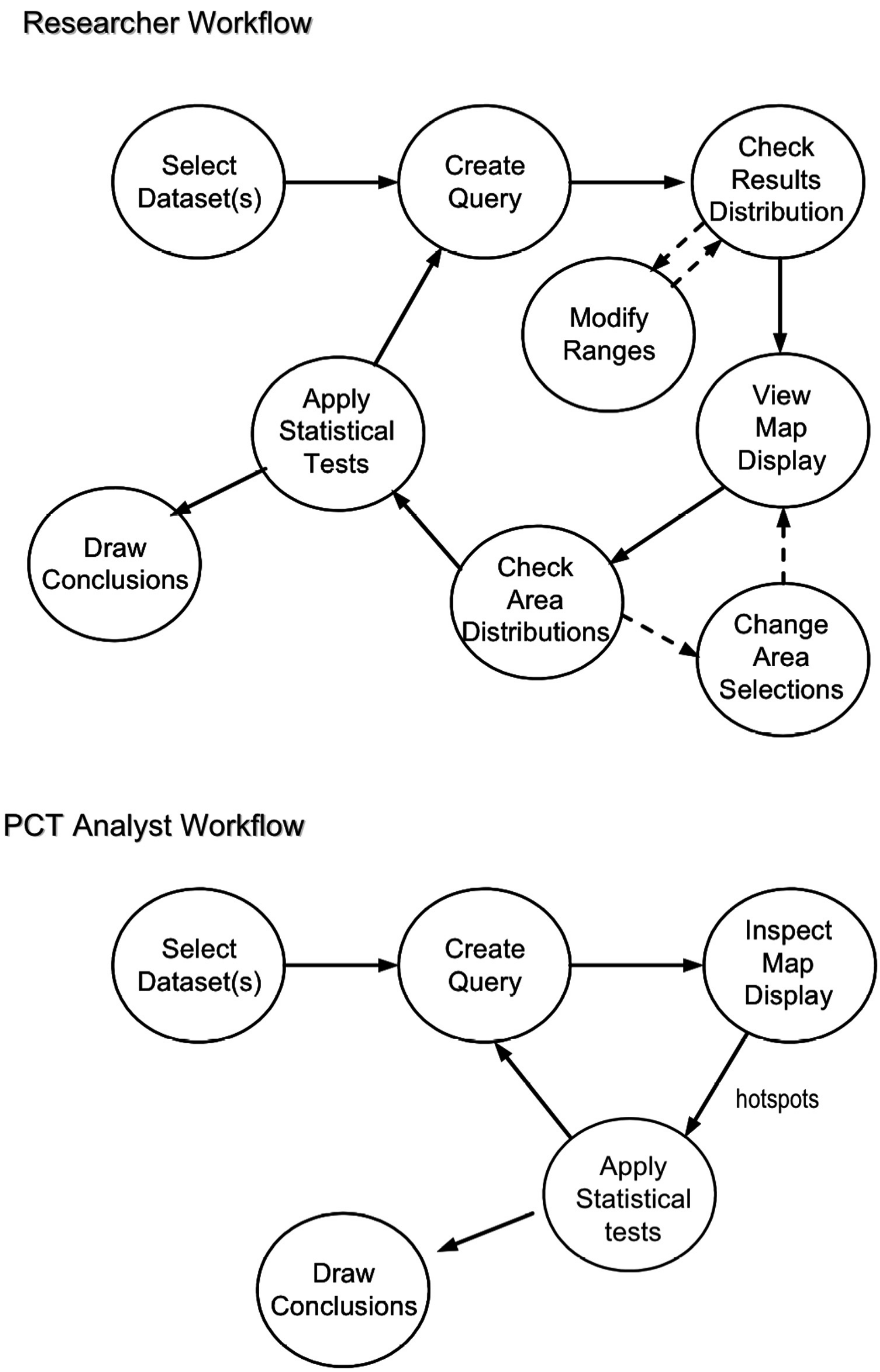

Fig. 2. Workflows for the research and public health analyst user stakeholders

between the stakeholder emerged during design exploration of prototypes, concerning customisation, adaptability and security. These were addressed by adding requirements for data security on servers, configurable workflows to match systematic or more opportunistic processes, while creative values were supported by interactive visualisation for data analysis. Collaboration and trust were fostered by an iterative user-centred RE process to build up trust, and by implementing the system as a collaborative application.

The workflows for each stakeholder group were quite different; see Fig. 2. The major functional requirements (goals) of the systems were for research and analysis support, namely database searches ranging from simple queries to complex associations between variables, leading to display of a detailed epidemiological data set in a context with map and graph overviews and functions to compare trends over time and different areas on maps. The researchers had a more sophisticated query investigation cycle and used more complicated statistical tests. In contrast, the public health analysts asked simpler questions directly related to spatial locations and used simpler statistical tests. Sociability, altruism and achievement motivations informed decomposition of stakeholder goals. For example achievement, altruism and systematic values led to a sub-goal to record analytic procedures, enabling academic researchers to track their own work, while also supporting public health analysts in sharing analysis techniques and results with colleagues. Another value clash between the stakeholders was the desire by the researchers to increase the statistical rigor of the analysts' investigation. Not surprisingly the analysts saw this as an imposition into their area of competence.

3.1 Implementation

The system was implemented in C# using MS Silverlight for graphics and animating map displays for trend questions, so that successive displays gradually morphed into each other to enable users to see change over time within different map areas. A distributed architecture (Fig. 3) was adopted and developed as a set of web services, with major class packages in the following functional areas:

- Dataset access: loads datasets from remote servers.
- Map display: displays maps using MS Charting libraries. Map displays can be overlaid with point data (e.g. location of health clinics, sports facilities).
- Charts and statistics display: runs basic statistical analysis scripts (R script calls) then displays range split histograms, box-and-whisker plots, etc., using MS Charting.
- Dialogue management: handles the query interface, interactive query-by-pointing and sliders.
- Expert advisors: classes that implement the statistics and visualisation experts, with data set monitors to trigger advice.

The prototype UI is illustrated in Fig. 4. The statistics advisor was a direct response to the value clash between the users' over-rigorous analysis procedures. The resolution was to provide a statistical expert advisor which encapsulates the researchers' knowledge; however, use of the advisor was discretionary so the analysts could ignore it if they so wished. The visualisation expert embedded knowledge about which charts

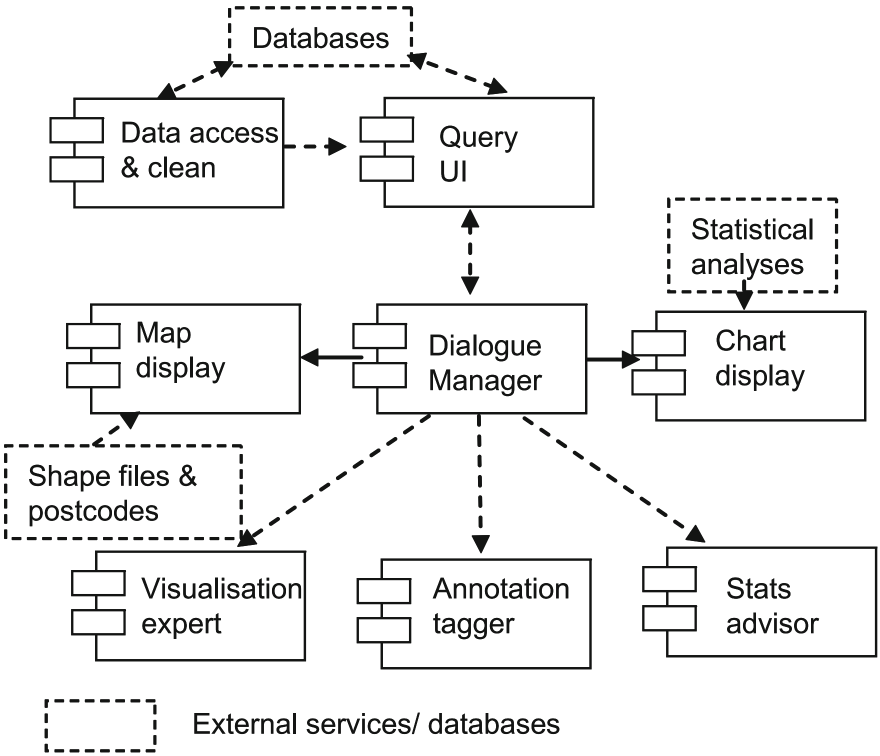

Fig. 3. System architecture of the implemented modules of ADVISES (UML package format)

to select for particular data types as well as choice of colours and shading to optimise the legibility of displays. This was a consequence of an implicit value clash between the users and system designers who wished to improve display design with cognitive knowledge (Ware 2000; Spence 2007). Fortunately both user groups were content with the visualisation expert which functioned non-obstrusively to configure the map-graph displays using a set of templates linked to frequent query types and their consequent data displays.

The original vision of ADVISES was designed to be a configurable system which could be adapted to other epidemiological applications, and in time to other e-health decision-support systems. This entailed developing adaptive data access and cleaning modules which could automatically adapt to new databases and data formats. However, it transpired that few external data sets have metadata description enabling such adaptation. Further configuration editors would have been necessary for tailoring output displays and the query interface. During the project it became clear that, technical difficulties notwithstanding, there was little appetite for developing more portable, configurable software since this served only the interests of the UK e-science programme, a remote stakeholder with less influence than the local, directly involved stakeholders (academic researchers and health analysts).

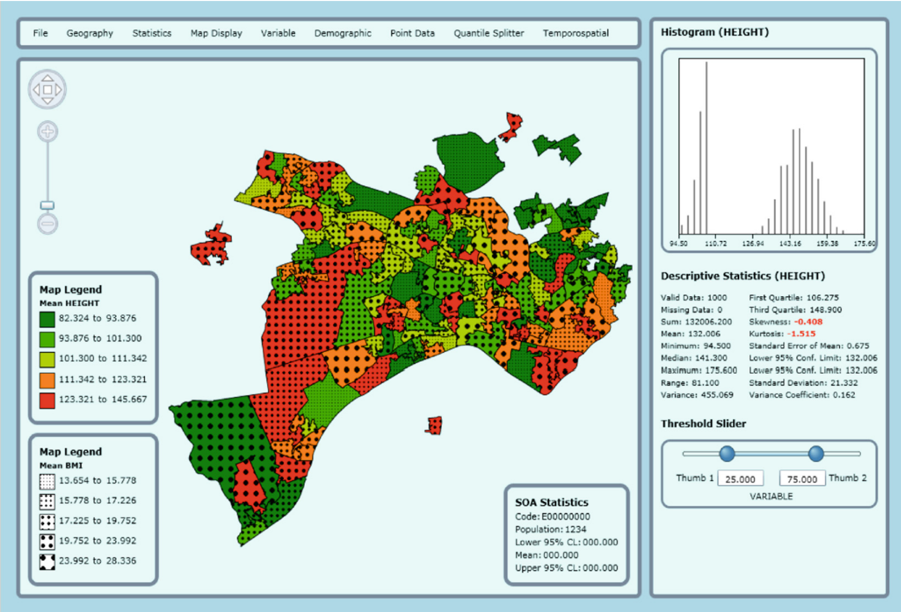

Fig. 4. ADVISES user interface showing the query results in map and graph displays

4 SAMS Experience

The SAMS (Software Architecture for Mental health Self management) project's main aim was to increase the proportion of dementia sufferers receiving an early diagnosis by detecting changes in their pattern of computer use (Stringer et al. 2015). At its core was a set of passive monitors that collect data as the user interacts routinely with the computer. This data is analysed to infer the stakeholders' cognitive health against a set of clinical indicators representing memory, motor control, use of language, etc. If the system detected potential problems, an alert message was sent to the user urging them to self-refer themselves to their GP for a check-up. There was a potential conflict between the clinical motivation to ensure that users responded to warning alert messages and users' need for privacy and self control.

The VBRE method was applied during interviews, scenario-storyboard requirements exploration sessions, and requirements analysis workshops. Requirements analysis was initiated with five workshops, conducted with a total of 24 participants (14 male, 10 female, age range 60–75). In the first session, the system aims, major components and operation were explained by presentation of PowerPoint storyboards illustrating design options (see Fig. 5), for the alert-feedback user interface, such as choice of media (video, text, computer avatars), content (level of detail, social network) and monitoring (periodic feedback, alert-only, explicit tests). Discussion focused on privacy issues in monitoring computer use, data sharing and security, ethical considerations, emotional impact of alert messages, stakeholders' motivations and their likelihood of taking follow-up tests. Requirements issues raised in the workshops were explored further in 13 interviews presenting scenarios to illustrate similar design options with discussion on privacy, security and ethical issues. The scenarios used in both sessions were designed to test different design approaches that tacitly explored values, such as human-like presence in exploration, social networks (trust, sociability values) and explicitly probing issues of security and privacy.

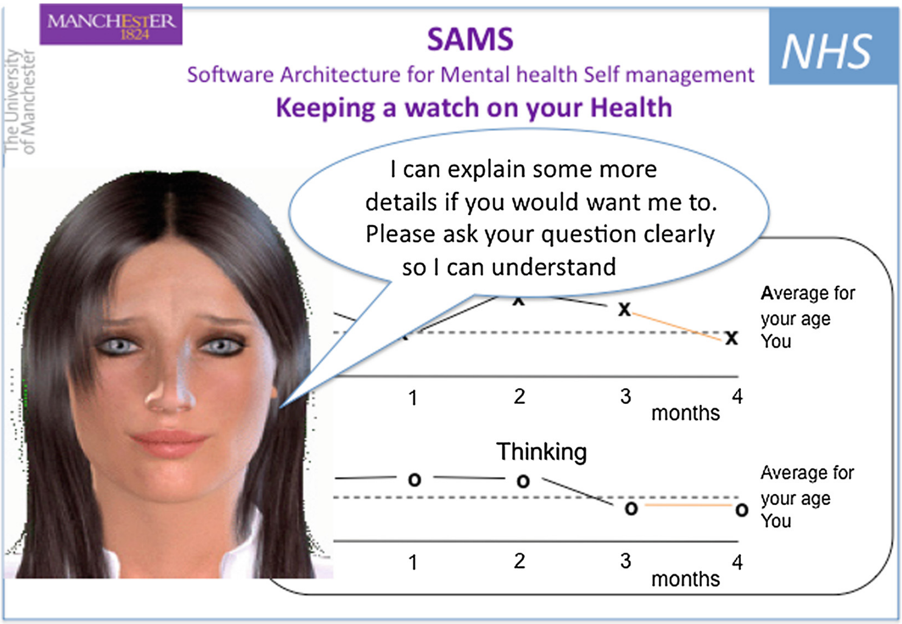

Fig. 5. Design options mock up illustrating avatar explaining feedback information display

Conflicts emerged in the values and requirements held by individual users as well as between end users and clinical-researcher stakeholders. End users expressed concerns over privacy and security arising from monitoring their computer use. Although they were reluctantly willing to share their data with the researchers for analysis, most participants insisted they should have control over their own data. Sharing data with their close kin/friends had to be under their control and the majority would not share information or the alert with their doctor. The majority were willing to allow monitoring of their computer use and e-mail text content, if it was anonymised to protect identity. Most participants expected to experience anxiety and fear if they received an alert message. Contact with a human expert or carer was cited as important support, with connections to support groups (e.g. the Alzheimer's Society) for reassurance (empathy) and as additional sources of information to motivate people to take follow-up tests.

Users had conflicting values (privacy, efficacy, altruism) which impacted on system reliability and accuracy. While these concerns were not UI properties they did influence non-functional requirements and design of the feedback UI. Users' motivations for self control over their own health care, demanded a reliable and accurate system that detected early signs of dementia. Signs of change and usual behaviour patterns in the recorded data might indicate dementia, but they could have many other causes, such as mental health problems, e.g. depression, and not pathological causes such as mood changes. Teasing apart the signal of potential pathology from the noise of normal variation was part of the research problem. The user implications were to avoid false positive alarms. Furthermore, even true positive indications were unlikely to be 100% accurate, so potentially disturbing messages had to be delivered sensitively. This posed a further requirements dilemma. On one hand, the feedback messages needed to urge users to self refer themselves to their doctors for a check-up, but on the other, messages should not alarm people unnecessarily. The 'fear of diagnosis' problem implies complex persuasive UI design which is part of our continuing research.

Privacy and security were the most common values, with implications for controls over any data sharing, encryption, secure transmission and depersonalised data for research. These values clashed with users' motivations for monitoring so they could manage their own health (efficacy, empowerment), the desire for self control, and altruism by participating in the research which might help research on dementia. Self control was prioritised by implementing a user control to 'stop recording', and information visualisation so users could view summaries of their own activity.

Trust in the SAMS system was closely related to security, but it also involved accuracy of system information and diagnosis as well as organisational trust in the healthcare professionals. Trust-building was helped by a co-design consultation processes that involved users in the research and its results. The value clash between the need for privacy and continuous recording of users' activity resulted from the need to record as much data as possible to improve the fidelity of the analysis. This improved the effectiveness of SAMS as a research tool, and its subsequent version as a healthcare self-management system, aligned with users' self-efficacy and altruism (help research) values. The privacy goal also clashed with the researchers' motivation to record as much data as possible for research purposes. Data security was a shared concern for all stakeholders.

4.1 Implementation

To resolve the privacy clash, a UI function was provided so users could turn off data recording at their discretion. The system then prompted users to turn the recording back on after set time intervals of 5 and 10 min. If users did not comply after three reminders this was visible to the researchers from recording log files. They had the choice to phone the user to ask them to re set the recording. Data security was ensured by encryption of the recorded data and secure transmission to the university's server. Data depersonalisation also protected user privacy.

Preferences between users for different styles of feedback UI was addressed by providing a limited number of options which users could select when the system was set up, e.g. verbosity and tone of messages (empathetic/terse); delivery modality (text only, speech, speech plus avatar) and information provision (on/off). The latter choice allowed users access to visualisations and graphs of their recorded data on demand, with a limited set of display options of the quantity of data and summarisation. Choices were limited by the cost of configuration and developing different UI displays. To date only a limited implementation of the feedback UI has been attempted, backed up by human intervention when the system detects potential problems. The persuasive UI design with its inherent conflict between the designer's goal of persuading people to take a course of action and possibly infringing personal freedom is still to be resolved.

5 Discussion and Conclusions

Conflicting UI properties and, more generally, conflicting user requirements, are inherent in many systems. This paper has reported some experiences in trying to make these conflicts explicit so they can be resolved by negotiation or design. Conflicts may appear as explicit differences in stated requirements; however, frequently different viewpoints between users are tacit and need to be analysed in terms of values and motivations. Methods such as VBRE (Thew and Sutcliffe 2017) and Value Sensitive Design (Friedman 2008) help in this endeavour.

If negotiation fails to resolve requirements conflicts, then a design response is necessary. Configuration at design time or adaptation at runtime are the usual choices. Configuration has the advantage of user participation, so they are aware of their choice and can pick design options that match their needs (Sutcliffe et al. 2006). However, configuration involves user effort and most users do not use customisation features provided by operating systems, and resent having to spend time choosing configuration options. Adaptation via an intelligent monitoring and automated change saves the user effort, but the changes are chosen by the designer and the change may produce inconsistency in the UI and induce usability problems (Fischer 2001). Apart from specialised areas such as recommender systems (Bonhard et al. 2006), manual adaptation or configuration has been preferred.

However, configuration imposes learning and operational costs on users. Furthermore, the configuration options are provided by designers, and this may limit the fit between the users' needs and the design options offered. In the ADVISES system we did not implement most configuration facilities because of constraints on developer resources. This decision was a trade-off between the perceived user demand for configuration, which was estimated to be low, and the considerable software development effect necessary. ADVISES implemented a resolution of clashes between user groups by giving users control over which facilities they chose to use, in particular the statistics advisor. This choice was a compromise since it failed to satisfy the researchers' wish to enforce statistical rigor in the public health analysts' work, although it did preserve the freedom of the analysts to control their own workflow.

In SAMS the value clashes between users' desire for privacy and their self-efficacy/empowerment motivation for healthcare self-management was partially resolved by provision of a UI control to temporarily halt data recording. The potential clash between the outcome of the monitoring where emotive messages had to be conveyed has not been resolved. This is an ongoing research issue concerning persuasive technology (Fogg 2009) where the designer or system owner's goal, i.e. to persuade the use to take a particular course of action, conflicts with ethical concerns that technology should not control people's behaviour by explicit or covert means.

In the perspective of the trade off framework in Fig. 1, in the ADVISES project the design choice was to increase complexity of the UI and impose more operational costs on users who had to search for the functions they needed. However, these costs were mitigated by providing limited configuration in the ability to turn the statistics advisor off. Avoiding product versions for the two user groups contained development costs. In SAMS the complexity of the monitoring UI was not an issue; however, the value analysis demonstrated than configuration at run time was vital by giving users the ability to turn off monitoring. Configuration of the persuasive users interface was not resolved during the project, although in future research we expect to provide configuration to match the style of persuasion to the user profile. This exposes the ethical dimension of user v. system control that needs to be added to the Fig. 1 framework.

Conflicts in the user interface may be overt in the form of different tasks, workflows or functional requirements owned by different user groups, as was the case with the researchers and public health analysts in ADVISES. In this case provision of tools to fulfil both sets of tasks is the answer. Harder to resolve are conflicts involving clashes between user values or non-functional requirements. These have to be refined into design choices which may partially satisfy one or more stakeholder groups; but as our experience has demonstrated, conflicts can often pose deep-seated irreconcilable dilemmas.

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Declarative Interaction Towards Evolutionary User Interface Prototyping

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Abstract. This paper examines the potential of describing interactive systems in a declarative manner with concepts familiar to both developers and designers. Such declarative interaction descriptions will enable evolutionary prototyping processes. This new type of design and development processes that can emerge with declarative interaction is described along with benefits for human-centred system design. A few challenges are raised for future research in this area.

Keywords: Prototyping · Declarative · User interface · Evolutionary Conflict

1 Introduction

Attempts were made to describe interactive systems declaratively for several decades, for example Model-Based UI Development (MBUID, e.g. [16]). Once a declarative description of an interactive system is available, there are several advantages: the system can be *analyzed* in regard to its associated usability, safety, human error (e.g. [7]) or other aspects, and it can be *transformed*, which includes the generation of code towards the running interactive product. These advantages stem from declarative models being relatively easy to process by computing systems, unlike procedural code

The downside of MBUID approaches is that they are often highly theoretical, aiming to drive the description of the interactive system from a very abstract model (e.g. the Tasks and Concepts level of the CAMELEON framework [5]), which is hard to understand by designers, users or even by developers. Furthermore, MBUID has very little support for user interface *prototyping* [1, 15]: when a user interface is generated, it is hard for users and designers to adjust it and iterate with it for improvement according to their needs.

As declarative research approaches like MBUID do not constitute a solution for achieving a more declarative UI design and development practice, the approach we can take is to analyze the current practice and consider where procedural code dominates. For that analysis, one could employ e.g. the *Model-View-Controller* [14] approach to conceptualizing an interactive system. Important parts of the *Model* are already declarative in current practice, at least in regard to describing how the data is structured, and what methods are available to process it. While the Model methods are most frequently implemented as procedural code, the declarative part of the model is often

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sufficient for describing the user interface in its other conceptual modules (*View* and *Controller*). Similarly, *View* templates are often described in a declarative manner, in languages such as HTML or variants of XML. In the quest proposed here to find fully or predominantly declarative representations of interactive systems, it is therefore the *Controller* where the procedural code still dominates. Since Controllers describe the "feel" of the user interface, the interaction itself, I use to refer this quest as "*Declarative Interaction*". It is important to note that once a declarative specification of an interactive system exists, a fully testable implementation can be produced. That is, if an online (running) prototype has been made in a declarative manner, with an approach that allows a declarative description of interaction, that prototype can be iterated into the running product. Therefore, declarative interaction can lead to *Evolutionary Prototyping* [1] processes.

In this paper I aim to address the issue of finding such *low-level declarative UI representations*, so that they are understandable for developers and end-users. A subsequent objective is to *support UI prototyping processes*, whereby developers, users, or customers have the freedom to iterate with the interactive prototype. This work is inspired from a large, long-term case study [2, 3] that observed users, designers and voluntary developers, who were able to develop, maintain and extend predominantly declarative interactive systems for long periods of time.

2 Potential of Declarative Interaction

2.1 The Traditional UI Design and Development Process

In order to illustrate the potential of declarative interaction for achieving a more flexible and human centred User Interface design and development process, it is important to visit the traditional process and emphasize its aspects relevant to this paper: various stages of prototyping and the transition between design and development. The top of Fig. 1 illustrates this current process of designing and developing interactive systems. A few (cheap) paper prototypes are produced, and based on designer judgment and user feedback, some ideas continue to the online prototyping phase. After a number of formative iterations, one of the online prototypes is delivered ("Online Delivered" in the figure) for the developers to implement. Variants of the *Model-View-Controller* [14] approach are often used, whereby the non-interactive *Model* (backend, business rules) is manipulated via a user interface programmed in the target technology. The interactive behavior, described by the *Controller*, is, for the largest part, implemented procedurally. The produced interactive system is iterated with, based on feedback from users and designers.

In this traditional approach, designers do not produce artifacts that can be directly used by developers, since most elements of an online (running) interactive system prototype refer to the *View* component, but they need to be rebuilt at the developer side. There are also power issues in this traditional arrangement: developers are often more powerful than designers and even managers [6], since their work is the most expensive and their work object (software) is resistant to changes. There exist therefore

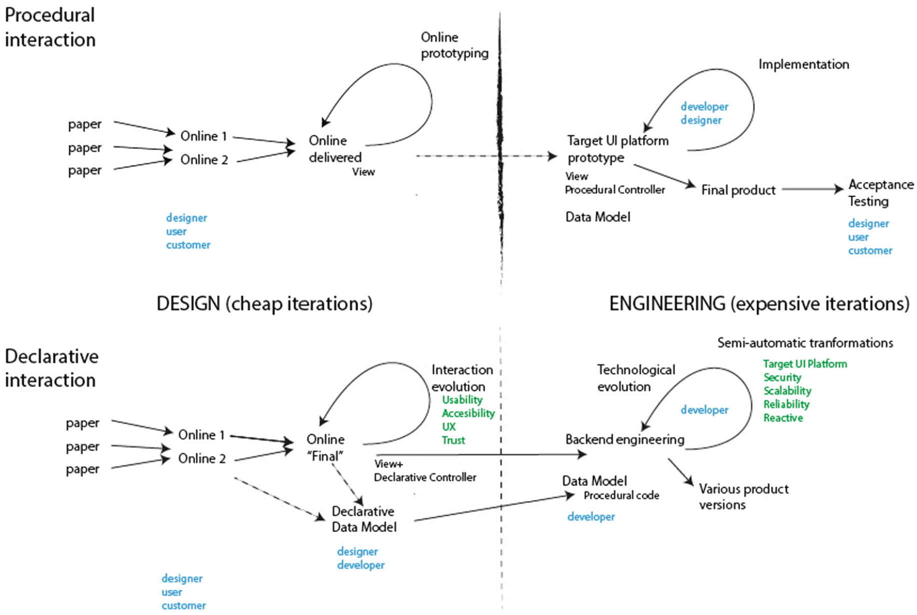

Fig. 1. Traditional interactive system design and development process (top) and the new process facilitated by Declarative Interaction (bottom).

technology 'viscosity' issues: one cannot iterate fast because iterations with non-prototype software are expensive. Usability problems found at later stages are difficult to address.

2.2 Example of a Declarative User Interface Approach

One approach to defining a declarative interaction (*Controller*) takes advantage of declarative constraints specified for the *Model*-*View* data correspondence (binding) and declares on which UI events these constraints should be updated. Figure 2 depicts a fully declarative user interface, where two *Views* of a factory production Lines containing production Tasks (diagram view at the top and table view at the bottom) show data from the same *Model*. The *Views* are connected to the *Model* by way of declarative SQL-like queries (studied with designers in [3]) shown in blue.

A simple declarative interaction can be illustrated in regard to the user editing in textboxes. For example the designer can choose to update e.g. the task customer name (the table left column) at each user keystroke, and the task duration (the table middle column) only when the user presses Enter or Tab. The declarative controller consists of specifying on which UI event the *View* should be synchronized with the *Model*, because the widget relation to the model is already set, similar to the drag-and-drop case.

A more advanced example of declaring interaction is drag and drop, described by its data semantics, for example a Task object can be dropped on a Line object. This

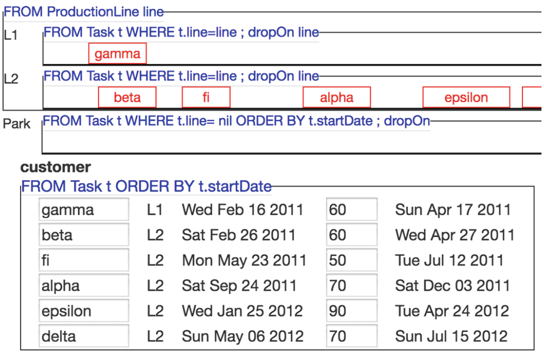

Fig. 2. Fully declarative user interface featuring advanced interaction like drag and drop

information is sufficient to generate a functioning UI, because the meaning of the drop action is already governed by the *View-Model* connection declared for the respective container widget representing the Line. The widget representing the Line in turn contains widgets that represent Tasks. Therefore, in order to define drag and drop interaction declaratively, it is sufficient for the designer (possibly with developer help) to declare what *Model* objects are being dragged and on which object can they be dropped.

It is interesting to reflect that the declarative annotations that achieve the interaction exemplified above require very little code comparing to the procedural controller needed for achieving similar interaction. If we take the drag and drop example, such a procedural controller would need to define a drag and/or drop handler for each involved widget. Such a handler should do a translation between the graphical domain (widgets) to the abstract domain (*Model* objects), and then invoke the appropriate Model methods to implement the drag and drop semantics.

2.3 Towards a New, Evolutionary UI Design and Development Process Based on Declarative Interaction

Based on such declarative controller definition techniques, the alternative proposed here to the traditional UI design and development process is the Declarative Interaction process, illustrated at the bottom of Fig. 1 along with its potential emerging evolutions. Declarative interaction was inspired to the author through field observations and own experience [2, 3]. Early versions of declarative controllers were demonstrated in [3] and refined in [9, 11–13]. We have also shown a combination with MBUID approaches in [10].

The specific aspect of this process is that the designer, with input from users and customers, can work not just on the *View*, but also on the declarative *Controller*, and on the declarative parts of the *Model* as they are represented as annotations of the *View* on which the designer usually works. The developer plays a role in this process, by helping in structuring a convenient data *Model*, and possibly also to help express more complex interaction. However, the designer drives the iterations, changing the UI look and feel (*View* and *Controller*) while the developer only helps when relevant aspects of the data Model require adjustment. Early on, or in more advanced phases, online prototypes can be directly made using the target UI technology.

Once a final UI is decided upon, it can be tested and validated with users in regard to its usability and acceptance. After that engineers can take over the prototype and optimize it for Computer Science concerns (e.g. Security, Reliability, Scalability) using semi-automatic tools. Automatic processing (similar to model transformations) and analysis are possible thanks to the declarative nature of the interactive system representation. Since most of the design side uses such declarative representations, the results of the design phase are *transferable* to the engineering side, thus achieving *evolutionary prototyping*. In the engineering side, procedural code can be added. It is interesting to note that in this case developers work mostly on the system backend, which is why their work is termed "backend engineering".

3 Declarative Interaction and Conflicting UI Properties

Design is a balancing act, a suite of tradeoffs that are made along the way between the needs and desires of various users and the institutions they may represent. Therefore conflicting UI design concerns are bound to occur. One way to address such conflicting concerns is the Participatory Design approach [8] of keeping the users involved at all stages of design, therefor ensuring that various conflicting qualities that users, designers and developers require are balanced in an acceptable way.

Declarative Interaction supports the resolution of UI requirement conflicts by supporting Participatory Design through (1) facilitating equal-footing communication between users, designers and developers and (2) encouraging iterations until the late stages of the product design and implementation, thanks to its Evolutionary Prototyping nature.

Even in situations where Participatory Design is not suitable, the balanced power relation facilitated by Declarative Interaction between designers and developers is likely to achieve, through iteration, a good balance between the interactive system properties championed by designers and those guarded by developers. Especially the Interaction Evolution (Fig. 1 left) iterations are also accessible to managers, letting them bring their own concerns. Therefore, *iteration* and the *balance of power* are the general process qualities that allow Declarative Interaction to support the resolution of conflicting UI design concerns.

4 A Case of Declarative Interaction

A European Non-Governmental Organization (NGO) with almost 100 locations developed their own systems for over 20 years: member database, document archives, summer course participant selection and management, virtual job fair, etc. All systems are tailor-made for the NGO rules and needs, ensuring greater user understanding and usability compared to general-purpose systems, if such systems are available at all.

Users of such systems are 1000 s of members and students of participant universities, creating 10000 s of new data objects per year.

A major role in this success is played by the Makumba framework [2, 3]. It was designed with learning in mind, so that members have to learn two small declarative programming languages (a SQL variant for data retrieval, and HTML for data formatting). More advanced members can continue their learning path and "career" within the NGO by using Java for more complex application logic. Furthermore, a few production Makumba systems exist that use declarative SQL code for most of their application logic, including authentication and authorization, leaving just a few functions to be implemented in procedural Java code.

Reflecting on this long process, I believe that much of the success of Makumba in NGOs is due to the declarative nature of its languages. Declarative code is often small: if a declarative language suitable for a specific programming problem exists, the code will typically be more compact than the procedural correspondent. For an NGO this means less code to track and maintain. Declarative code is often intuitive to read, reducing the initial threshold that junior NGO volunteers have to face before they can contribute with code of their own. Once one makes the code work during development, declarative code is reliable to run, reducing the NGO maintenance costs. Because declarative code can be analyzed and transformed into other representations or technologies, it reduces technology lock-in for the NGO.

Another Makumba success factor stems from its facilitation of evolutionary prototyping, being therefore an early incarnation of Declarative Interaction. Systems are typically prototyped in HTML or directly in Makumba first, and are iteratively refined to become the production system. Systems are often prototyped starting from the user interface (and much of the system code is the user interface), which is intuitive and motivating for the developers, as they can work directly with the artifact that their fellow NGO members will use.

The first generation of Makumba technologies, based on Java Server Pages (JSP) and pre-Web 2.0 user interaction, is by now outdated. Kis [11–13] has explored the possibilities of combining data from a multitude of APIs into one interactive application, rather than data from a single relational database, thus using data as a "prototyping material". This has resulted in Endev [12], a Javascript framework that is, however, not production-ready. One major reason is that, unlike Makumba, Endev does not optimize the number of queries sent to its data sources (a very complex problem when there are multiple data sources).

The current approach in modernizing Makumba recognizes that most organizations have one single main data source, and that the Makumba approach of binding data to elements of a HTML user interface has been taken by many other technologies such as AngularJS[1]. However, Angular still requires a lot of procedural Javascript code to be written, which breaks the principle of declarative development. Therefore the current approach is to develop 'plugins' for Angular and other suitable technologies to replace the current Makumba JSP layer, while keeping the declarative engines of Makumba: optimal SQL query combination, SQL query inlining for code re-use, authentication

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[1] https://angularjs.org.

and authorization, etc. This approach is well under way and since Angular does much of the data binding that Makumba-JSP did, the resulting Angular 'plugin' is quite small and easy to maintain.

While the problem of Declarative Interaction has not yet been fully explored with Makumba, a number of experimental prototypes exist that allow fully declarative description of complex interaction such as Drag and drop, or simpler interaction such as form fill-in with UI update as the user types. One of the next steps considered is to describe declaratively various UI design pattern libraries (e.g. [4]) or other exemplary systems.

5 Declarative Interaction: Challenges for the Future

There are many ways to achieve declarative interaction, the Makumba approach (using declarative queries to connect the UI to the data model) is just one. *Exploring alternative declarative interaction approaches* is thus one important future challenge.

Is any user interaction possible to describe declaratively based on simple abstractions, familiar to designers and users? *Addressing declaratively a wide palette of interaction patterns* is probably the biggest challenge faces by researchers in the field.

While the impact on the human centered software engineering processes has already been considered, *assessing further the impact on process* is another important challenge. This includes *considering further ways to empower the designers and users,* but also to *improve their communication with developers.*

Most of this work was conceptualized within the classic Model-View-Controller paradigm. MVC is known to be sensitive to cross-cutting concerns, and an investigation of declarative interaction in relation to such concerns is therefore important. Alternatively, future work can consider other UI development approaches for declarative interaction.

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QBP Notation for Explicit Representation of Properties, Their Refinement and Their Potential Conflicts: Application to Interactive Systems

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Abstract. This paper presents a notation called QBP (Question, Behavior, Property) to represent software and system properties and their relationship. The properties are structured in a tree-shape format from very abstract and generic ones (such as safety or security) to more concrete (leave of the tree). This tree-shape representation is used in the paper to represent properties classification in several areas such as Dependable and Secure computing and Human-Computer Interaction. The notation makes it possible to connect the properties among each other and to connect them to concrete properties expressed in temporal logic. Those concrete properties are, in turn, connected to behavioral descriptions of interactive systems satisfying (or not) the properties. An example is given on a set of different traffic lights from different countries.

Keywords: Properties · Interactive systems · Safety · Security
Usability · User experience

1 Introduction

With the early work on understanding interactive systems [1] came the identification of properties that "good" interactive systems should exhibit (e.g. honesty) and "bad" properties that they should avoid (e.g. deadlocks). Later, guidelines for the design of interactive systems [22] were provided, identifying in a similar way "good" properties (e.g. guidance), in order to favor usability of these systems. In the area of software engineering, early work [7] identified two main good properties of computing systems namely safety (i.e. nothing bad will ever happen) and liveness (i.e. something good will eventually happen). In [10] a hierarchy of software properties is proposed identifying for the first time explicit relationships between properties gathered in a hierarchy (e.g. "reactivity" divided in "recurrence" and "persistence"). While in the area of Human-Computer Interaction the properties were initially expressed in an informal way, [16, 17] proposed the use of temporal logics to describe these properties.

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Beyond these “generic” properties, it might be of interest to represent specific properties related to the very nature of each system. These properties might also be of a high level of abstraction (e.g. trust for a banking system) or of very low level (e.g. only possible to enter a personal identification number 3 times on a cash machine). The detailed property would contribute to the high-level one.

2 The QBP Notation

TEAM notation [6, 11, 13] is an extension of MacLean and al.’s QOC (Question Option Criteria) [9] that allows the description of available options for a design question and the selection of an option according to a list of criteria. TEAM aims at supporting argumentation and rationalization as introduced by Toulmin [21]. The TEAM notation extends QOC to record the information produced during design meetings. For the purpose of work presented here, we propose a refinement of TEAM to explicitly represent properties and their relations including:

- Questions that have been raised (Square colored in pink in Fig. 1),
- Behavioral representations of a system providing an answer to the related question (s) (Disc coloured in orange in Fig. 1),
- Concrete properties (which could be represented in modal logics) describing a desired property that could be met (or not) by the related behavioral description (Triangle colored in green in Fig. 1),
- Refined properties and Properties that represent a hierarchy of “generic” properties that are desired. (Rectangle-triangle colored in blue in right-hand side of Fig. 1).

QBP models make explicit both the hierarchies of properties (that would be represented on the right-hand side of the models) and the concrete design of a system (represented on the left-hand side of the models).

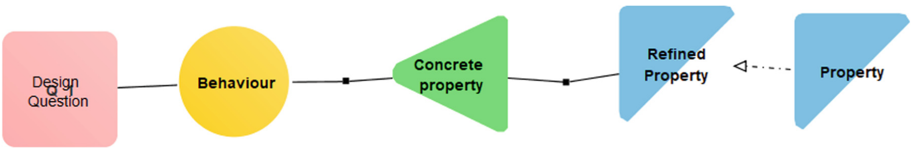


Fig. 1. Main elements of the notation TEAM forming a QBP model (Color figure online)

The software tool DREAM [6, 11, 13] provides support for the editing, recording and analysis of QBP diagrams. In previous work, we have proposed an approach for the selection and management of conflicting guidelines based on the TEAM notation [12]. More specifically, the notation was used for exhibiting choices and trade-offs when combining different guidelines sets. Similar modeling and analysis of models can be performed with QBP.

3 Representing Hierarchies of Properties

This section presents the modeling of several classification of properties using QBP. Some of them are dedicated to interactive systems (see Sects. 3.1 and 3.3) while other ones are more generic to computing systems (see Sect. 3.2).

The aim is double: first to highlight the fact that the literature has been already proposing hierarchies of properties, second to provide a list of properties dedicated to interactive systems.

3.1 Usability and User Experience

These two major properties in Human-Computer Interaction don't have currently the same level of maturity. Usability has been studied since the early 80's and has been standardized by ISO in the ISO 9241 part 11 since 1996 [5]. Its structure is presented on the (a) section of Fig. 2. The standard specializes Usability into three sub-properties (efficiency, effectiveness and satisfaction) while some researchers would also add at least Learnability and Accessibility [14, 18, 19] as important aspects of Usability.

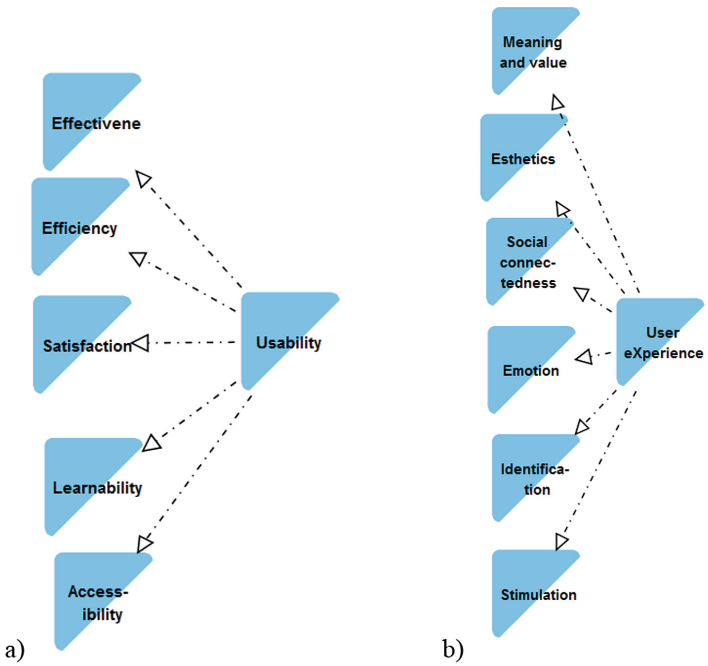


Fig. 2. Representation of the hierarchical relationships between factors and sub-factors of (a) Usability [5] and (b) User eXperience [15]

User Experience is a more recent concept that is under standardization but still not mature. Sub-properties of User Experience (usually called dimensions) are diverse in terms of level of abstraction and vary widely amongst authors (see [4] for a description of user experience in terms of hedonic and ergonomic qualities – another word for properties). [15] proposes the only set of dimensions that has been carefully check for orthogonality and proposes six dimensions at the same level of abstraction (see right-hand side (b) section of Fig. 2).

3.2 Dependable and Secure Computing and Concurrent Programs Properties

The first issue of the IEEE transactions on Dependable and secure computing included a paper [8] dedicated to a taxonomy of properties of those systems. The taxonomy is presented in part (a) of Fig. 3. Beyond a very clear definition of each property this classification shows that some sub-properties such as availability are related to higher-level properties namely safety and security. Indeed, a loss of availability might impact dependability of the systems (if the service not available is requested) while security attacks might target at a reduction of availability of service (as in the classical DDoS – Distributed Denial of Service).

The right-hand side of Fig. 3 presents a very old and classical decomposition of properties of concurrent systems: safety and liveness that have been introduced in the introduction. Beyond this separation, Sistla proposed in [20] a refinement of these properties in more precise ones contributing to the presence or the absence of the more high-level ones.

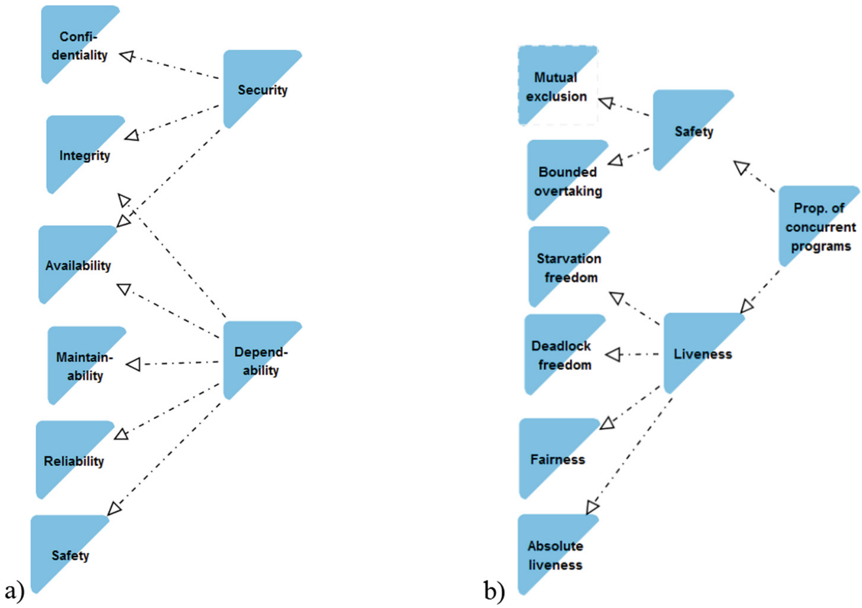


Fig. 3. Representation of hierarchical relationships between factors and sub-factors of Security and Dependability [8] (a) as well as of concurrent programs [16, 17]

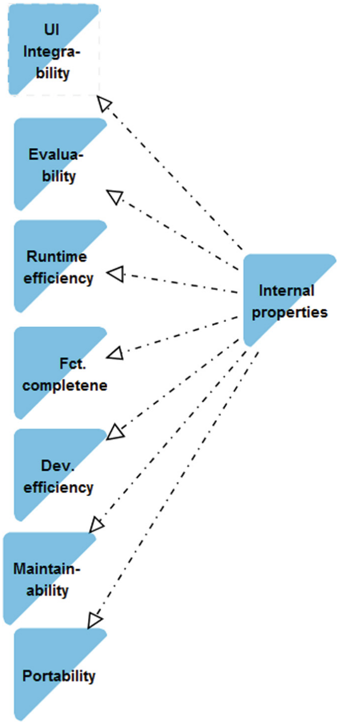


Fig. 4. Representation of hierarchical relationships between factors and sub-factors of Internal properties of user interfaces [2]

3.3 Internal and External Properties of Interactive Systems

In his seminal work in the domain of formal methods for interactive systems [1], Dix proposed a detailed classification of properties in two main groups: external and internal properties. This refers to the fact that part of the interactive system is perceivable by the user and that what is presented to the user might be of "good" quality (which means the presence of the external properties as detailed in Fig. 5). The internal properties (see Fig. 4) refer to the quality of the interactive system focusing on its internal behavior. These properties are thus closer to the ones presented above in the area of computing systems.

4 The Traffic Lights Case Study

This section presents the application of QBP notation on a simple interactive system. The system has been chosen as it is both simple and widely known so being easily understandable by the reader. It can also serve as a benchmark for other research work on properties descriptions.

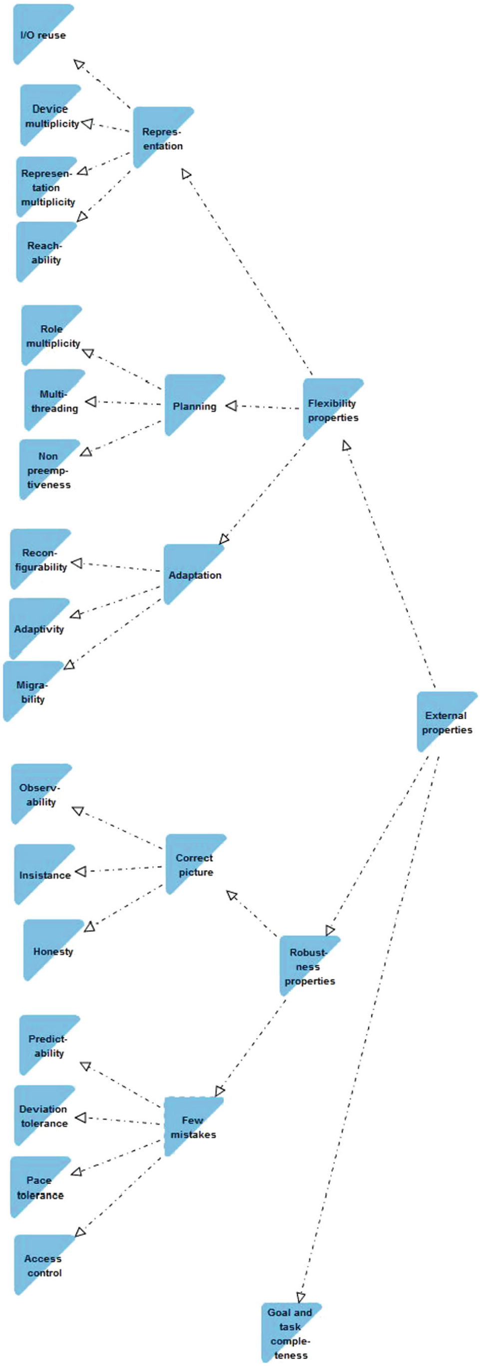


Fig. 5. Representation of hierarchical relationships between factors and sub-factors of External properties of user interfaces [3]

4.1 Informal Description of the Case Study

Our case study is an application simulating a traffic light. This application, displayed in Fig. 6, is made up of three light bulbs (the top one is red (see Fig. 6b), the middle one is orange (see Fig. 6c) and the bottom one is green (see Fig. 6d)). The traffic light exhibits three different modes of operation: (i) when it is stopped, (ii) when it is working and (iii) when it is faulty. In the stopped mode, all the light bulb are switched off (see Fig. 6a). In the faulty mode, the orange light bulb is blinking (it is switched off during 400 ms and switched on during 600 ms). Finally, the working mode is different following the countries in which it is deployed. We will further details this working mode in the following section for four difference traffic lights: French, British and the Austrian traffic light (for which two different alternatives will be provided).

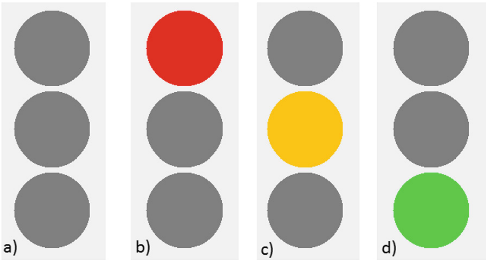


Fig. 6. Screenshots of the traffic light application: (a) when it is stopped, (b) when the red light bulb is switched on, (c) when the orange light bulb is switched on and (d) when the green light bulb is switched on. (Color figure online)

4.2 Behavioral Modelling of the Case Study

This section presents successively the four behavioral models for each of the traffic lights in the case study.

French Traffic Light

Informal Presentation. The French traffic light is the simpler one and the other ones are more complex and precise behavior of the French one. When entering the working mode, the traffic light starts with only the red light on, after 1000 ms the red lightbulb is switched off and the green lightbulb is switched on. This bulb remains on for 2000 ms before being switched off while the orange light is switched on for 500 ms. When this delay is elapsed, the traffic light comes back to the initial state with only the red light on.

At any time, a fault event may occur that will set the traffic light to the faulty mode. When entering this mode whatever light which is on is switched off and the orange light is switched on for 600 ms (as explained in the informal presentation of the case study above). At any time, a recover event may be triggered setting the traffic light to the initial state of the working mode (i.e. only the red light switched on). A fail event may also occur. When this occurs, whatever state the traffic light is in, it is set to the Fail mode (represented by the state A in Fig. 7).

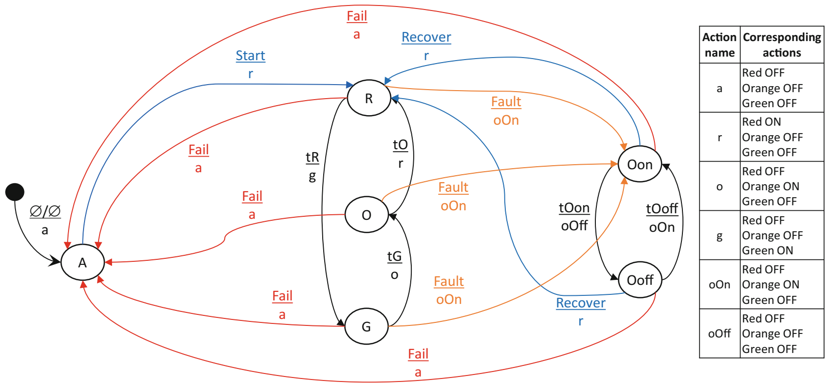


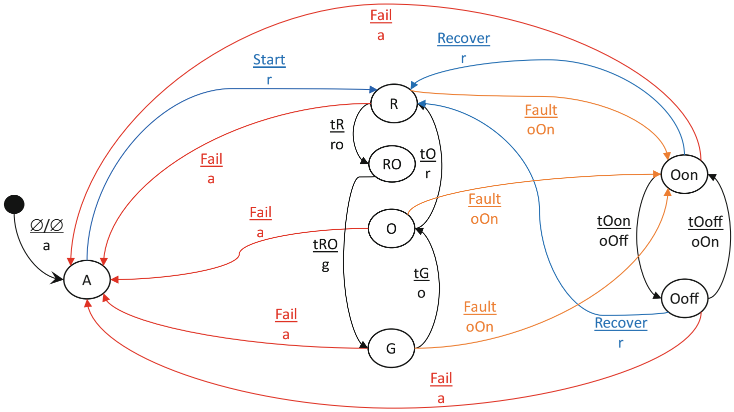
Fig. 7. Automaton of the French traffic light (Color figure online)

Behavioral Model. Figure 7 represents with an Augmented Transition Network [24] the behavior described informally above. In the initial state, the traffic light is in the Fail mode (state A in the diagram). When an event Start is received, the traffic light changes state to the R state in the diagram. During this state change, the red lightbulb is switched on ("r" action on the arc label from state "A" to state "R"). From that initial state of the working mode, the timer "tR" will be switched on starting the autonomous behavior of the traffic light in this mode, alternating from Red to Green, from Green to Orange and then back to Red.

British Traffic Light

Informal Presentation. Informally, the behavior of the British traffic light is very similar to the French one. The only difference is the fact that, in the working mode, the traffic light does not go directly from Red to Green. An intermediate state has both orange and red lights on before the green lightbulb is switched on. The rest of the behavior (fail and fault modes) remains the same. This behavior makes possible to users to know that the traffic light is going to be green (when both orange and red lights are on).

Behavioral Model. Figure 8 presents the behavior of the British traffic light. As explained above the only difference is the addition of a stated "RO" between "R" and "G" states (at the center of the Figure).



Action name	Corresponding actions
a	Red OFF Orange OFF Green OFF
r	Red ON Orange OFF Green OFF
ro	Red ON Orange ON Green OFF
o	Red OFF Orange ON Green OFF
g	Red OFF Orange OFF Green ON
oOn	Red OFF Orange ON Green OFF
oOff	Red OFF Orange OFF Green OFF

Fig. 8. Automaton of the British traffic light (Color figure online)

Austrian Traffic Light

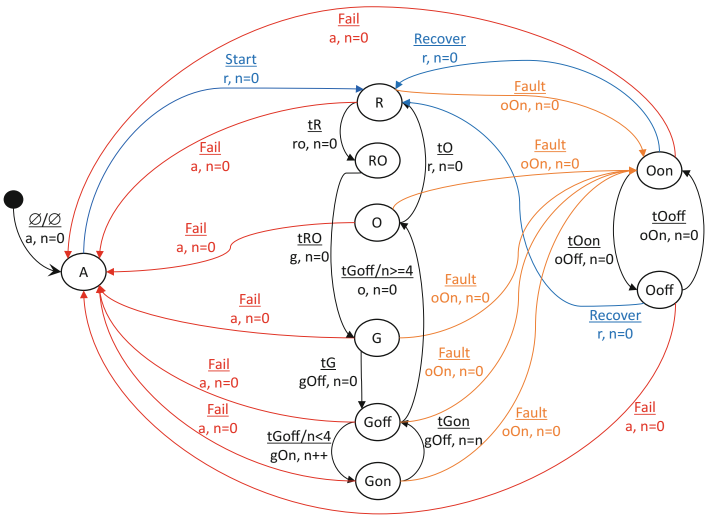
Informal Presentation. Informally, the Austrian traffic is an extension of the British traffic light. The only difference is when the green light is on. In that state, the Austrian traffic light will present a blinking green status. The green light will blink 4 times before the green light goes definitively off and the orange light is switched on. This allows users to know that the green light will finish soon and that it is thus better to start to break (or to accelerate in order to avoid being stuck at the red light).

Behavioral Model Simple. The model in Fig. 9 presents one possible description of the behavior presented above. The “G” state in previous models is now a set of three states, the original “G” state plus a set of two states “Goff” and “Gon” modelling the blinking in green light. A timer will alternatively set the automata from state “Goff” to “Gon” until this has been performed the adequate number of time. The number of blinking is stored in the variable (called register in ATNs) n that increases each time the green light is switched on (label n++). When this has been performed 4 times (precondition n >= 4 on the label from state “Goff” to “O”, the orange light is switched on and the traffic light goes to the state “O”.

What is interesting with this model is that it is very easy to increase or decrease the number of times the traffic light will blink green. Indeed, only the values of the two preconditions for the event TGoff have to be changed. Replacing the value 4 by a value 6 would make the traffic light blink six times in the Green blinking mode.

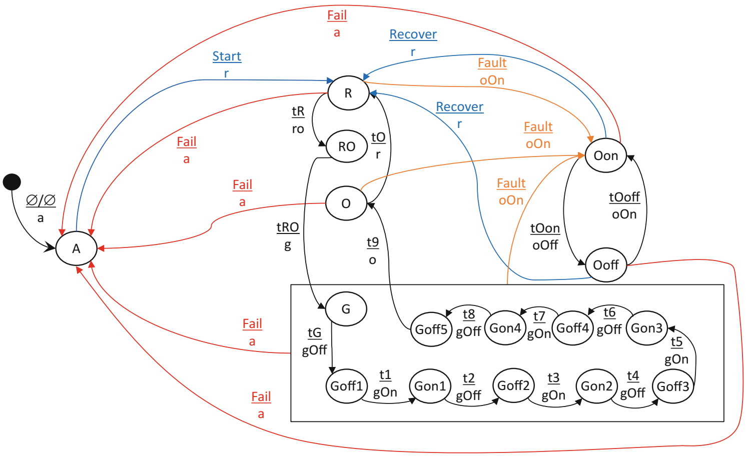
Behavioral Model Revised. A revised version of the model above model is presented in Fig. 10. It exhibits the same behavior but does not include a precondition to count the number of blinking. Instead these blinking states are unfolded in a number of sequential Goff and Gon states.

The main advantage of this model is that it is very easy change the blinking speed (for instance if we want to model a faster blinking speed when the traffic light get closer to orange). However, adding more blinking will deeply change the automata (adding 2 states and 2 timers for each additional blinking to be added).



Action name	Corresponding actions
a	Red OFF Orange OFF Green OFF
r	Red ON Orange OFF Green OFF
ro	Red ON Orange ON Green OFF
o	Red OFF Orange ON Green OFF
g	Red OFF Orange OFF Green ON
gOff	Red OFF Orange OFF Green OFF
gOn	Red OFF Orange OFF Green ON
oOn	Red OFF Orange ON Green OFF
oOff	Red OFF Orange OFF Green OFF

Fig. 9. Automaton of the Austrian traffic light (Color figure online)



Action name	Corresponding actions
a	Red OFF Orange OFF Green OFF
r	Red ON Orange OFF Green OFF
ro	Red ON Orange ON Green OFF
o	Red OFF Orange ON Green OFF
g	Red OFF Orange OFF Green ON
gOff	Red OFF Orange OFF Green OFF
gOn	Red OFF Orange OFF Green ON
oOn	Red OFF Orange ON Green OFF
oOff	Red OFF Orange OFF Green OFF

Fig. 10. Automaton of the Austrian traffic light revised (Color figure online)

4.3 Description of Properties on the French Traffic Light

Figure 11 connects the relevant properties from the literature that have been presented in Sect. 3 with the French traffic light from the case study. A set of 8 concrete properties have been represented that are, in turn, connected to higher-level properties.

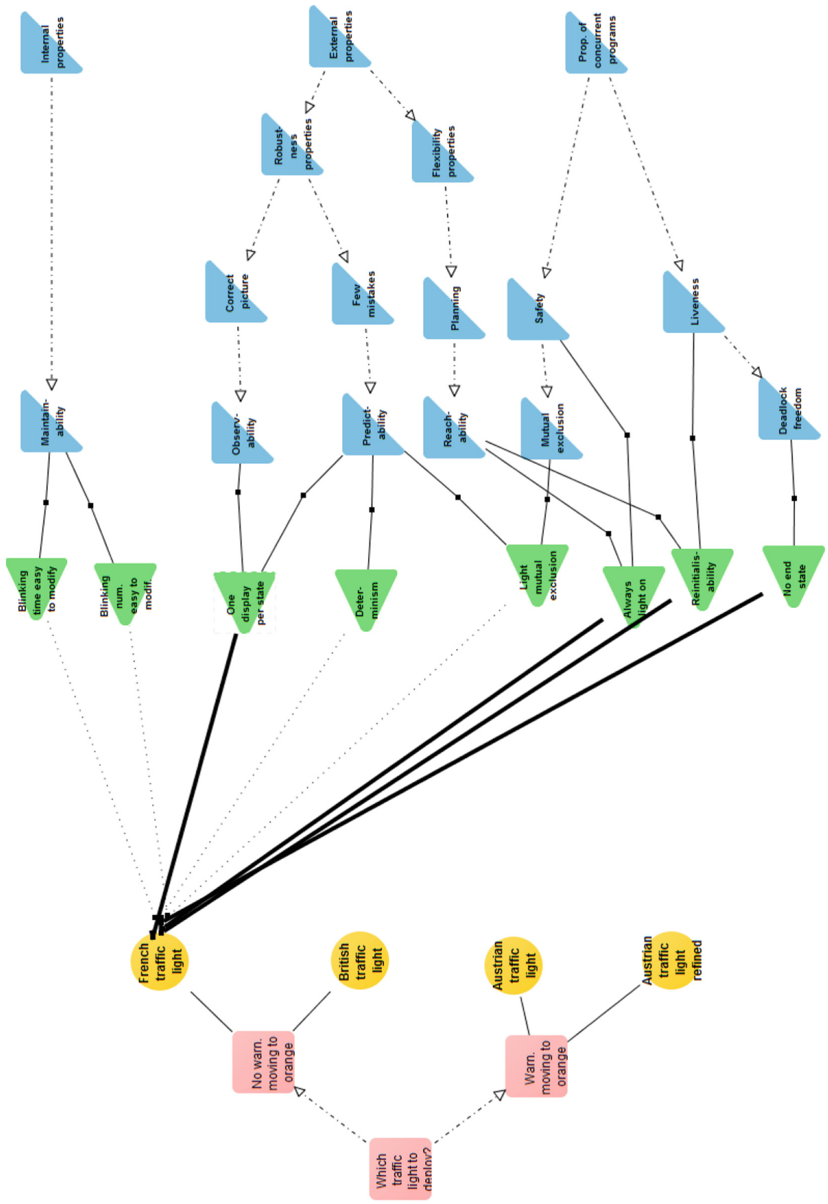


Fig. 11. DREAM diagram for the design options of the traffic light (focus on the relationships between first option and criteria) (Color figure online)

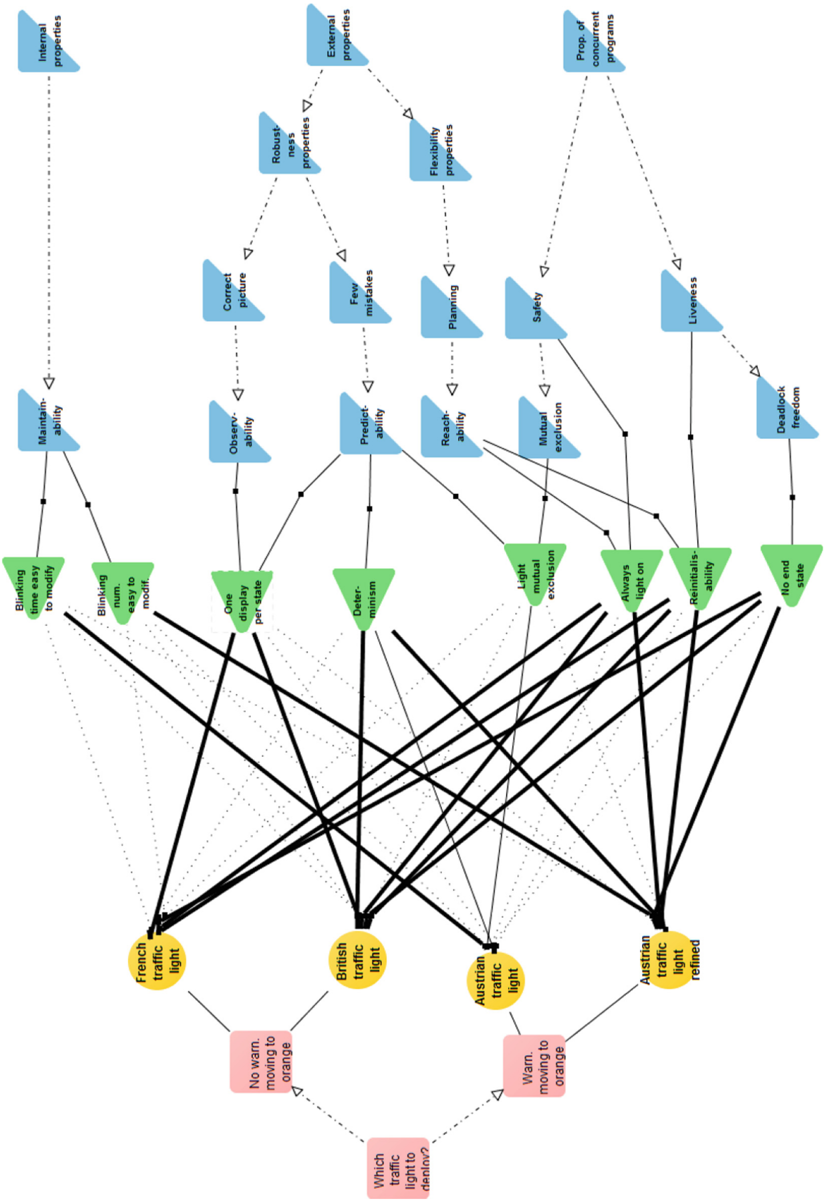


Fig. 12. DREAM diagram for the design options of the traffic light (Color figure online)

The concrete properties are (from top to bottom):

- Blinking time easy to modify
- Blinking number easy to modify
- One display per state
- Determinism
- Light mutual exclusion
- Always at least one light on
- Reinitializability
- No end state

As the French traffic light has no green blinking state, it is not easy to modify the number of blinking nor the speed of blinking. This is why the relationship between the behavior of the French traffic light and these properties is a dashed line (meaning that the property is not true with this model). These dashed and bold lines were previously used in QOC [9] to represent the fact that a given option (orange circle) favors a given criteria.

The property "One display per state" is true (bold line) as or each state in the model; there is either a switching light on or a switching light off when entering the state.

4.4 Description of Properties for the Entire Case Study

Figure 12 presents a summary of the properties that are true or false for the four behavioral model of traffic light presented above. It is interesting to note that the Austrian traffic light holds more properties than the other ones. This is because this traffic light has more perceivable states (with different lights on and off) than the other ones and to the fact that the first two properties are only meaningful for Austrian traffic lights.

Accessibility is another property that can be related to the case study. Indeed, the fact that the lights are located on 3 different locations (top, middle and bottom) it allows color-blind people to understand the current status of the traffic light. Another design with 3 lights (of different colors) in the same slot would result in a traffic light with accessibility problems.

5 Discussions and Conclusion

This paper has presented a notation allows representing the hierarchical relationship between properties for computing systems in general but also adapted for interactive systems. This notation has been applied to exiting classifications of properties available in the literature of these domains.

We have used a set of behavioral models from a simple case study to connect an application to this hierarchy of properties. The notation can thus be used for comparing design alternatives as this has been demonstrated on the alternative traffic lights that are deployed in real life.

Understanding and managing conflicting properties in systems design and analysis is not only addressed in computer science, even though security and usability aspects are getting more and more attention [25]. Indeed, in natural sciences evolutionary models require multiple properties to be embedded in living organisms [23]. QBP could thus be used beyond Computer Science to express such relationships between properties.

Further work will be devoted to a deeper understanding and representation of the various types of relationships that could connect two properties. For instance, the notion of inclusion could be represented as well as other more complex ones such as composition or inheritance.

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Reflections on System Properties Valued by End Users in Designing End-User Development Systems

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Abstract. Over the years, interaction design has become increasingly complex due to the evolution of end users of interactive systems. Approaches such as user-centered design (UCD), which proved effective in the creation of usable interactive systems, have to deal with this evolution. As HCI researchers working at the design of interactive systems in several and various application domains, we are experiencing the effects of this evolution, in particular when we have to weigh up every usability aspect depending on the specific context or the target end users. In this position paper, we report our experience from the perspective of designing End-User Development (EUD) systems, i.e., software artifacts that can be modified, extended, or even created by non-professional software developers.

Keywords: User-centred design · Competing UI properties

1 Introduction

Exponential technological advances push end users to evolve from having traditional roles as passive information consumers to more active ones. Users are increasingly willing to shape the systems they use to adapt them to their needs, tasks and habits, by manipulating and tailoring software artifacts and create new configurations or new designs. Accordingly, the goal of human–computer interaction (HCI) has been evolving from just making systems easy to use (even though that goal has not yet been completely achieved) to building frameworks that can lead to systems easy to create. This challenge is addressed by the End-User Development (EUD), an emerging paradigm that aims to empower end users to let them develop and adapt systems by themselves. A widely accepted definition of EUD is provided by Lieberman et al.: "A set of methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create, modify, or extend a software artifact" [1].

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Enabling EUD entails providing end users, who in most cases are not technologically skilled, with appropriate environments and tools that allow them to contribute to the design, development and evolution overtime of software artifacts. Tasks that are traditionally performed by professional software developers are thus transferred to end users, who become co-designers of the tools and products they will use. This does not imply transferring the responsibility of good system design to them. It actually makes the work of professional developers even more difficult, since end users have to be supported in their new roles as designers and developers.

Building systems that permit EUD activities requires a shift in the design paradigm, which must move from user-centered and participatory design to meta-design, characterized by two main phases [2, 3]. The first phase consists of creating the design environments that allow system stakeholders to participate in the design (meta-design phase). The second phase consists of the design of the final applications, carried out by the joint work of the various stakeholders, who collaborate through their design environments (design phase).

According to the meta-design paradigm, all system stakeholders, including end users, are active members of the design team. The professional developers involved in the traditional design are the team of meta-designers, who create software environments through which the other stakeholders, acting as designers, can be creative and can adapt the software to fit their specific needs. They can create and modify elements (objects, functions, user interface widgets, etc.) of the system of interest, and exchange the results of their activities to converge to a common design.

Since 2004, the researchers at the Interaction, Visualization, Usability and UX (IVU) Lab have worked on theories, methodologies, models and tools to foster the adoption of EUD systems by non-technical end users in real and various contexts such as e-health, e-commerce, serious games, and cultural heritage (see [4] for a short description of these tools). Later, starting 2012, they have been collaborating on these topics with researchers of the Politecnico di Milano, in particular on the development of EUD platforms for web mashup [5] and smart objects configuration [6]. In the following of this paper, we describe our experience in designing an Electronic Patient Record (EPR) EUD systems in the e-Health domain and a web mashup platform that has been customized to the Cultural Heritage (CH) and the Technology Enhanced Learning (TEL) domains.

2 The Electronic Patient Record Case Study

The first case study refers to the medical domain. The authors collaborated with the physicians of the “Giovanni XXIII” Children Hospital of Bari, in Southern Italy, to develop some applications to support their work. In some meetings, the advantages of an Electronic Patient Record (EPR) for managing data about patient history were discussed. They clearly remarked the difficulties of accepting one of the many proposals of EPR, because they impose to practitioners predefined document templates and masks. Physicians, nurses and other operators in the medical field are reluctant to accept such unified templates; as various authors also observed [7–9], they want to customize and adapt the EPR to their specific needs. Thus, the EPR is a natural target for EUD.

First, a contextual enquiry was carried out to study the domain, to identify and analyze the main system stakeholders, and to acquire the necessary knowledge to inform the model-based design. The following stakeholders for the EPR management were identified: (1) practice manager; (2) head physicians; (3) physicians; (4) nurses; (5) administrative staff, (6) patients. In particular, the head physician has the right and the responsibility to decide about the patient record adopted by physicians and nurses of his ward. The analysis of the work activities clearly showed that each ward personnel use their specific patient record.

Then, we created the meta-design team composed by software engineers, HCI experts and the practice manager, a domain-expert whose knowledge is necessary to design the EPR modules. The meta-design team created the software environments for the different stakeholders, as well as the data modules, which are the basic component of the EPR, and the application template to allow each head physician to design the EPR for her/his ward by directly manipulating data modules in her/his SSW. The main interface of the head physician's software environment is shown in Fig. 1.

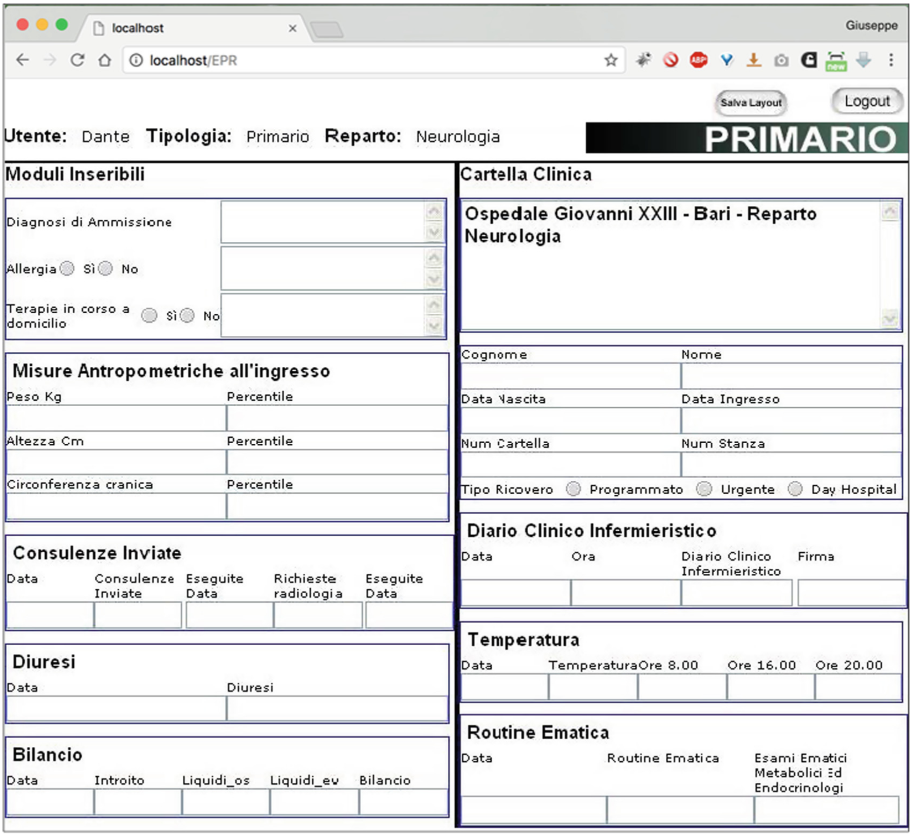

Fig. 1. Screenshot of the software environment used by the head physician for creating the EPR for the personnel in his ward by dragging the data modules from the left side to the right side

The feedback received from the involved end users was positive and encouraging. The domain experts appreciated very much the meta-design approach, which allowed them to contribute to the design of the final applications. The head physicians the authors worked with at the hospital were never satisfied of the various proposal of EPR they had examined, which forced the adoption of a format not adequate to the needs of their wards; thus, they liked a lot the opportunity to eventually shape the EPR tailored to their wards. Another positive remark of the domain experts was that they felt to be actually aided in their designer role both by the appropriateness of the tools available in their design environment.

3 Web Mashup Platform Case Studies

Web mashup platforms accommodate very well EUD, as they allow end users to create new applications by integrating functions and content exposed by remote services and Web APIs [10]. We performed two field studies in different application domains, as reported in details in [11]. One study was carried out in the context of visits to archaeological parks. Two professional guides composed a mashup application for retrieving content relative to an archaeological park using a desktop application, accessible through a PC placed in their office (Fig. 2a). They associated media contents, such as photos, videos, and wiki pages with park locations to be visited during the guided tour, by searching for them on public API sources. Later, during a guided visit of the archaeological park, two guides used the mashup application to show the content to visitors by using a large interactive display when introducing the visit (Fig. 2b) and a tablet device during the tour in the park (Fig. 2c). Content was represented by a pin on a Google map centered on the park. By tapping on an icon, a pop-up window visualized the corresponding media.

Another field study, performed in a context of Technology-Enhanced Learning (TEL), allowed us to analyze the use of the platform in a situation where students learn about a topic presented in class by their teacher, complementing the teacher's lecture by searching information on the Web (see Fig. 3). The retrieved information can also be communicated and shared with the teacher and the other students using interactive whiteboards, desktop PCs and personal devices (e.g., laptop, tablet and smartphone).

Both the studies demonstrated that the platform is sufficiently easy to use and users felt quite supported in accomplishing their tasks. Most participants appreciated the value of the platform in enabling easy and effective integration of content retrieved on the fly from online APIs. Low response time of the platform was indicated as a negative aspect, but this was due to the very poor technology infrastructure available both at the archaeological park and at the school lab.

Participants highlighted the lack of collaboration tools, such as chats or forums. Other remarks also concerned distributed collaborative creation of components and functions to annotate services, widgets, and information items.

The studies also revealed new requirements that mashup platforms should feature to foster their adoption in real contexts. The users expressed the need to "manipulate" data

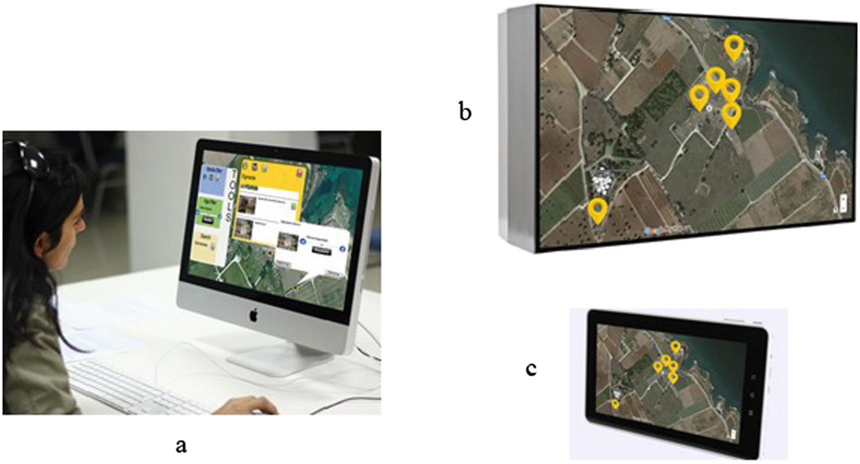

Fig. 2. A professional guide interacts with the mashup platform visualized on a PC for retrieving and organizing content on a map (a), which is later shown on a large interactive display (b) or a tablet (c)

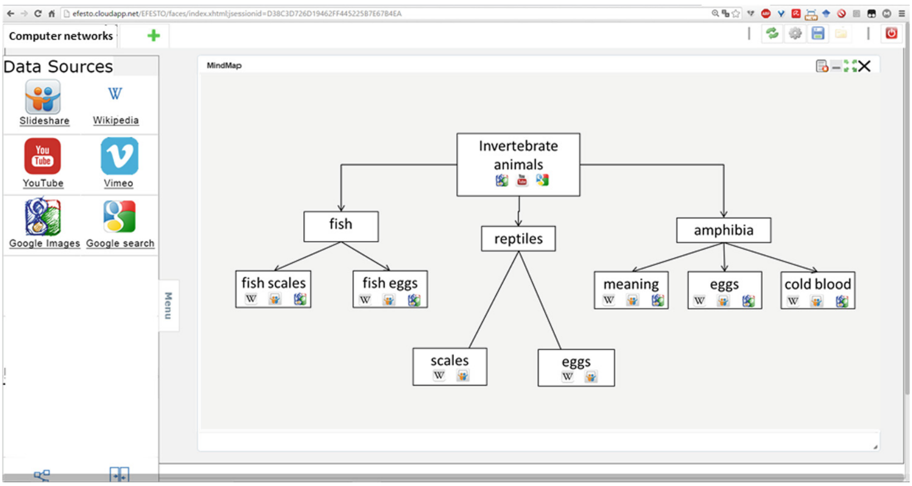

Fig. 3. A workspace on *Invertebrates animals*, organized as a mind map, created by the teacher using a desktop PC and later integrated by the students with further content as part of their homework.

extracted from services. They highlighted that through the platform they could not perform much more than visualizing data, modifying visualizations, and inspecting data details. They would instead appreciate functions to make the displayed information *actionable*, i.e., suitable for being manipulated according to their task goals [12]. For example, in the content retrieval task, beyond composing services and choosing how to visualize retrieved content, participants also wanted to perform ordering, filtering, or selecting a specific part of a content item, possibly annotating the selected parts with comments. Another important requirement that emerged is related to the information retrieval power of the mashup platforms: users reported that, in order to satisfy complex information needs, data should be gathered from the entire Web - not only from web service APIs.

4 Discussion and Conclusion

EUD has started the trend toward a more active involvement of end users in the overall software design, development, and evolution processes, to allow them becoming co-designers of the tools and products they will use. The studies showed that the users of EUD tools are focused on aspects related to the effectiveness in supporting the tasks they are performing and the customizability of the system in respect to the their tasks. Therefore, other system properties come into play. One is the system flexibility, an ingredient that can be favored by the identification of elementary components that can then be assembled together to give life to brand new interactive systems. In this case, the focus on usability is more related to the composition paradigm offered to the end users than to the final interactive applications the end users build by themselves.

In the specific context of the mashup platform, in which the overarching goal was information retrieval, end users also considered important other factors such as quality, completeness and trust of the retrieved data [13], as well as peer communication, sharing and annotating features. Nobody considered other attributes related to aesthetic, graphic aspect, security, privacy. The results of previous evaluations of EUD tools, applied in different application domains and based on various technologies (e.g., electronic patient records, e-commerce websites, cultural heritage authoring tools), also confirm that end users consider important the capability of their own tools to support them in hitting their goal.

This analysis suggests that in this new process the responsibility of good system design cannot be transferred to end users, who have to be assisted by other ICT professional stakeholders in this new role of designers and developers. This actually makes the work of professional developers even more difficult, since: (a) it is still their responsibility to ensure the quality of the software artifacts created by end users [14], and (b) they have to create proper tools that support end users in this new role. In order to address these issues, our methodology for designing EUD systems is based on a meta-design model. Differently than in traditional design, professional developers do not directly create a final application, but they build software environments thorough which non-technical end users, acting as co-designers, are enabled to shape up the application they are going to use.

Another issue, which emerged in the field studies that we have conducted to validate our tools, is that some problems occur when the proposed EUD systems are too “general”, claiming that one single design might satisfy the requirements of many domains. We therefore proposed domain customization as a solution to make meta-design still more effective in creating platforms that really fit the end-user needs [15]. For example, in the case of the mashup platform experiences, customization occurs by selecting and registering into the platform services and data sources (public or private) that, for any different domain, can provide content able to fulfill specific users' information needs. Service registration is kept as simple as possible, so that even non-technical users can possibly add new services if needed.

Our current research is focused on designing EUD systems for the configuration of smart objects by non-technical users [16]. As future work in the direction of investigating which system properties are valued by EUD-system users, we will exploit this new application domain to address issues such as how our meta-design and customization approach can be possibly modified in order to manage competing properties. In particular, we want to revise the role of the HCI expert, already included in the meta-design team, so that he/she can be empowered in providing guidance and feedback to end users when they act as designers.

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Similarity as a Design Driver for User Interfaces of Dependable Critical Systems

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Abstract. Assuring that operators will be able to perform their activities even though the interactive system exhibits failures is one of the main issues to address when designing and implementing interactive systems in safety critical contexts. The zero-defect approaches (usually based on formal methods) aim at guaranteeing that the interactive system will be defect free. While this has been proven a good mean for detecting and removing faults and bugs at development time, natural faults (such as bit-flips due to radiations) are beyond their reach. One of the way to tackle this kind of issue is to propose redundant user interfaces offering multiple ways for the user to perform operations. When one of the interaction mean is failing, the operator can select another functional one. However, to avoid errors and increase learnability, it is important to ensure that the various user interfaces are "similar" at presentation and interaction levels. This paper investigates this relation between dependability and similarity for fault-tolerant interactive systems.

Keywords: UI properties · Similarity · Dependability · Usability Learnability

1 Introduction

Usability [9] and user experience [7] properties have received (and are still receiving) a lot of attention in the area of Human-Computer Interaction to the extent that they are perceived as the main properties to study and consider while designing interactive systems or while performing research activities in HCI.

Beyond this main stream of research and design, other more marginal approaches have tried to investigate the relationship between these properties and other ones such as security [18], accessibility [16, 19], dependability [3] or privacy [6] (among many others).

Each of these specific domains bring specific issues in order to ensure that the associated properties have been taken into account. Taking into account these properties usually requires identifying and managing trade-off i.e. favoring one property above the other. For instance, adding an undo function to an interactive system will improve usability by make it more efficient for users to recover from errors. However, adding undo functionality to a system increases significantly the number of lines of code and thus the likelihood of bugs. This paper focuses on dependability related issues

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and how dealing with them might bring additional concerns for the design of user interfaces and their associated interaction techniques. However, despite this specific focus on one property, similar constraints would apply to other conflicting properties.

Assuring that operators will be able to perform their activities even though the interactive system exhibits failures is one of the main issues to address when designing and implementing interactive systems in safety critical contexts. Exploiting methods, techniques and tools from the dependable computing field [10] can ensure this even though they have not been designed and developed to meet the challenges of interactive systems [4]. Such approaches can be dived into two main categories:

- **The zero-defect approaches** (usually based on formal methods [21]) that aim at guaranteeing that the interactive system will be defect free. While this has been proven a good mean for detecting and removing faults and bugs at development time, natural faults (such as bit-flips due to radiations) are beyond their reach.
- **The fault-tolerant approaches** that promote the use of **redundancy** (multiple versions of the system), **diversity** (the various versions are developed using different means, technologies and providers) and **segregation** (the various versions are integrated in the operational environment by independent means e.g. executed on different computers, using different communication means, …). Segregation ensures that a fault in one of the versions will not induce a fault in another version – usually called common point of failure.

One of the way to apply dependability principles to the user interface of the interactive system is to propose redundant user interfaces offering multiple ways for the user to perform operations. This can be displaying the same information on different screens or offering multiple input devices for triggering the same action. This can also be performed at the interaction technique level as presented in [15] where mouse failures were mitigated by the use of "similar" configurations based on use of multiples keys on the keyboard. However, to avoid user errors (such as capture errors [17]) and increase **learnability**, it is important to ensure that the various user interfaces are "similar" at presentation and interaction levels. This concept of **similarity** has already been used in the field of web engineering [8] but only with a focus of designing new web systems being consistent with legacy non-web systems.

This paper refines the concept of similarity and shows how this concept is relevant at different levels of the architecture of interactive systems. The paper then presents a set of examples from the avionics domain where dependability is a major concern and where development of fault-tolerant mechanisms is a requirement from standardization authorities such as DO 178C standard [1]. These examples present how similarity has been driving the design of multiple user interfaces even though they are as different as hardware only (interaction taking place through knobs and dials) and software mainly using WIMP interaction techniques. Conclusions and discussions for the workshop are presented in the last section.

2 Conflicts and Congruence Between Similarity, Diversity and Redundancy in the Area of Interactive Systems

In order to increase resilience to failures, fault-tolerance (i.e. guaranteeing the continuity of service), requires **duplicated user interfaces** for the command and control of a single system. This ends up with **redundant user interfaces** serving the same purpose. If those interfaces are built using the same processes and offer the same interaction techniques, it is possible that a single fault could trigger failures in both user interfaces. This could be the case for instance when using the idea of cloning the UI as proposed by [20]. In order to avoid such common points of failure the redundant user interfaces must ensure **diversity**. Diversity can be guaranteed if the user interfaces have been developed using diverse means such as different programming languages, different notations for describing their specification, executed on top of different operating systems, exploiting different output and input devices, … Such diversity is only efficient if the command and control system offers confinement mechanisms avoiding cascading faults i.e. the failure of one user interface triggering a failure in the duplicated one.

Such fault tolerant basic principles raise **conflicting** design issues when applied to user interfaces. Indeed, diversity requires the user interfaces to be very different in terms of structure, content and in terms of interaction techniques they offer, even though they must guarantee that they support the same tasks and the same goals of the operators [5]. Another aspect is that they must be located in different places in the system i.e. distributed as this is one of the most efficient way of ensuring confinement of faults.

In that context, distribution of user interface does not concern the presentation of complementary information in different contexts (as presented in [12]) but the presentation of redundant information in those contexts.

In terms of design, it is important to be able to assess that the various user interfaces make it possible for the operators to reach their goals (this would be called similarity in terms of **effectiveness**). Beyond that, it is also important to be able to assess the relative complexity and diversity of these interfaces in order to be sure that operations will not be drastically degraded when a redundant user interface has to be used after a failure has occurred on another one. Studying the effective **similarity** (in terms of **efficiency**) at the level of input and output is thus required even though different type of displays and different types of input devices have to be used. This goes beyond the study of similarity at effectiveness level, but both contribute to the usability of the systems. It is important to note that all the other properties mentioned previously are intrinsic or extrinsic properties of a given interactive system. Similarity is very special as it only has a meaning when two interactive systems are considered (or two different versions of a same interactive system). Such relative properties are usually less studied than absolute properties as the focus of interest is usually to favour a given property of a given system.

3 Examples from the Avionics Domain

The case study presents (in the area of aircraft cockpits) examples of redundant user interfaces. More precisely, we present in the context of the cockpit of the A380 (see Fig. 1) aircraft. In this new generation of large civil aircrafts, the cockpit presents display units (that can be considered here as computers screens) of which some of them are offering interaction via a mouse and a keyboard by means of an integrated input device called KCCU (Keyboard Cursor Control Unit). Applications are allocated to the various display unit (DU).

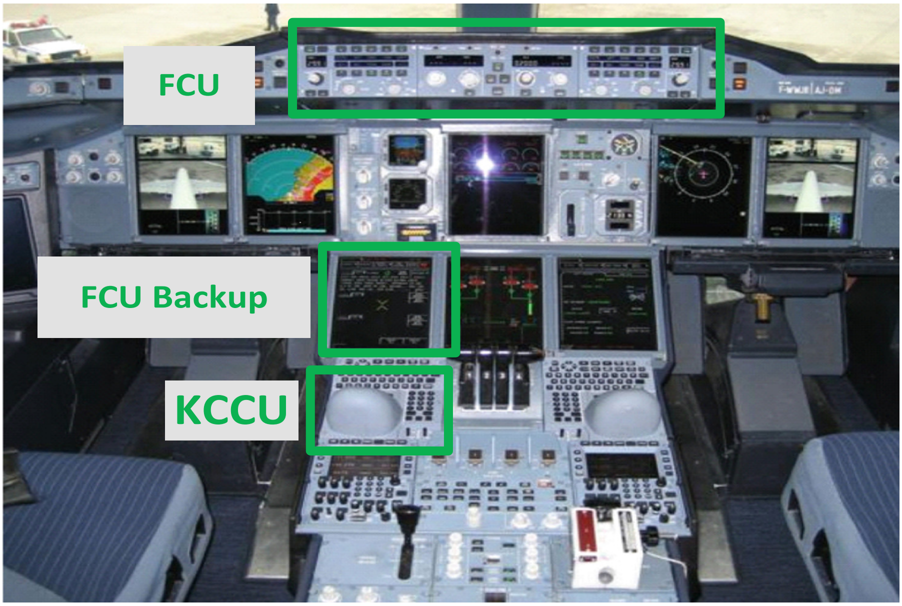

Fig. 1. Two possible means to control flight heading within the A380 interactive cockpit, one using the FCU and the other using the FCU Software application and the KCCU

In the A380, two redundant ways of using the autopilot are offered to the pilot in order to change the heading of the aircraft. One is performed using the electronic user interface of the Flight Control Unit (FCU on top of Fig. 1) while the other one exploits the graphical user interface of the Flight Control Unit Backup interface and the KCCU (bottom of Fig. 1).

3.1 Example One: Entering a New Value for Heading

Figure 2 presents a zoomed view on the two means for entering a new heading of the aircraft. On the left-hand side of the figure, the editing of the heading is performed using a physical knob, which may be turned to set a heading value (this value ranges from 0 to 360). The selected value can be sent to the autopilot (called "engaged") by pressing the physical LOC push button below the knob. On the right-hand side, the heading is set using the keyboard of the KCCU and engaged by using the KCCU and its manipulator to click on the dedicated software LOC push button.

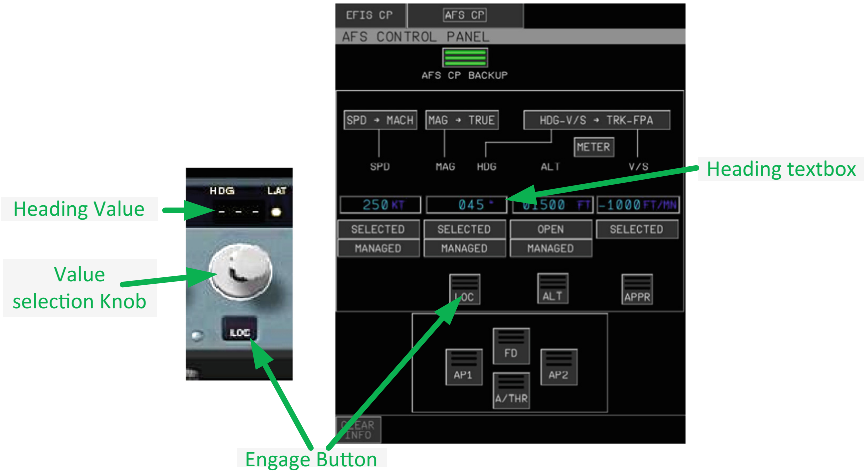

Fig. 2. Heading selection.

At a high level of abstraction (i.e. not taking into account the input and output devices), the task of setting a new value for the heading is the same on both user interfaces (they are similar at the effectiveness level). If described at a lower level, the description of these two tasks would be different, as they would require different physical movements from the pilots (they are thus not similar at the effectiveness level as for instance, the pilot would have to execute the FCUS application while the hardware FCU is directly reachable). It is important to note that there are other additional means to perform the same task (for instance controlling directly the aircraft using the sidestick) that are not presented here.

3.2 Example Two: Entering a Set of Parameters for the Navigation Display

Figure 3 presents two different means to handle both barometer settings and parameters of the navigation display (ND – pilot ND is the second screen on the left in Fig. 1 while first officer ND is the second screen on the right). It illustrates how physical input devices (on the left-hand side of Fig. 3) have been transposed into software components (right-hand side of Fig. 3) handled using the KCCU (as in the FCUS presented in Fig. 2). The general layout of both interface is quite close to that one, but the translation into a software application leads to different design options:

- On the physical interface, the **two barometer settings** options (highlighted in yellow and on the bottom left part of both physical and software interfaces) are handled using two physical labelled push buttons (LS and VV) that are lighted on

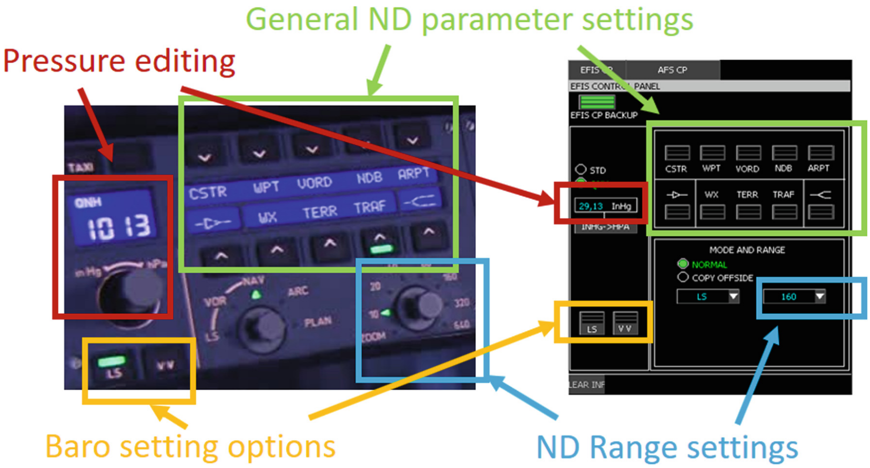

Fig. 3. Baro settings and Navigation Display configuration

with a single light when the option is selected. The transposition of these two buttons in the software user interface results is a set of two software buttons that may be highlighted by changing the color of three horizontal lines. In this case, the two design options are quite similar.

- The **General ND parameter settings** (highlighted in green and on the top right part of both physical and software interfaces) are physically handled using physical push buttons without labels associated to labels displayed on a dedicated screen. These buttons behave in the same way as the two previous buttons. The software transposition is similar to the previous one, using both software push buttons and labels, and following the same layout constraints (relative position and size) as the physical interface.
- The **Pressure editing** (highlighted in red and located on the left-hand side of both physical and software interfaces) consists in the editing of a numeric value. The physical and software representations of this function follow two distinct design option. With the physical interface, this value is modified using a physical knob and the edited value is displayed on a dedicated screen while on the software transposition, this editing is performed using a classical text field that embed both editing and display of the value. It is thus possible on the software UI to use the arrow keys to navigate into the text box and modify one specific digit of the pressure, which is not feasible on the hardware UI.
- The **ND range setting** (highlighted in blue and on the bottom right part of both physical and software interfaces) is performed by selecting a range amongst a finite set of predefined values. In this case, the two design options are quite different too. On the physical interface, the task is performed using a knob that can rotate between the set of values, these values being physically written around the knob (making it visible at any time). The software translation of this interface is made up using a drop down combo box that embed both the display and selection of the value. In this case, the selectable values are only displayed while using the software component.

3.3 Example One: Visualization of Aircraft Pitch and Roll

Figure 4 presents two different design of the gyroscope instrument that aims at providing the pilot with information about the position of the aircraft relatively to the horizon (both pitch and roll). At the bottom right-hand side of Fig. 4 the cockpit presents the physical analog display of these values. This device is also called the artificial horizon as the information it displays is similar to the view the pilots have when they look outside through the windshield. The software transposition of this instrument (on the left-hand side of Fig. 4 – called Primary Flight Display) embeds several other functions such as an altimeter or a speed controller. The graphical layout of the software UI is clearly inspired by the physical one which was, in the early days of aviation only a physical ball emerged in a container filled with liquid.

Fig. 4. Physical and software representation of the aircraft gyroscope.

4 Research Directions

While the examples above focus on the presentation and interaction aspects of interactive systems, we are investigating other means to support similarity analysis and assessment also at user level:

- Investigating means of describing past experiences and practice of users to understand the level of familiarity a user may have with a given interaction
- Investigating means of describing tasks (including knowledge, information and objects used to perform the tasks) such as with the HAMSTERS tool [14] to assess similarity of tasks and goals
- Investigating means of describing users' errors (including causes called genotypes and manifestation called phenotypes) in order to identify potential unexpected types of errors that could occur see [2].

In the area of aviation, the design driver for cockpit has been on targeting at similarity of command and displays even though this is not clearly stated. Indeed, looking at training, most airlines propose Cross Crew Qualification programs for pilots [11]. As training is mainly based on tasks execution [13] such a goals and task-based approach is critical and is the only way of designing and evaluating training programs evolutions.

5 Discussions and Conclusion

This paper has presented the similarity property for interactive systems offering redundant ways for the users to enter and perceive information. In order to ensure diversity and segregation (that are required for building dependable interactive systems) the similarity property may be violated. We have shown on the first example that the hardware and the software user interface are similar at the effectiveness level but distinct at interaction level. The following examples have shown bigger gaps in terms of similarity as the use of computing systems and graphical interfaces provides designers and developers with more advanced communication and interaction means. Digital devices are thus more informative and more efficient than the hardware ones. However, they are also less reliable than hardware systems and must not be used if failures are detected [3]. This means that the design and the evaluation of the training program is a complex and expensive activity requiring tools and technique to assess (and explain to trainees) gaps in similarity.

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Value Creation and Delivery in Agile Software Development: Overcoming Stakeholder Conflicts

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Abstract. Agile software development aims at early and continuous value delivery. Yet the concept of value in agile development is underdefined and the meaning can be different for different stakeholders. Successful value delivery requires continuous collaboration with relevant stakeholders which is a main challenge in agile development. In fact, most software project failures are caused by poor communication and misunderstandings between stakeholders. This position paper discusses the meaning of value for business owners, customers, users, software developers, and user experience specialists and works towards an understanding on how to align and articulate value and its delivery in a software project.

Keywords: Software design tradeoffs · Agile software development
Collaboration in software development · Value creation
Requirements engineering

1 Introduction

Value creation is a continuous process throughout the development life cycle in agile software development and it can be described as follows. User or stakeholder needs are frequently written in the user story format: "*as a <role> , I want <a goal> so that <benefit /value>*" which captures both the requirement and its value. To create user stories the development team needs first to identify the relevant stakeholder roles, dig out what those roles value and what kind of value proposition would then help the team in trying to make the role happier or solve their problem. Then the team needs to chunk down those values and needs to the size and format of a user story. Finally, as the last step before implementation, the created stories are to be ordered based on their business value which might or might not be in line with the original stakeholder value. After this the team implements the user story into working software and gets feedback from the stakeholders for improvement. The development team then grooms and reorders the stories after each implementation increment when they have learned more about the stakeholders and their needs. The process is repeated until the customer is satisfied or the project otherwise comes to an end.

The described process is not straightforward and there are no established guidelines or tools to support stakeholder value identification and prioritization. In fact, it often

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remains unspoken in teams what value means in the project context [3]. Business value frequently represents only the most important customers' point of view and it can differ from the user value [19]. In addition to business value, the required developer effort (cost of implementation) has an impact on the order of the user stories. Thus, from the beginning of the project, there are at least four competing forces – the voice of the business owner, customer, user and developer - which might all base on conflicting values.

There are no established means to balance between these values although several approaches have been presented. Decisions are habitually made based on the business owners', product owners' or customers' gut feeling. On the other hand, as the process is iterative and incremental, decisions can and should be made as late as possible with the then understanding throughout the software lifecycle and improved later when further information is available. Nevertheless, the concept of value remains often vague as the project proceeds and a shared idea of value between different stakeholders is rarely formed [3].

Thus, in a software project, several people can work together towards undefined value goal which each of them might understand in their own way from their own perspective. The big picture of the project then becomes blurred from the beginning and does not improve towards the end either [22]. Moreover, working with different stakeholders means working with people from various disciplines and backgrounds, which inherently makes communication more difficult as the used concepts and foci are different.

This position paper discusses the values and needs of different stakeholder roles and the assumptions these roles habitually have on other roles. Furthermore, it discusses how to overcome value conflicts to develop highly valuable software. Section 2 discusses the concept of value in software engineering. Section 3 presents the five focal roles (business owner, customer, developer user, and UX specialist) and their needs and values. Finally, Sect. 4 presents conclusions over this emerging work.

2 Value in Agile Software Engineering

This section discusses the concept of value in agile software engineering literature.

Graeber [6] defines value from three perspectives; in *sociological, economic* and *linguistic* sense as the conception of what is *ultimately good in human life*, as a *person's willingness to pay a price* for certain product or service benefits and as a *meaningful difference*. The three perspectives are relevant to software development as well. Software engineering aims at enabling the creation of complex computer-based systems which will meet the needs of users in a timely manner with quality [24]. Thus, a software system is both "*the programs, documents, and data*" created during the development and "*the resultant information that somehow makes the user's world better*" [24]. In general, software developers traditionally have their focus on the programs, documents and data whereas user experience specialists focus on ensuring that the resultant information will make the user's world better. Thus, user experience specialists' task is to understand the sociological side of value whereas the business owner brings in the economic perspective. As the software project proceeds, each software increment should bring in a meaningful difference (growth) in value.

The approach where distinct business and user experience specialists bring social and economic value to the project works in traditional development where developers implement predefined requirements. However, developers are in a central role in agile and the development team should be able to make decisions that foster business, customer and user value as well as technical quality and rapid development. Multidisciplinarity and cross-functional teams help in rapid decision-making on issues related to different value types [14]. The developer must learn from other disciplines to think about economic and societal value and the other internal roles should understand something about the technical side to make the work effortless and improve the communication [13, 14]. Also, it is beneficial for the customer to understand about the economic, technical and user side of the software project to be able to make informed decisions about the scope of the project, where to have users involved and so forth [19].

In software engineering, value is frequently understood as usefulness, utility, and importance or as the relative worth or monetary worth of something [3]. These types of value often necessitate that external stakeholders outside the development team (customer, user etc.) assign the value. Thus, the team must learn what the external stakeholders such as customers and users value during a development project. However, estimating, calculating, and measuring business value of software delivery is abstruse [25]. Software is ubiquitous and increasing in size and complexity. For these reasons, software development decisions have a crucial impact on the value delivery and better ways to address the value proposition are needed.

3 Stakeholder Views on Value

This section presents value from different stakeholder perspectives. The views mostly reflect on our own previous research but are also built on other literature. The roles are according to business to business development where a company orders software from another company typically for its own internal users who will use the software in their work.

Business or product owner is the person in the company developing the software whose main role is to ensure the economic revenue for the developing company but also to guarantee the customer satisfaction. Business or product owner's view is on the business and monetary value of the project for the developing company; how to maximize the return on investment for the shareholders. The secondary goal is to keep the customer happy and to build the relationship with the customer. Thus, the product owner might, for example, drive the development of features that they know are not useful for the user but which the customer wants for some reason [17, 19]. Sure, some business owners might want to explain why such a feature would be a bad idea and suggest a more feasible solution for example, to improve the long-term customer relationship and trust between the partners. For business owner, it is good to keep in mind that customer and user values are distinct. Customer does not necessarily know what the user values although they might say so [16, 17, 19]. Moreover, assessing the impact of a business decision on user experience can be beneficial in cases where user value differs from customer value [17].

Customer is a person from the purchasing company who often manages the requirements engineering and scoping of the project. Thus, a business customer values a solution for their problem. Typically, it includes a more efficient, robust, safer, faster, automated or cheaper approach compared to the current one. It can also be a novel approach or field for the customer. Software projects are typically mainly negotiated between the customer and the business or product owner roles. Customer usually selects the way of working in the project on a high level. They decide whether users are involved, whether the project is agile and so forth. It is crucial that the person who represents the customer has the required power of decision to enable fast and agile decision-making throughout the project. It is also critical that the customer understands the importance of user involvement and does not think they can decide for the user only because they understand the business process behind the software being purchased [19].

Software developer designs and implements the software. They value the work itself [2, 4]. Their goal typically is to build working, technically sophisticated software. Many developers are motivated by the thought that someone will use the software and that they are helping other people whereas others are mainly driven by being able to solve challenging technical problems [21]. Feeling good about the work, being in control of the development tasks, sense of competence, and being able to work with the development environment without effort are associated with developers' motivation and good developer experience [15, 18]. A pitfall for a developer is to love too much the technical side of the software and forget about the user or vice versa [17].

User is the person who interacts with the system [11]. Hassenzahl [8] sees user as a person with multiple hierarchical goals they are to achieve by interacting with a system. Users have instrumental goals, so called "*do-goals*", such as making a phone call. These instrumental goals can be satisfied with traditional usability properties such as ease of use, efficiency and usefulness. Hedonic goals or "*be-goals*" on the other hand are supported by systems hedonic quality, the perceived ability to self-expression, competency, autonomy, stimulation, relatedness and popularity. In professional life, the system's ability to motivate and create sense of professionalism are indicators of hedonic quality [20].

User experience specialist is responsible for the social value of the software under development. Their main goal is to satisfy users' needs and design for good user experience. UX specialist is typically the one who ensures that users' voice is heard from the beginning and throughout the project. UX specialist diffuses the user value from what the user is saying or showing. UX specialist is especially responsible of the hedonic quality of the software since the users cannot express that by themselves. Moreover, understanding and designing for the hedonic value is difficult without deep understanding of UX [20]. Thus, the other stakeholder roles are usually not able to do it although they can successfully learn many other UX tasks [13, 14, 20].

4 Overcoming Value Clashes

This section discusses practices found in literature that can help the agile team to identify and create value in a software project.

Business value is characteristically ambiguous and it is difficult to define it accurately in an agile software project [25]. Supporting social interactions between stakeholders [1] and having value workshops [23] can make it easier to identify value and form a mutual understanding of it. Even a short workshop between the business owner and users before writing user stories can help to clarify the project focus and lead to better economic and user value [16]. Also, different stakeholder roles can be identified and participated into thinking of what value means for that role. These role-biased values are then discussed together for example in a value workshop to create a mutual understanding of the overall business value before starting the actual development. The mutual understanding can then be groomed later as required.

A software value map [12] can broaden the thinking of value. It presents various value perspectives such as those of customer, financial, internal business learning and innovation. Customer value consists of perceived value including usability, reliability, delivery time and cost and lifetime value including customer revenue and different sources of cost.

Value points [9] or benefit points [7] can be used to concretize and order identified sources of value. They are used similarly to agile story points. Whereas story points measure the required implementation effort of a user story, value points or benefit points measure its value. For example, numbers 1, 2, 4, 8, 16 or Fibonacci series can be used to evaluate the value. The scale and scoring is arbitrary and subjective and the idea is not to create absolute value scores but to enable comparing between the importance of different sources of business value.

As value is not independent from cost, Gillain et al. [5] suggest that value should be assessed together with cost-estimates. The customer can consider one feature more valuable than another per se, but if there is a substantial difference in cost, they might change their opinion. One practical tool for assessing both value and cost is a scale that takes both value and cost points into account. This encourages to select between features instead of giving high value points to all of them.

Agile embraces change. The overall value can be unknown when the project starts and it can be challenging to conceptualize it. Therefore, revisiting and reordering the sources of value in increment reviews can be beneficial. Also, assessing the ability of the implemented software to generate expected value can make it easier to focus the project and in making estimations of the anticipated business value of the future increments. Continuous customer and user involvement helps in reassessing value as most of the business value ought to be assigned by external stakeholders [3].

5 Conclusion

This position paper presented views on value identification and creation in agile business to business software development. Early and continuous value delivery is a core function of agile software development. However, the value itself often remains undefined in agile projects and each stakeholder role might take it as given from their own perspective. That can lead to misunderstandings and make the project goals unclear. It can also lead to arbitrary decisions on product scope which may endanger the delivery of good user experience. This paper presented common pitfalls and thinking biases different stakeholder roles might fall into if they are not aware of those. Furthermore, this paper presented practices that can help in the identification and prioritization of value in agile software projects. Future work includes observing the value creation process in organizations to generate a sounder understanding of value sources and conflicts between them.

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Human Work Interaction Design meets International Development

Looking for "the Big Picture" on a Small Screen: A Note on Overview Support in Cooperative Work

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Abstract. Large, shared displays – such as electronic whiteboards – have proven successful in supporting actors in forming and maintaining an overview of tightly coupled cooperative activities. However, in many developing countries the technology of choice is mobile phones, which have neither a large nor a shared screen. It therefore appears relevant to ask: How may mobile devices with small screens support, or fail to support, actors in forming and maintaining an overview of their cooperative activities? This note contrasts the strengths of large, shared displays with those of small, mobile devices and briefly describes the mKrishi app for providing fishers in the Maharashtra state of India with an overview of the locations where there is likely to be many fish.

Keywords: Overview · Awareness · Cooperative work · Small-screen devices

1 Introduction

In tightly coupled collaboration, the actors coordinate their activities by monitoring what the others are doing and by displaying their own activities for others to monitor [1]. The ways in which this monitoring and displaying is accomplished vary across contexts, as evidenced by the considerable research on awareness [e.g., 2] and overview [e.g., 3]. Unless the actors are permanently co-located, awareness and overview must be mediated by technology. These technologies include large, shared displays, which are becoming increasingly common in settings where the actors are locally mobile but co-located part of the time. Hospitals are a prominent example of such work settings. In European and North American hospitals wall-mounted electronic whiteboards are replacing dry-erase whiteboards [4], and the clinicians who use these large, shared electronic displays experience an improved overview of their work [5]. In contrast, the technology of choice in many developing countries is mobile phones with comparatively small screens [6, 7]. Thus, in systems that target developing countries the need for supporting actors in maintaining an overview of their cooperative work will often have to be accomplished on a small screen.

Before proceeding it should be noted that it obviously is a simplification to associate display size with country. The argument is neither that large, shared displays such as electronic whiteboards are non-existent in developing countries, nor that small interfaces are rare in developed countries. Rather, the argument is that the ways in

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which large, shared displays support actors in maintaining an overview are irrelevant in settings characterized by small interfaces. To develop for these settings we need to understand how small interfaces may support, or fail to support, actors in maintaining an overview of their cooperative work. Clearly, this need is accentuated if the application of large, shared displays is not feasible, economically or otherwise.

2 Overview and Large, Shared Displays

Hertzum and Simonsen [8] find that in a collaborative setting with an electronic whiteboard the users adopted a strategy that could be described as: visual overview, oral detail. That is, they glanced at the whiteboard to get "the big picture" and augmented this visually acquired overview with asking their colleagues for clarification and detail. This finding can be seen as a cooperative-work extension of Shneiderman's [9] visual information-seeking mantra (overview first, zoom and filter, then details-on-demand). Specifically, the focus on cooperative work emphasizes that an overview is the users' awareness and understanding of the information relevant in the situation; it is not merely a property or component of a user interface [10]. The overview is a collaborative accomplishment in that the individual actors consult each other for information that elaborates and supplements the information they glean from the whiteboard. Apart from the obvious difference in screen real estate between a 52-inch. whiteboard and a 4-inch. smartphone the large, shared displays have at least three strengths that appear to be absent on small screens:

- *Artefactual multiplicity*. The whiteboard may hold different pieces of information that are relevant to different groups of users, and it may also interrelate these pieces of information, thereby facilitating the coordination among user groups [11]. The interrelating of the pieces of information is accomplished through their simultaneous presence on the display.
- *Social translucence*. Because the whiteboard is shared it makes the same information visible to all actors. The actors are, however, not simply made aware of information they are also held accountable: As an actor I know that everybody knows what information I can read on the whiteboard [12]. Thus, actors can rely on each other to glance regularly at the whiteboard and react on its content.
- *Information hotspots*. In addition to being an information display, the whiteboard also creates a physical place where actors meet [13]. They may visit the area around the whiteboard to interact with the whiteboard or to consult a colleague, who is there to interact with the whiteboard, consult a colleague or make herself available for consultation [14].

While the three strengths are described on the basis of studies of electronic whiteboards, it appears likely that the same strengths exist for wall-size displays, tabletop interfaces, and other large, shared displays. The affordances of small, mobile devices are different.

3 Overview and Small, Mobile Devices

On a mobile device the functionality of the applications is narrowly focused to fit the small screen. This narrow focus reduces the possibilities for artefactual multiplicity. In addition, the personal nature of the device reduces social translucence because it is less apparent to others what information I have available and when I have the opportunity to access it. Finally, the mobility of the device prevents it from functioning as a physical location for actors to meet. While it is tempting to presume that actors who collaborate using small, mobile devices need other means of achieving these three ends, it is also possible that they transmute artefactual multiplicity, social translucence, and information hotspots into alternative ways of gaining and maintaining an overview. Either way, it is important to human work interaction design to understand how the actors gain and maintain the overview they need to conduct their activities cooperatively and competently. Studies of the use of mobile phones in developing countries are beginning to address these issues, but tend to investigate loosely coupled activities. The studied activities include societal as well as local collaborations that exploit the widespread adoption of mobile phones:

- Nearly everybody has a mobile phone, thus making it possible to reach most people with information and include many people in cooperative activities. For example, multiple African initiatives use mobile phones as tools to disseminate and collect health information via text messages, to improve the transparency and accountability of elections by sending local observations about polls to central monitoring groups, and to promote reforestation by transferring payments to rural farmers for planting trees [7].
- The actors carry their mobile phones everywhere, attend to them repeatedly, and may, thereby, interact with each other when needed rather than when they happen to be in the same place at the same time. For example, geographically distributed herders of livestock in rural Kenyan communities use mobile phones to share information about the changing location of water resources for the livestock and of rangers likely to disrupt herding practices [15].
- Mobile phones can broadcast information about the whereabouts and activities of actors, thereby providing information for others to monitor. However, this possibility may primarily have been exploited in developed countries. For example, studies of collaborative web search have found that such activity information supports remotely located actors in aligning their search activities and progressing on a shared task [16].

The ways in which mobile devices may support actors in forming and maintaining an overview of their cooperative activities appear an important research area. Similarly, it is important to research the ways in which cooperative work arrangements may transmute what overview is about or what role technology plays in supporting it. This research should, in particular, attend to the conditions in developing countries, in which mobile phones are widespread whereas large-display technologies are not.

4 Example: Use of mKrishi App by Alibaug Fishers

In coastal Indian villages fishing provides jobs and income for nearly a million fishers and even more people in the processing and marketing of the landed fish. To support the fishers in the Maharashtra state an app for mobile phones has been developed in a decade-long collaboration between Tata Consultancy Services (TCS), Central Marine Fisheries Research Institute (CMFRI), Indian National Center for Ocean Information Services (INCOIS), Indian Council of Agricultural Research (ICAR), and local fishery societies. Maharashtra has a coastline from Mumbai in the north and 720 km southward. One of the fishery villages along the coastline is Alibaug (Fig. 1), which we visited in September 2017.

Fig. 1. Fisheries landing center in Alibaug village. Photos by the author.

The app, mKrishi, is freely available to the fishers. Its main feature is a map indicating the locations at which the concentration of fish is predicted to be high at the moment. The predictions are derived from satellite data about the thermal fronts in the water and the water color. For example, the water color gives an indication of the amount of plankton, which is a crucial source of food for the fish. Thus, a large amount of plankton is likely to coincide with a high concentration of fish. A second important feature of the app is weather forecasts, specifically forecasts of the speed and direction of the wind. See Fig. 2 for screenshots of these two features of the mKrishi app. In addition, the app provides information about good fishing practices and a few other issues. With respect to gaining an overview the app has affected the fishers' ways of working in multiple ways:

- After the introduction of the app the fishers use less diesel. It has been possible to document this reduction at the community level because the distribution of diesel is the responsibility of the local fishery societies and they keep careful records. The

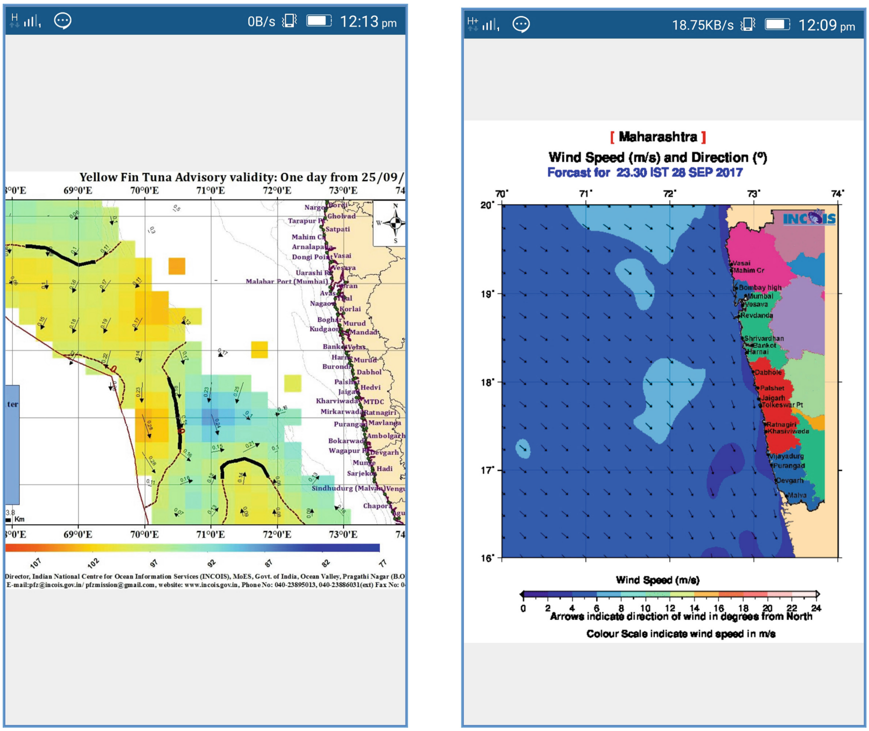

Fig. 2. The mKrishi app showing the predicted location of fish (left) and the forecast for wind speed and direction (right). Screenshots courtesy of TCS, ICAR, CMFRI, and INCOIS.

reduced diesel consumption indicates that (a) the fishers engage in less searching to find the fish and (b) select routes with more tailwind when they are returning with their catch to one of the landing centers along the coastline. The former suggests a better overview of the location of the fish, the latter a better overview of the weather conditions.

- Previously, fishers would often try to keep it a secret if they had a hunch about where to go to get a good catch. Now, up-to-date information about where fish can most likely be found is available to all the fishers. The chairperson of the Alibaug fishery society considered this equal access to information a benefit; individual fishers may agree or disagree. With the app the fishers have an increased need to coordinate, or negotiate, who goes where to avoid going to the same place. The app provides no support for this coordination and creates no physical meeting place for it.
- In its current version the app appears to bypass the cooperative aspects of the fishers’ work. The fishers have proposed to extend the app with information about the price at which different fish can currently be sold at nearby landing centers. Another possible extension would be to track the location of the fisher boats. Knowing their location could help in coordinating who goes where and in coming

to rescue during emergencies, which are all too frequent. Instead of artefactual multiplicity, the app pursues a fairly singular purpose. Activities related to, but different from, this purpose are handled through other arrangements, such as the fishery society for coordination/negotiation and the control center for emergency response.

The mKrishi app does not have the strengths of a large, shared display but it has enabled the fishers to gain a better overview of the location of fish and the possibilities for tailwind back to the coast. The app is but one component in a large sociotechnical network and has been designed to improve, not obliterate, this network. While many things are best handled outside the app, it appears worthwhile to consider including some support for the cooperative aspects of the fishers' work.

5 Conclusion

Forming and maintaining an overview is pertinent to the competent performance of cooperative work. While technical support for forming and maintaining an overview has received considerable research attention in developed countries with ample access to large, shared displays, less is known about how small, mobile devices may support – or fail to support – actors in developing countries in overviewing their cooperative activities. The mKrishi app illustrates that at least some aspects of an overview can be provided on a small, mobile device but also that it is important to consider how overview support is distributed between the app and the other systems and arrangements that form the sociotechnical network in which the app is embedded.

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Socio-technical Design of an App for Migrants Rescue Operations

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Abstract. This position paper illustrates the research and development work done in the last years for understanding how to support domain experts in the rescue operations of migrants who attempt to reach Italian coasts via sea journeys on Mediterranean routes. The context, characterized by humanitarian, social, and organizational issues, presents complex challenges that can only be tackled with a multidisciplinary, participatory, and internationalized approach. The final system takes inspiration from other projects developed for different purposes but acting in similar context and according to similar socio-technical dimensions.

Keywords: Participatory design · Human work interaction design International development · Domain experts · Migration Emergency medical services

1 HWID for Emergency Medical Services

In recent years, Italy is handling the difficult situation of migratory flows ending with landing on the southern coast of the Country. According to UNHCR (United Nations High Commissioner for Refugees) report [1], since the beginning of 2017, 50,275 immigrants have entered Italy from the Mediterranean. In [2] World Health Organization defines a mass casualty incident as "an event which generates more patients at one time than locally available resources can manage using routine procedures. It requires exceptional emergency arrangements and additional or extraordinary assistance". This definition is well suited to describe what happens during the rescue operations for managing immigrants 'landing when it is necessary to offer medical assistance to a number of people who often exceed what the relief structures can accommodate. These conditions make it essential to study and implement specific strategies and work plans observed by all actors involved. Assistance operations are carried out by staff specialized in various disciplines such as doctors, nurses, and paramedics. Experts from different domains are called upon to perform their profession in a complex environment and with very challenging timing and intervention modes.

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This means having to perform sensitive tasks in a short time, though maintaining a high level of security, efficiency, and reliability of performance. This leads to the need of designing and developing IT applications to support the whole rescue operations. In particular, our research and development work is framed into studying how to design the interaction of IT solutions for enabling Emergency Medical Services (EMS). EMS are defined in [3] as "[…] the ambulance services component that responds to the scene of a medical or surgical emergency, stabilizes the victim of a sudden illness or injury by providing emergency medical treatment at the scene and transports the patient to a medical facility for definitive treatment". However, the issues in this context do not relate only with medical assistance: operation workflows have to be put in place and leadership and organizational aspects have to be faced. To manage rescue operation in an efficient way means to nominate one or more managers who can successfully lead and coordinate all team members. One of the most critical actions to be taken in rescue operations is the triage, i.e. efficiently determining severities of injuries and prioritizing treatments; this action constitutes one of the most important tasks for basic life support. Furthermore, there are other crucial activities, like organizing and running specifics areas of operation for triage, treatment and transportation. Therefore, it is mandatory to take care of the specific flow of information between the operation managers and the team members. Such a research context can be clearly seen as framed into Human Work Interaction Design (HWID) [4–7], a lightweight version of Cognitive Work Analysis, addressing the concept of Work in Human-Computer Interaction. The background and experience we bring in the field is twofold. On one hand, INMM – In Manibus Meis - is a registered supplier to NATO and is responsible for providing medical information support systems for first responders and military rescuers, medical control systems for first aid rescue teams, supporting systematic collaborative to emergencies management. On the other hand, the members of MIPS (Multimedia Interaction Perception Society) Laboratory of Università degli Studi di Milano bring into play their experience in interaction design for domain experts in several application domains [8–12].

2 Motivations

The project aims at investigating how mobile digital tools used during critical and emergency activities not only facilitate the intervention on the field but also guarantee a benefit to whole related organizational structure.

The idea takes inspiration from other projects carried out in different contexts but designed around similar socio-technical principles. One example can be mKrishi@-fisheries (see Fig. 1), an app developed by Tata Consultancy Services (TCS) in collaboration with the Innovation Lab Mumbai, Central Marine Fisheries Research Institute (CMFRI), Indian National Center for Ocean Information Services (INCOIS) and Indian Council of Agricultural Research (ICAR). This app aims at providing fishers in the Maharashtra state of India with a geo-referenced map indicating to where there is likely to be many fish. Through an algorithm able to analyze satellite images, weather conditions, data of the past catch, this app can help fishers to find locations which higher concentration of fish can be reached in safety condition.

Fig. 1. A screenshot of the mKrishti app with indications to where finding fish (left) and Fisheries landing center in Alibaug village (right). Screenshots courtesy of TCS, Innovation Lab Mumbai, ICAR, CMFRI Mumbai, and INCOIS.

Besides a real help to fishers, the app offers great benefits to the network of local fishery societies. For example, it was possible to register a reduction of consumption of fuel, whose distribution is under the responsibility of the fishery societies. The equal access to the information for each fisher has favored their cooperation and collaboration. Moreover, the growth in the use of mKrishi has seen and is still seeing the birth of a platform that includes services for equal fish marketing and suggestions for a more sustainable fishing procedure.

Examples like this leads us to believe that a single app used to support rescue and assistance operations in Italy can improve the whole organizational structure favoring better cooperation between all operative units and government agencies in order to enable more equal immigrants' treatment and distribution among all European countries.

3 Challenges

In designing and developing IT solutions to be used in such a critical context, we identified six main challenges:

1. **Time and resources management:** the applications need to support the rescuers in gathering medical data and in managing the operation as a whole as quickly as possible but keeping a high-level quality of the actions.
2. **Clinical risk reduction:** electronic guides are provided to avoid incomplete and incorrect medical data collection in stressful situations, which could impair the final outcome exposing patients to possibility of mistakes along the rescue chain.
3. **Human rights preservation:** the entire workflow needs to be addressed efficiently and in reasonable time but always paying attention to not overcome human rights

and dignity in the process. Specifically, discriminations on any ground have to be avoided.

4. **Privacy preservation:** medical data have to be managed in compliance with law requirements. This means to collect, store, protect and use all gathered data in conformance with the requirements of legislation and regulations, both on a National and EU level [13].
5. **Internationalization:** there are two different aspects of the context that require an internationalized approach. Firstly, the migratory wave is characterized by a multiplicity of different nationalities. To enable the collection of medical data and informed consent, and to efficiently and effectively deploy medical care, any IT application has to be designed and developed in more than one language. Secondly, it is desirable to trigger an information exchange process in order to facilitate the transmission and analysis of the data between European countries.
6. **Security:** information security controls had to be implemented to protect databases against compromises of their confidentiality, integrity and availability.

4 Our Contribution

INMM in collaboration with researchers of Università degli Studi di Milano have designed and developed ITHEALTH (International Traveller Health Surveillance System), a digital tool that through a tablet device provides rescuers with a set of functionalities for gathering patients' medical data and for managing and coordinating rescue operations. ITHEALTH allows rescuers to assign a bracelet to the patient tagged with a unique alphanumeric code (manually, by reading an NFC chip or scanning a QR Code), and then screening is assisted by the system in use at entry points (seaports and on board of ships) and along with transfer and relocation of migrants and refuges.

Each authorised caregiver is assigned a portable device (tablet or smartphone); each migrant is assigned a medical tag. All personal data is securely encrypted in it, the medical tag is worn by the migrant as his/her right to access to health care.

The resulting electronic health records (EHRs) are automatically and securely stored locally both in the ITHEALTH storage system and on the medical tag. Only authorised personnel who have access credentials to the system can see the data, thus physically the data is sent and visible only on authorized devices: laptop or desktop computer.

When any connection is available data can be transferred to a server, installed on a laptop computer, normally placed at an operating centre and/or at the Hospital.

There are additional features included:

In case of arrival from an epidemiological 'area of risk', the system, updated with previous preloaded information, matches data and instruct caregivers to deepen screening while alerting of a possible threat. In case a disease is confirmed, the caregiver is assisted to command the prompt evacuation by adopting the EVAC protocol, hospitalisation ad or isolation of the case, sending an alarm to the main Institution that there may be the risk of a public health threat to monitor.

The workflow implemented in ITHEALTH follows official protocols and standard procedures, so that screening is guided through unified protocols, throughout the whole chain of care.

The digitalization of such protocols allows to face the first two challenges mentioned in the previous Section – i.e. time and resource management and clinical risk reduction. The quality of the workflow is guaranteed by the implementation of standard protocols, whereas the digital processes enable a quick data collection, management, and delivery. When a rescuer collects data, an informed consent is shown to the migrant to be signed. This page is translated in a set of languages and offers information about the reasons behind the data acquisition process.

Figure 2 depicts a set of screenshots that present some steps of the medical acquisition process of ITHEALTH. Figure 2(a) requires to insert or a new immigrant or to load data previously registered in an electronic bracelet assigned to an immigrant. The forms in Fig. 2(c) and (d) are used for collecting immigrant's status and biographical data and medical data respectively. In this latter case, data concern heart rate, oxygen saturation and body temperature. Finally, Fig. 2(d) requires immigrant signs the informed consent about the gathered data. This page is translated into the immigrant's language if it is possible.

When an intervention is completed, the resulting EHRs are automatically and securely stored locally both in the ITHEALTH storage system and on the medical TAG. When communications are available, the rescuer can send the EHRs and the additional information through any communication channel available (recently radio communications have been exploited too). The server keeps a database that securely stores all that has been done during the operations, enabling the creation of reporting to use for coordinating different rescues and for enabling the cooperation between various intervention agencies. About human rights and privacy presentation, EHR systems need to manage new and additional safeguards to address the fundamental conflicts and dangers of exchanging information in an electronic environment [13]. As said in the previous section, any IT application has to be designed and developed in more than one language. This is to mitigate misunderstandings between the rescuer and the immigrant about data processing and collection purposes could block or slow down the information transmission process. To face off this possible communication gaps ITHEALTH tries to report medial information by using appropriate images and very simple interfaces that can be understood even if the migrant does not speak one of the languages known by the rescuers.

Figure 3 presents another screenshot used for reporting possible pain, fractures, burns, wounds, skin manifestations or amputation. By sketching on the figure, the rescuers can annotate where the problem is located by using a color code to specify the type of problem. This visual strategy is very useful and simple to use for the rescuer and very understandable for the immigrant too.

Finally, to deal with the second aspect concerning international issues we designed an information exchange protocol among the parties in order to: (i) set forth the information to be exchanged, the operational procedures to be followed, and the security mechanisms and other safeguards to be maintained; (ii) and set out the ways that such exchange of the particular information would be consistent with the purposes. To this aim, ITHEALTH provides modules that allow coordinators of the involved

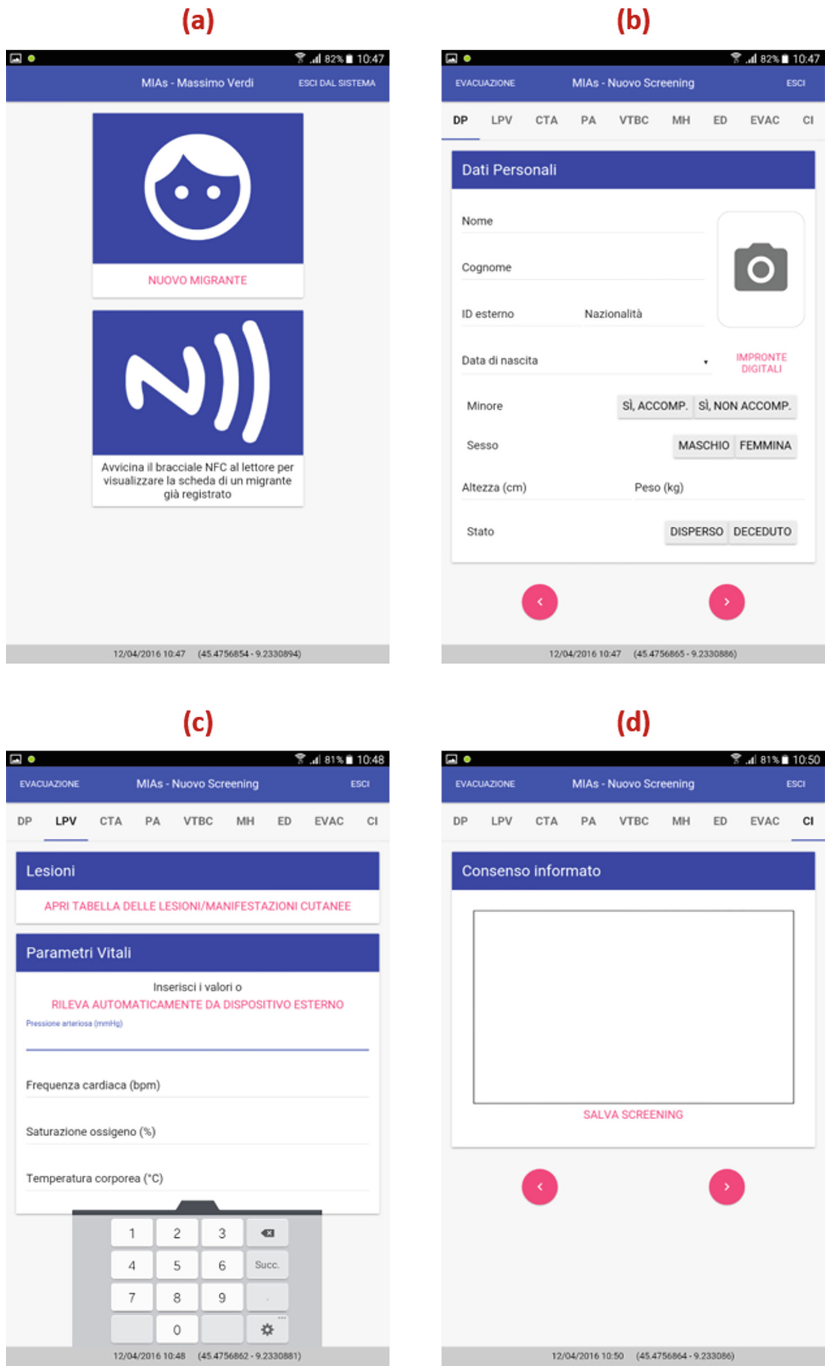

Fig. 2. Screenshots of some pages of the ITHEALTH medical data acquisition process

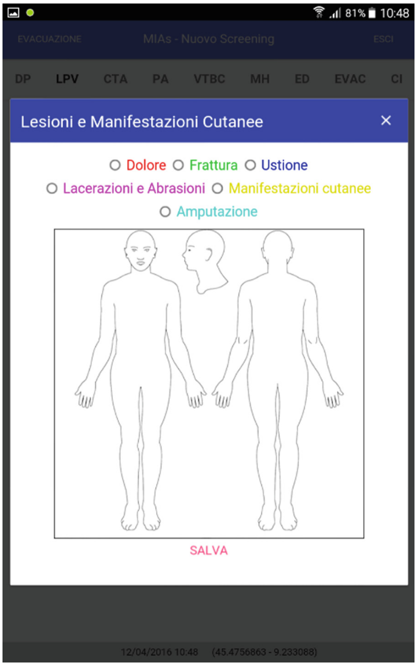

Fig. 3. A screenshot that depicts how medical data are gathered in a visual and intuitive way.

teams to follow remote rescue operations, giving orders, guiding the actions of the individual rescuer, recording data about injured, and setting up coordination tasks. In order to evaluate ITHEALTH we carried out several tests in different scenarios for testing how the tool can support rescuers during their actions and other rescue operations in order to decrease their workload while accomplishing several unusual tasks in parallel and under time pressure.

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Socio-technical HCI for Ethical Value Exchange

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Abstract. Ensuring ethical value exchange is moving to the forefront of the global challenges that HCI will have to address in the coming years. In this position paper, we argue that applying a context-sensitive, sociotechnical approach to HCI can help meet the challenge. The background is that the life of marginalized people in contemporary society is challenging and uncertain. The marginalized can face health and cognitive issues as well as a lack of stability of social structures such as family, work and social inclusion. Three questions are of concern when innovating together with people 'at the margins': how can we describe users without attempting to stereotype badly, what sociotechnical HCI methods fit the local societal context, and how to make the design sustainable in face of current planetary challenges (e.g., climate change)? We adapt the sociotechnical HCI approach called human work interaction design (HWID) to meet the challenges of designing for ethical value exchange. We present three cases of service design, and suggest how to add a fourth similar case using the HWID approach during a field trip and workshop at the INTERACT 2017 conference in Mumbai. We conclude that applying a context sensitive sociotechnical HCI framework implies that both the backend and frontend of service design and product innovations should be executed and valorized from within the local context.

Keywords: Sociotechnical · Human work interaction design
International development · Ethics · Service design

1 Introduction

Ethical value exchange is moving to the foreground of Human-Computer Interaction (HCI) in these years, adding a new dimension to the current user experience and web 2.0 platform designs [1]. For example, an emerging network focused on product and service innovations in resource constrained environments explores new design methods, experiences and knowledge of doing innovation with people 'at the margins', for example in South Africa, India, Brazil, Denmark and UK [2]. In these projects that look at Global South Service Innovation there is a lot of focus on a frontstage mindset (e.g., touchpoints, user friendliness, user interfaces), but the methods, tools and infrastructure used to analyze and/or do backstage 'work' are envisioned and driven to a large extent

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by Global North assumptions (e.g., analytical cognitive styles, horizontal decision making structures, economically-driven thinking). We argue that through a sociotechnical HCI design approach, exemplified with the Human Work Interaction Design (HWID) model [3], researchers and designers can visualize and do something about these critical gaps, and more generally, contribute to an 'HCI of ethical value exchange'.

The life of marginalized people is challenging and uncertain. The marginalized lack stable social structures such as family, work and social inclusion. People are typically said to be marginalized due to unequal social structures and a lack of education, proper housing, it-services and healthcare. Marginalized people in Denmark and UK share some of these traits, but in what we might call a first-world guise. Meaning that for example the elderly, refugees, and the disabled in UK or Denmark compared to Brazil or South Africa have more economic resources. However, relative to the rest of the British and Danes they are marginalized and suffer the ill effects associated with that position such as estrangement and a lack of participation in innovation. The elderly may for example be marginalized due to cognitive and physical decline associated with the aging process. In South Africa, black students are presented with equal opportunities to attend university, but its very different socio-economic and cultural background make it challenging for them to remain in higher education leading to high drop-out rates for this sector of society. Approaching marginalized people is challenging – their exclusion from society and societal resources has created estrangement. Moreover, a lack of resources may make it hard to take part in the dominant patterns of innovation and consumption. In addition, a significant problem is that stereotypes of these marginalized people fail to understand their experiences and life perspectives [4].

There is therefore a need to revisit sociotechnical HCI analysis and design methods with the aim to co-create alternative patterns of innovation that include the marginalized. Furthermore, in the emerging transformation economy, the focus on ethical value exchange with trust and collaboration in the foreground requires empathic, in-context experimentation and data collection through living labs [1], which requires a sociotechnical, context-sensitive approach such as HWID [3].

The larger questions that we want to discuss by analyzing cases of innovating together with people 'at the margins' are: how can we describe users without attempting to stereotype badly, what sociotechnical HCI methods fit the local societal context, and how to make the design sustainable in face of current planetary challenges (e.g., climate change)? We suggest the IFIP WG 13.6 Human Work Interaction Design HWID framework as an example of a sociotechnical HCI approach to frame service design cases and assess the extent to which HWID is suitable and how it should be modified to support open, bottom-up innovation in the global south.

2 Why Service Design Cases?

The service design field emanated from the appearance of information technology and an increased design focus within management and organizational studies. The field is relatively new, but stems partly from interaction design and participatory design (PD), [5–7]. PD plays an important role in service design [6]. Thus, what is transferred to service design is a basic structure consisting of involvement techniques, collaborative approaches, and liberating objectives.

As Fig. 1 points out there are three key elements in service design: users, touch-points, and the service journey. Contrary to many design methods service design tries to capture what is outside of the IT system and has a focus also on the surroundings and contexts of use as well as the different sequences of interactions. Similar to PD techniques such as future workshop, service design looks at both the frontend and the backend users of the IT system [8]. Service design focuses on the contexts around the solutions and as such has a holistic approach to problem solving.

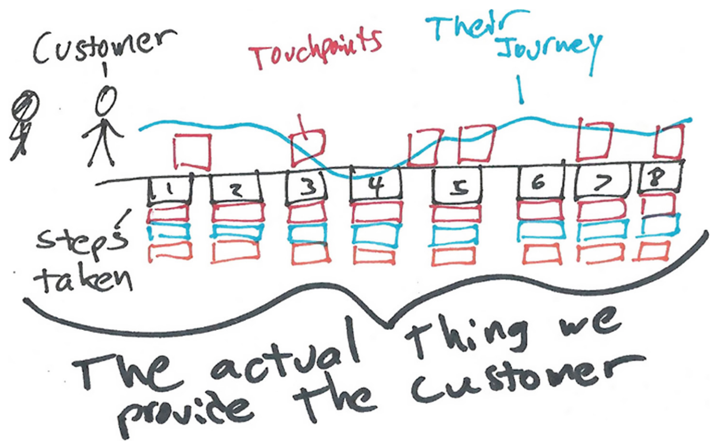

Fig. 1. Customer service journey

3 Sociotechnical HCI for Ethical Value Exchange

The value propositions for a design approach should be rethought in relation to the paradigmatic economy that the designers attempt to contribute to [1]. In this paper, we use Human Work Interaction Design (HWID) to contribute to ethical value exchange, and hence present the HWID approach in relation to value propositions relevant to ethical value exchange. HWID is illustrated in Fig. 2.

The left side of the figure illustrates the *social,* which is analyzed as end-users' work tasks performed through IT systems within a given work domain. The right side illustrates the *technical* in HWID, which focuses on interaction designs as such, and on interaction design methods and techniques. The approach is *context-sensitive*, which is illustrated by the lower bar. The top bar indicates that researchers need to choose appropriate theories and methods for the phenomena under study. Obviously, at the center of the approach is the services and products being designed.

The value propositions for a HWID for ethical value exchange are inspired by Gardien [1]:

- End-user benefit – apply HWID theories to conceptualize not only interaction at individual level, but also HCI as organizational, societal, and global issues, and to help determine what is ethical peace of mind when speaking of HCI
- Cause of decline – using HWID to mitigate HCI's native risk of focusing too much on interface functionality and forgetting the social life of humans
- People research objective – the aim with using HWID should include not stereotyping users (badly), executing sociotechnical HCI methods from within the local societal context, and designing for planetary sustainability (e.g., climate change)
- People research method – HWID analysis and design should be conducted in the context of everyday life
- Aesthetics – HWID as a design approach should be thought of as a parametric platform that can be valorized for a given local context
- Innovative integration – cradle to cradle sustainability achieved by the continuous, never ending analysis-design relations in HWID
- Brand – transparent and easy to understand what HWID analysis and design activities that have been done so far, and thus instantiating trust.

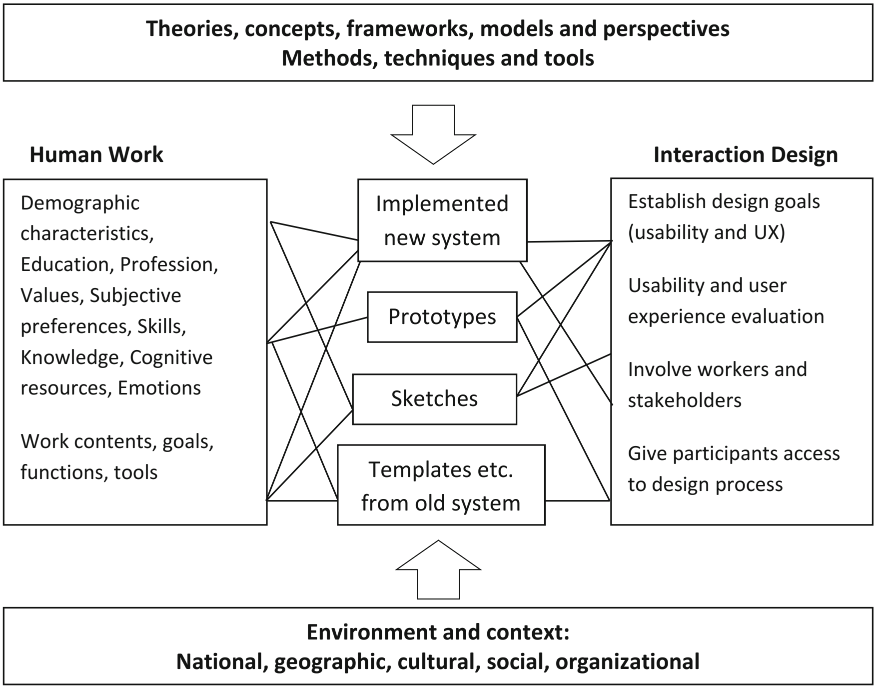

Fig. 2. The HWID framework [3]

4 Description of Three Service Design Cases

Each of the projects described below shares a common interest in answering the questions presented in Sect. 1 within a service design framework.

The first project is concerned with socio-cultural and human interaction approaches in the design of interventions to support students at risk in South African universities. In South Africa (SA) 25% of schools are functional, the rest are dysfunctional in terms of accountability, teachers' knowledge of content, absenteeism, coverage of curriculum; high dropout and poor performance on national assessments [9]. Many dysfunctional schools are in townships and rural areas - in black communities. Consequently, many black students are underprepared to enter university and successfully complete their studies within the set time. There is a 50% higher completion rate for white students compared to black students [10]. The dropout rate at university is a serious concern that results in wastage and perpetuates the vicious poverty cycle. Research on designing information systems as intervention for students at the risk of dropping out or failing to complete their studies in the minimum set time is critical in SA.

SA universities attract students from diverse races, religions and cultures. Sometimes students at risk are identified late and the tendency is often to offer more readings and remedial classes thus adding an information burden to them. Given the situation, through an existing Newton Mobility Grant between the University of West London (UWL), University of Cape Town, and Cape Town University of Technology, we are exploring how service design approaches can be used to design an intervention information system for students at risk in SA universities.

The second project is led by the University of Bradford, IIT Madras and UWL and is concerned with critically examining city-wide strategic framing using concepts such as smart cities and sustainable cities and embedding inclusiveness as a central plank of such city-wide frames. In this regard, achieving Sustainable Development Goals (SDGs) at the city level requires resolving overlapping and inter-connected SDGs whereby inclusiveness becomes a very important element. Though the rhetoric suggests that all cities claim to be inclusive, in reality smart cities exclude those who do not have access to digital technologies; sustainable cities focus on environmental issues the benefits of which are predominantly manifested through housing price appreciation in better neighborhoods. Chennai is one of 100 smart cities chosen by the Government of India and it has also been one of the earliest members of the UN-Habitat's Sustainable Cities Programme. In our project, we are examining the scope for such city-wide framing approaches to exclude particular groups including women, children, elderly people, and those living in slums.

The third project is at the proposal stage with the Danish research councils and is concerned with establishing a strong alliance between related research interests in two different continents: The IT University of Copenhagen, Universidade do Estado de Santa Catarina, and The Institute of Computing in Brazil. In Brazil and in Denmark digitalization of both public and private services are implemented and are to be implemented in the nearest future. The digitalization of services often overlook the less privileged citizens - the marginalized. By marginalized we understand the elderly, handicapped, poor, not educated, among other main categories. The main question to explore from the HWID perspective is how service design methods, originating from the global north, should be changed and innovated upon in order to adapt to local contexts in the global south. The focus is on design with and for people at the margins, in this particularly case focusing on Brazilian run projects in game design for elderly and interaction design for down syndrome children. Through this exploration new design methods may arise that can bridge the differences in cultural circumstances and contexts.

5 The Alibaug Fishery Case Study

The above projects illustrate the kind of cases that sociotechnical HCI for ethical value exchange aims to support. For the INTERACT TC 13.6/13.8 workshop WS11: Human Work Interaction Design meets International Development reported in this paper, the approach was similar. Since the workshop took place at the INTERACT 2017 conference in Mumbai, there was a unique opportunity to observe technology-mediated innovative work practices in informal settings. In this context, away from the mainstream industrial sites of the global north, the workshop used the HWID approach to analyze findings related to opportunities for design research in this type of work domain. On day one, workshop participants did a field trip to visit a fishery in a small village that has had a ICT business solution implemented with the support of the India-based company TATA and the Central Marine Fisheries Research Institute (CMFRI). On day 2, the workshop participants gathered at the workshop and reflected critically over the ethical value exchange aspects of the ICT solution, and proposed possible add-ons and new designs. The workshop participants and the TATA and CMFRI representatives shared interpretations from the field trip and discussed HWID activities for ethical value exchange.

An observation script based on the above presented HWID model and research objective was used to collect data and engage during the field trip and workshop. Below we present selected findings and insights on the Alibaug fisher case.

5.1 Interaction Design Related Findings

The ICT solution was based on an Android app consisting of screens that offered functionality to the fishers. During interviews with the fishers, it was revealed that a key service provided was wind speed, as shown in Fig. 3 and in the interview excerpt below involving a researcher, a TATA designer, and a fisher. The designer also took the role as interpreter between the researcher and the fisher.

> Designer [interpreting what the fisher is saying]: *so here is this where his experience [fisher's] and the information match, and that is why his confidence in the app is there…*
> Researcher: *and then what happens?*
> Designer [interpreting what the fisher is saying]: *and he actually calls those people and say don't go, and the people who are already gone, they started to ….they were called on the wireless radio and asked to come back.*

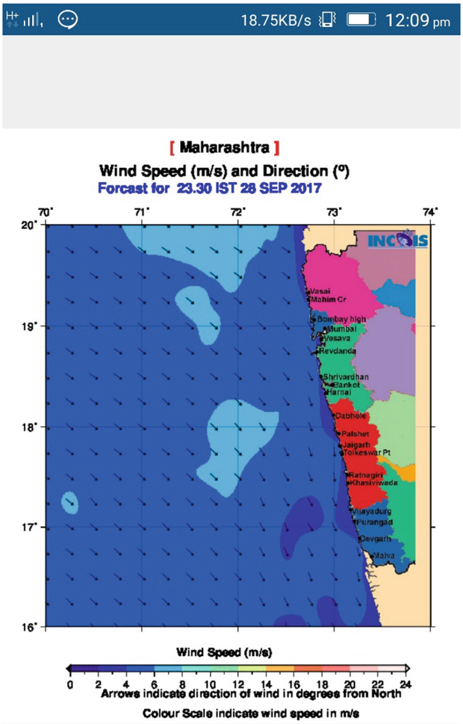

Fig. 3. Screen from app, showing wind speed danger areas

Researcher: *how much money did you save by that?*
Designer [interpreting what the fisher is saying]: *so they think it was a loss, because they had to come back without fish, but at least the boats were saved.*
Designer: *also fifty people did not go so that is a saving, correct?*

In the excerpt above, the TATA designer explains how the fisher uses the wind speed information to warn his colleagues not to go fishing if the wind is too strong or coming from the wrong direction, and how this functionality saves the boats from damage. Fishers do have opinions and feedback to the designers, as can be seen below when a fisher, the TATA designer and researcher discuss the bottom bar in Fig. 3.

Designer: this is good info, he [fisher] is saying that the index shows meter per second and it should be km/hour.
Researcher: so you [TATA designer] will change that?
Designer: yes.

The designer/translator who is from TATA acknowledges that the fisher has a point about the format of the wind speed, and says that the designers will change that.

The key important service, however, is shown in Fig. 4. The location of fish is marked by thick curved lines, each illustrating a probability band that there will be fish in this km-wide zone. The map is based on a satellite photo from the day, which captures the color, i.e. the amount of plankton [fish food], and the temperature of the water, and uses this to infer the amount of fish in each square of the map. Then the squares with most fish are marked to make it easy for the fishers to find the fish location of the day.

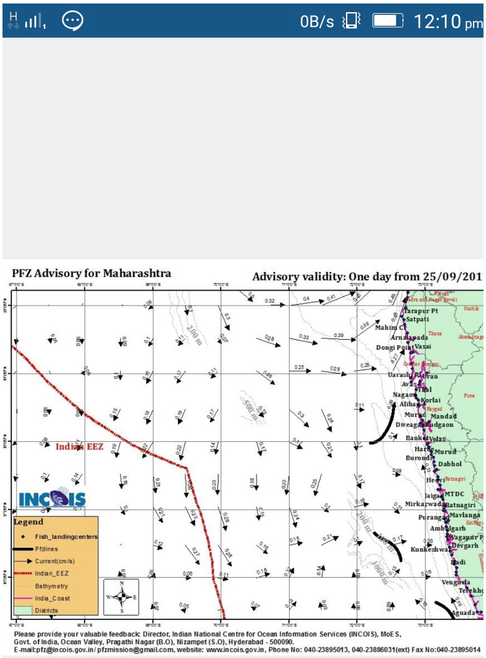

Fig. 4. Map showing the location of fish

Designer [interpreting what the fisher is saying]: *this is a different service, this map shows potential fishing zones, where the fish are….you can go and catch fish everywhere but the marking shows more fish there.*
Researcher: *how much trust do you have in this service?*
Designer [interpreting what the fisher is saying]: *confidence…approximately 70%, minimum*

As the excerpt illustrates the fishers has great confidence in this fish location service. However, it is not entirely clear to the fishers how this is calculated:

Researcher: *another thing, so if we look at this [the line showing the location of the fish], how is this calculated? how does he think it is calculated, what is his mental model?*
Designer [interpreting what the fisher is saying]: *so he says [Fisher] the only thing he knows is that he does not know how it is calculated.*
Researcher: *can you ask him to guess?*

Designer [interpreting what the fisher is saying]: *he says that probably they understand the environment in which the fish lives, and environment information can tell where the fish is - which is actually right*
Researcher: *so ask him where the scientist get the information about the environment from.*
Designer [interpreting what the fisher is saying]: *he cannot, does not know.*

So, not surprisingly, the basic wind speed service in Fig. 3 is understandable by the fishers and quite useful, while the more advanced algorithm behind the fish location service is less understandable though it is still trusted to a high degree.

5.2 Human Work: Related Findings

The meeting with the fishers' association, see Fig. 5, revealed the key role of this organizational body in the fishers' use of the ICT solution. The fishery association distribute the diesel to the boats, and in other ways is the central coordinating and support body. The discussions were mediated by Dr. Singh, the scientist and project lead from CMFRI, who also took the role as translator between the fishers and the researchers.

Fig. 5. Photo from meeting in fishers association, Alibaug

Researcher: *how many people come here every day?*
Project lead scientist [interpreting what the fisher is saying]: *100 people come every day, but there are 300 in total, some are at sea.*
Researcher: *what do they do when they come here?*
Project lead scientist [interpreting what the fisher is saying]: *they get the diesel, they are given the diesel, the government diesel*
Researcher: *in a carry on can?*
Project lead scientist [interpreting what the fisher is saying]: *in a drum, and that drum they carry to sea, so when they are at sea, they can add more diesel*
Researcher: *diesel is cheap?*
Project lead scientist [interpreting what the fisher is saying]: *government of Maharashtra subsidize the diesel, 8 rupees per liter, so if market price is 60 rupees, they will get it for 50 [something] rupees.*

The above excerpt shows how the society has a key role in the everyday practice of the Alibaug fishers. However, the society also acts as the interface between fishers and the larger society, represented by the designers from TATA who need data for their research, and the state government who needs someone accountable for the support they provide to the fishers. This is illustrated in the next excerpt.

Project lead scientist: *and that is why it was very easy for us to know the consumption, number of boats, how much diesel each boat consumed, before our app and after.*
Researcher: every fisher gets the same amount of diesel or it depends on the size of the boat?
Project lead scientist [interpreting what the fisher is saying]: *yes, size of the boat, or rather, how many cylinders is there [in the engine], so a small boat has one cylinder, a little bigger has two cylinders, so according to that, they [the association] decide the amount of diesel.*
Researcher: *are all fishers always honest, they never cheat and say I have two cylinders?*
Project lead scientist [interpreting what the fisher is saying]: *largely* - *because these societies have been founded in Maharashtra, based on [name] movement. these societies are unique in Maharashtra and in the country. This society is 70 years old (…) they spend the money from the society, and then twice a year, they get the money from government. They maintain a 100% record.*

As the excerpt illustrates, the fishery society distributes diesel across boats. The diesel is cheap due to specific government support. In fact, it turns out that nobody in the fishery community pays any taxes to government. The app plays a key role in the optimum use of diesel as fishers will welcome any information about good areas to fish. However, this also disrupts to some extent the previous division of labor and fishing knowledge between small and big boats, and potentially undermines the competitive advantage of certain fishers, who were better at finding fishing spots without the help of the app.

Taken together, the fishers' trust in the fish location algorithm and the key role of the fishers' society in providing information to the TATA ICT designers may indicate that though the initiative by researchers to support the fishers is based on deep knowledge of fishers' practices, the app solution places more emphasis on the introduction of new practices, than on the support of existing individual fishers' subjective view of their world and previous knowledge. This requires a sociotechnical effort to also 'redesign' the social system by trying to mitigate or rearticulate some of these potentially negative effects. This could be done through helping to change the value systems underpinning fishing practices in these communities as well as co-designing new rules of engagement between all stakeholders involved in the fishing support service.

6 Overall Objectives

In summary, the overall objective of this paper was to hint at a possible sociotechnical HCI framework, customize value propositions, and present cases, to enable discussion of:

- how can we describe users without attempting to stereotype badly?
- what sociotechnical HCI methods fit the local societal context?
- how to make the design sustainable in face of current planetary challenges (e.g., climate change)?

One of the answers that the cases may support is to see service design's backend issues as the *social* side of HWID, and the frontend issues as the *technical* side of HWID.

The Alibaug fishers case study surely provided another case study where we can explore how service design could be adapted, through the sociotechnical lens of HWID, to articulate ethical issues of value exchange. In this case study it is highlighted how a focus on the frontend use and experience of the service provided by the app could overlook delicate and tacit social and cultural backend arrangements. Given the *context-sensitivity* of the framework, both sides and their interrelations should thus be considered as a design platform that is executed and valorized from within the local context. This is what we hoped to illustrate with this paper.

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