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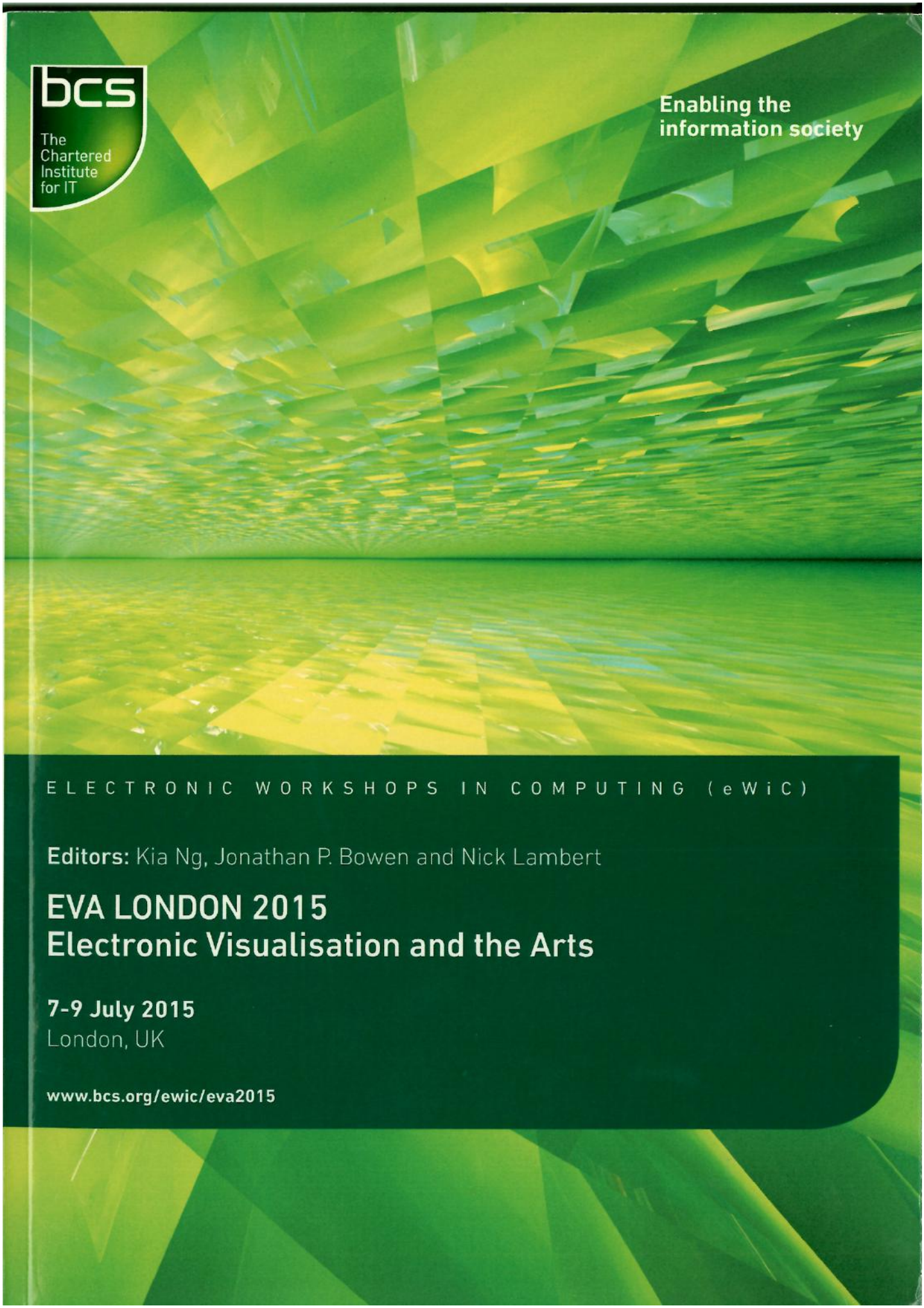

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Editors: Kia Ng, Jonathan P. Bowen and Nick Lambert

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Robots and Cultural Heritage: New Museum Experiences

Maria Luce Lupetti
Politecnico di Torino
Corso Settembrini, 178, Turin, Italy
maria.lupetti@polito.it

Claudio Germak
Politecnico di Torino
Corso Settembrini, 178, Turin, Italy
claudio.germak@polito.it

Luca Giuliano
Politecnico di Torino
Corso Settembrini, 178, Turin, Italy
luca.giuliano@polito.it

The introduction of new technologies to enhance the visiting museum experience is not a novelty. A large variety of interactive systems are nowadays available, including virtual tours, which makes cultural heritage accessible remotely. The theme of increase in accessibility and attractiveness has lately been faced with the employment of the service robotics, covering various types of applications. Regrettably, many of robotics solutions appear not really successful in terms of utility and usability. On the basis of this awareness, a design for a new robotic solution for cultural heritage has been proposed. The project, developed at the royal residence of Racconigi Castle, consists of a telepresence robot designed as a tool to explore inaccessible areas of the heritage. The employed robot, called Virgil, was expressly designed for the project. The control of the robot is entrusted to the museum guides in order to enhance their work and enrich the cultural storytelling.

Service robotics. Robo-ethics. Service design. Human centred design.

1. INTRODUCTION

In the 17th century, the magic lantern technology (a projection system which was the forerunner of the cinema) was used mostly in the earliest forms of museum, the *Wunderkammer*, to make visits more attractive and engaging.

Nowadays, three centuries later, visitors interact with the museum contents via multimedia systems and technologies (projection, hologram, app, robot, etc.) and in a variety of ways (touch, free actions, voice), either on-site or remotely (Ippoliti 2011). This helps expand access to museums, pursuing the Laws and Agreements for Cultural Heritage, as initiated by the first declaration of the Italian Franceschini Commission (1967): *"The actions of conservation, defence and enhancement of cultural heritage are all founded on the social function that is achieved as long as the most extensive public use is guaranteed"* (Ippoliti 2011).

An increasing trend in the fruition of museums is, also, represented by *virtual tours*, based on the same concept of wide accessibility. Virtual tours, indeed, aim to make the cultural heritage visible for remote cultural activities, such as study and research, to encourage people to visit the museum and to give them a preview of the location. The most popular example is, probably, represented by Google Art Project (Proctor 2011), a sort of repository of digitalised masterpieces and museums from all over the world. Through the web, people are able to navigate autonomously into realistic environments that reproduce famous galleries and museums combining 3D modelling and HD pictures. It is also possible to zoom on artworks and observe details undetectable by human eyes. It is possible to recognise different typologies of virtual tour, on the base of the technological orientation, and each one offers a slightly different functionality. The affordance, combined with the effectiveness of the technology applied, determines the usability and the consequent adoption of the service (Salvini et al. 2010). With regard to this, Sylaiou at al. conducted a Usability Evaluation study (Sylaiou et al. 2014) of these different typologies evaluating their quality on the base of the indications of the ISO-9241, which relates to the usability and ergonomic requirements of interfaces (ISO 2011). The evaluation is mainly based on five parameters, namely: ease of learning, efficiency of use, ease to remember, few errors production and pleasantness of use. From this analysis arise the fact that the effectiveness of a virtual museum is related to its ability to offer the visitors an experience rich of features, but most of all, imageability, navigability, interactivity and narration (Sylaiou et al. 2014). People, indeed, largely appreciate the ability to explore freely the virtual museum, choosing when and where to deepen, whereas a low quality of the displayed environment leads to the disengagement. The

employment of virtual museums, hence, even if to aims to increase accessibility and attraction of the museum, in some cases could lead to the opposite result. As stated by the London Charter, this kind of solutions has to be employed when they can provide added value in comparison with other methods (Beacham et al. 2006).

In this sense, a new frontier is represented by service robotics. Features common in robotics applications, such as connectivity, abilities of interaction, autonomous movement, people and objects recognition, enable new ways to face the recurrent themes of Cultural Heritage innovation, such as remote exploration, increase of the accessibility, attraction and the improvement of the user experience.

2. METHODOLOGY

This paper, therefore, discusses the remote fruition experiences of museums, with particular reference to **service robotics** for the development of a new museum experience. In particular, the research concern a project developed at the Residences of the Royal House of Savoy in Piedmont (Italy).

The first part of the research is dedicated to **related work**, an overview of international case studies analysis assessed by looking at the quality achieved by the design of the service referring to the parameters indicated by the ISO-9241, shown in the introduction. The strengths and weaknesses of the two types of virtual tour, on-site and remote, are analysed, assessing the degree of empathy created between the visitor and the museum. The museum, indeed, is not just a collection of artworks, but rather a physical and emotional context (Suchy 2006) in which is fundamental to not lose the perception of details compared to the whole, of the contrast between light and darkness, of the scent of the materials, of the sounds and the silence. For this reason, there has been developed a deepened **scenario analysis**, in which both physical aspects of the context and human activities have been taken into account. From the scenario analysis, with a special focus on ethical aspects, there have been defined **requirements** on which have been developed the robotic service **concept**. The project includes, also, a **product design** phase, in which the robot Virgil has been desined.

2.1. Related work

The use of robots in museum context is not a novelty indeed there is a large scientific literature about it. Since now, the robots were used mainly in three modalities: museum guide, telepresence and installation.

Museum guide Definitely, the robotic museum guide category is the most common and includes applications from all over the world. These robots are all characterised by the ability of autonomous navigation, obstacle detection and verbal interaction with visitors to describe the contents of the museum.

Already in 1998, at the Carnegie Museum of Natural History in Pittsburgh, has been introduced the use of a robot, named *Chips* at first and *Sage* later (Nourbakhsh et al. 1999), to accompany visitors in the Dinosaur Hall and to give audiovisual information about it (Willeke et al. 2001), provided to the user as a unidirectional narrative speech (Nourbakhsh et al. 1999). Subsequently, in the same museum, were introduced other robots with the same purpose (Willeke et al. 2001).

In the following year, at the Smithsonian's National Museum of American History has been introduced the robot *Minerva*, which gave tours to tens of thousand of visitors (Thrun et al. 1999). This robot was equipped with a moving head able to produce facial expressions and communicate its emotional state, defined in accordance to the people's behaviour. These expressive skills improved the attractiveness of the robot and the effectiveness in the guidance (Thrun et al. 1999).

The common and central problem of the effectiveness of speech interaction has been faced in the *CiceRobot* project, tested at the Archaeological Museum of Agrigento, in Italy. In this case the robot, entrusted of the guide activity, allows visitors to make questions. In order to improve the adaptation of the speech and the coherence of the answer, the robot cognitive architecture has been provided of a semantic module that filter the information received listening visitors' questions. (Macaluso et al. 2005).

In 2000, a group of three different robots have been introduced at the Museum fur Kommunikation, Berlin. These three robots were entrusted of different duties: instruction, incitation and entertainment. The instructive robot was, indeed, a museum guide that accompanied visitors in the tour giving explanations about the exhibit. It was able to move the head up and down to indicate which object it was referring to and also it was provided of a screen on which it could show additional contents (Schraft et al. 2001).

From the engagement and effectiveness points of view, an interesting step forward is represented by *Urbano*. This guide robot, employed in different exhibition spaces around Spain, was able to show emotional behaviour (Alvarez et al. 2010), in addition to facial expressions. Its behaviour was adapted on the base of the visitor's behaviour, in order to modulate the rhythm with which it gives information, and consists of three main emotional states: afraid, happy and curious (Alvarez et al. 2010).

Recently, the world most advanced humanoid robot, *Asimo*, has been tested as museum guide at the Japan's National Museum of Emerging Science and Innovation (Falconer 2013). The basic purpose was the same of previous project, but in this case there was a particular attention to the interaction with group of people. For example, in order to understand who from the public is asking a question, it suggests people to rise a hand before. Unfortunately this feature, such as others, was still not working as it was supposed to and the overall experience resulted negative from the engagement point of view (Falconer 2013).

Telepresence The category that, probably, is witnessing the wider expansion is the one of telepresence robots. These consist of robots that, connected to the web, allow visitors to explore the museum remotely. In general, these are all mobile robotic platform equipped with a screen and a camera. The use of this kind of robots is applied with different purposes.

The robot *Csiro*, for example, has been introduced at the National Museum of Australia, in order to allow people unable to reach the museum, e.g., students from rural areas of Australia or the aged in nursing homes, to visit it anyway (CSIRO 2015).

The robot *Norio*, from Droids Company (Droids Company 2015) instead, was designed to allow people with limited mobility, e.g., wheelchair users, to visit a museum, which, otherwise, would result impervious for them. This robot was placed, and is still working, at the National Centre for Monuments, Château d'Oiron, France. At the ground floor of the museum is a cockpit from which, through a computer, the visitor can remotely drive the robot located at the first floor (Oiron 2015). Another interesting example is the *After Dark* project, which involved the Tate Britain, in London (Tate 2015). The concept of the project is to allow people to explore the museum rooms during the night, playing with the sense of prohibition and exploiting the charm that this place assumes during the night. During this experience, available for five nights, in August 2014, some people, chosen randomly, have been connected, via internet, to the four robot placed in the museum and drove them via computer (Tate 2015).

Installation This category is mostly art oriented and the robotic technologies part of it are, generally, embedded in an artistic or educative setup. One example is the *TaraScope*, an educative installation that enable, groups of students, to interact from a space observatory in Ireland to a robotic telescope located in San Francisco, California (Hogan et al. 2015). The installation comprises tangible interfaces and digital displays. The artist-scientist Patrick Tresset, instead, developed a robotic art installation called *Paul*. This installation, exhibited at Tenderpixel Gallery in London for the first time, in 2011, consist of a left hand robotic arm holding a black biro and a pan-tilt camera, both bolted to a table in front of which is located a chair for visitors (Tresset et al. 2012).

These three types of museum robotic applications have been empirically evaluated on the base of the parameters indicated by the ISO-9241 (ISO 2011), shown in the introduction. Specifically, these parameters are meant to evaluate the quality of the interaction.

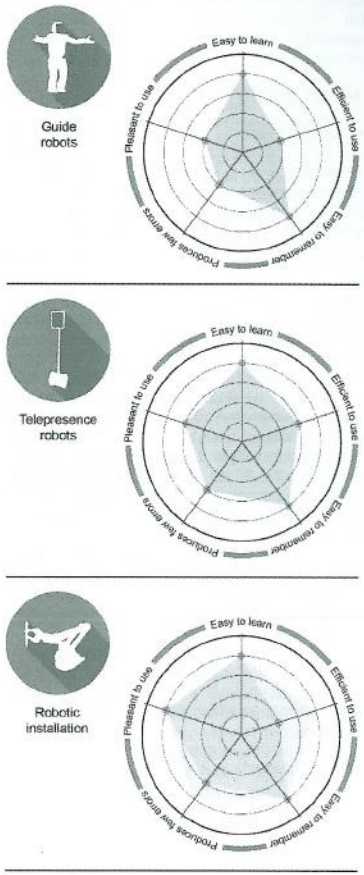

Figure 1: *Empirical usability evaluation of the three main category of museum robotics*

The interaction with guide robots, indeed, appears easy to learn and to remember, due to the fact that it is based on natural interaction modalities, such as speech, facial expressions, gestures and proxemics. On the other hand, this kind of solutions frequently produces errors (Falconer 2013), which, in addition to the low adaptability of the tour, causes a poor efficiency and, consequently, not much pleasantness to use.

Telepresence robot, instead, achieve an higher level of use efficiency and the interaction is easy both to learn and remember, due to the fact that adopt a mediating interface familiar to the users. The robot control, as a matter of fact, occurs through a computer or a tablet, and the control consists of teleoperation, ability that most of people have experienced at least in childhood. These aspects, thus, determine a higher level of use pleasantness.

Regarding the robotic installations category, it is not possible to make absolute considerations. Nevertheless, it is possible to assume that the easiness of use and remembrance are common as well as the pleasantness. The error production and the efficiency, instead, are the most variable aspects from project to project.

From these considerations emerges the fact that, in most of cases, the robotics is employed in museums regardless the evaluation of the physical aspects of the context and the human activities which are carried out there.

3. VIRGIL: NEW ROBOTIC MUSEUM EXPERIENCE

Virgil (Germak 2015) is a telepresence robot, result of a project for the enhancement of Cultural Heritage and improvement of the fruition experience. This project has been developed for a specific museum context: the royal residence of Racconigi Castle, in Piedmont, Italy. This castle, called over time as "*villa of delights*", was a holiday residence of the Savoy royal family. This residence is a surprisingly rich context (artworks, furniture, everyday objects, clothing, working machinery etc.) but, simultaneously, extremely delicate. All the Cultural Heritage, indeed, are places to which are entrusted two main activities: the preservation and fruition (Barile et al. 2012). Regrettably, in some cases these two activities are incompatible. For this reason, at Racconigi, some rooms of the residence are currently excluded from the visit tour, mainly, because of the state of conservation, fragility and logistic management of the visit. It has been estimated, indeed, that more than 60% of the residence remains inaccessible to visitors during a standard guided tour.

This phenomenon, in which part of the cultural heritage remains hidden, does not only concern the Racconigi Castle, but it is diffused throughout Italy.

However, in most of cases the main concern relates to the fact that a large amount of artworks and artefacts remains closed in the archives, whereas the problem of areas excluded from the tour route is not widely addressed.

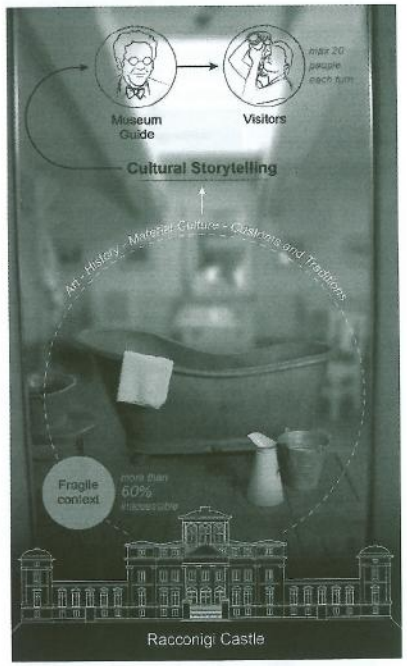

Figure 2: *The Racconigi Castle scenario overview*

For example, many newspapers and journals highlight this issue of hidden artworks that would represent an asset to be exploited (Pirrelli 2012). This kind of statements are confirmed by the *Istat* (National Institute for Statistics) reports in which is shown that the 31.1% of museums expose just around the 50% of the owned goods (Istat 2013). The delicate nature of the castle influences, further, the visitor tour. The access of visitors, indeed, is organised in groups of maximum 20 people, mandatorily accompanied by a museum guide or a castle guardian. Therefore, the museum guides assume a central role in the experience of museum visit and, as is well known, their competences have

a strong influence on visitor satisfaction (Mc Donnell 2001). The storytelling activity performed by the museum guide, thus, comprises three main aspects: selection, information and interpretation. The last one is the aspect that mostly determines the uniqueness of the experience due to the fact that the museum guide use the interpretation to create a link between the heritage contents and the visitor culture. An effectively interpretative approach, indeed, is what determines the transference of cultural understanding (Mc Donnell 2001).

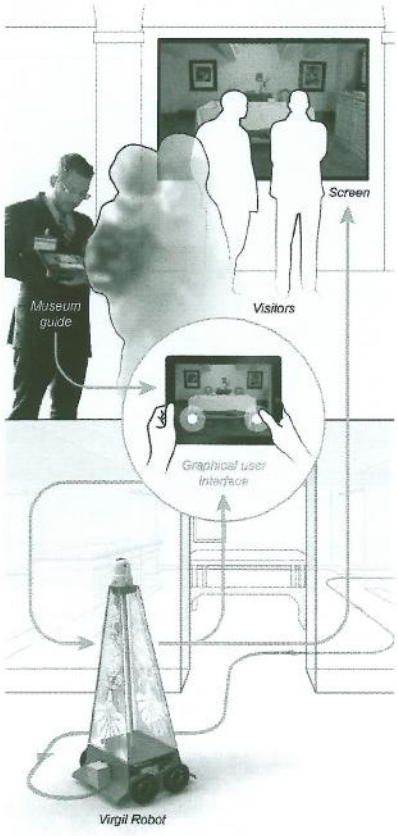

Figure 3: *New Robotic Museum Experience: general scheme of the service*

From these considerations, therefore, emerge two requirements: *make accessible to visitors areas of the residences excluded from the tour and enhance the activity of the museum guides*. The proposed service meets these requirements, extending the museum tour through a real-time virtual tour, made possible by the *Virgil* robot placed in inaccessible areas. The museum guide assumes a fundamental role since, in addition to the usual accompanying and deepening role in the fruition of the cultural heritage, he is entrusted of the remote control of the robot.

The new robotic service introduces the concept of human-robot collaboration (Epstein 2015). Conversely to many robotic solution applied in museums, as shown in the related work paragraph, the storytelling activity continues to be entrusted to the museum guide and a robot assumes a role of remote collaborator, which explore the areas inaccessible for people. Keep the storytelling activity performed by the museum guide is fundamental due to the fact that only a human can provide the interpretative aspect. The interpretation (Mc Donnell 2001), as previously explained, is the process in which the museum guide can create links between the visitor culture and the heritage contents. This process allows visitors to develop an empathic relationship with both the museum guide and the cultural heritage itself.

A further consideration has to be addressed in the comparison of this robotic service with other existing technologies, especially virtual tour. As a matter of fact, virtual tours currently seem to be the cheapest and easiest technology available, however involves considerable limitations in terms of imageability and narration. Even if this solution can achieve high level of image quality, the visual result is never realistic due to the fact that navigating through these environments the adaptability of the image and the fluidity of movement are not like the natural. In addition the narrative activity, if entrusted only to multimedia contents, can appear boring, not really adaptable and restricted.

3.1 Robot Design

The robot, designed specifically for the project, consists in a mobile robotic platform, equipped with a camera that sends a streaming video displayed to visitors on a dedicated screen or on personal devices.

The design process was based on specific requirements, namely the robot should be unobtrusive and homogeneous to the context in which is going to be inserted. This is due to the fact that it is necessary to ensure maximum visibility to the artistic good exhibited in the heritage. For this reason, the cover of the robot is made of PMMA (poly-methyl-methacrylate) and is composed in a

shape of truncated pyramid, reminding to the similar shape largely diffused in Savoy tradition, used in obelisks, bollards and other architectural elements or furniture. The choice of a transparent material, thus, was lead by willingness to avoid the distraction of the visitors from the cultural goods to the robot and besides to meet a technical requirement of maximum lightness.

This solution, therefore, provides a substantial physical and visual lightness, also in line with the *way-finding* elements already present in the royal residence. In addition, in the design process has been introduced the concept of customisation based on the context, consisting in a decorative pattern applied on the robot coverage. The pattern represents the *Palagiana* palm, an already existing decorative motif that can be found in the castle applied in many elements, from the floors to the furniture.

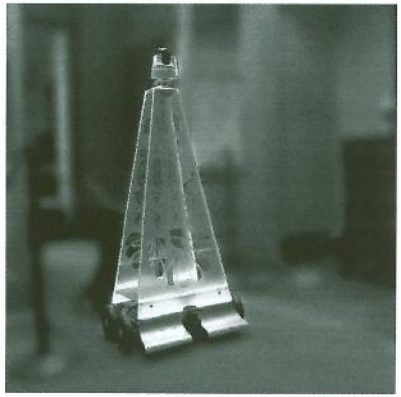

Figure 4: *Virgil, telepresence robot at royal residence of Racconigi Castle*

3.2 Ethics

From the beginning, this project was developed considering ethic aspects as mandatory. Each design choice was made, not just on the base of technical feasibility, but rather with the evaluation of the alternatives answering to questions such as: *is it effectively useful to introduce the robot in this way? Is it preferable the use of the robot compared to other technologies? Is the use of a robot fair towards the various stakeholders?*

According to this approach, the ethical dimension of project is achieved in the attempt to ensure respect both for the location and the various stakeholders.

From the location point of view, the service proposes a possible solution to the issue of inaccessibility of some castle's areas. The concept of widen the accessibility meets the statements of the Franceschini commission according to which the social fruition of cultural heritage have to be guaranteed for the widest possible audience (Ippoliti 2011). This is also reaffirmed by the Decree Law no. 112, which states that a Cultural Heritage have to guarantee the full accessibility, physical and intellectual, of its collections, also ensuring the consultation of goods excluded from the exhibition (D. M. 2001).

The service makes possible the exploration of additional areas of the castle even if is not currently possible to conduct restoration and safeguarding works. In addition, the proposed solution does not require a fixed implantation to perform the activity. Both the robot and the docking station are movable and this meets the requirement to not overbuild in the context, which is a building structured and evolved over the centuries and, hence, can't be modified by structural interventions (D. M. 2001).

From the stakeholder's point of view, the project brings benefits to all the actors involved. The visitors, indeed, benefit from the expanded visiting experience, enriched by the additional knowledge about the robotic solution.

The museum guide, instead, assume a central role in the visiting experience, due to the fact that are entrusted of both the cultural storytelling and the robot control. This generates an enhancement of human work and additional professionalization. This aspect is particularly crucial since it relates to a widely diffused concern about the introduction of robots. The diffusion of robots in industrial field, indeed, generated a substantial replacement of human work and, consequently, an increase of unemployment (Salvini et al. 2010). The introduction of robotics in other fields rises the concern that the same phenomenon could occur. For this reason, during the design process is necessary to consider the human work, avoid its replacement and, moreover, enhance it (Bisol et al. 2014).

Finally, the institutions, to which is entrusted the Cultural Heritage management, benefits from the improvement of visibility and attractiveness.

4. FUTURE WORK

In the following months, there will be the first experimental phase with visitors, in which the early data on the experience by the users will be collected. For this phase, a museum guide will be first trained to drive the robot. This action does not appear easy at first due to the fact that, in the meantime, the guide has to carry on the usual activity of explanation about the museum contents, which includes also a direct interaction with visitors.

For this reason, a more intuitive and usable GUI will also be developed. Subsequently, the user experience will be improved, introducing gamification elements, in order to reach a higher level of engagement and cultural contents enhancement.

5. CONCLUSION

The improvement of Cultural Heritage fruition is a recurrent theme and has been faced with the application of the most diverse technologies. The exemplary case represented by virtual tours, which offers the opportunity of a remote visiting experience, enabled a wide range of new design opportunities. Nevertheless, the limits of this kind of solutions drove to a deep reflection on the effectiveness of a totally virtual experience.

For this reason, the use of Service Robotics in museums is becoming increasingly common. Robots, indeed, represent a bridge between the virtual and the physical world, due to their composite nature. However, the observation of international case studies of museum robotics shown that, since now, many of the proposed solutions were not actually meeting the location and stakeholders' requirements, which usually vary on the basis of the context.

Based on this consideration, a new robotic museum experience has been designed, with the aim to increase the museum's attractiveness, offer a more involving experience to the visitors, and enhance museum guides activity. The proposed solution was developed paying particular attention to the ethical aspects and is meant to represent a shifting in the robotic design process. The applications of new robotic solutions, indeed, are usually based on the opportunities offered by the technology, whereas this project was developed applying a human centred design approach, which focus on people instead of technology.

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ABOUT THE EDITORS

This conference proceedings was edited by:

Dr Kia Ng, PhD, FBCS, FRSA, FIoD, CEng, CSci, is Director of the Interdisciplinary Centre for Scientific Research in Music (ICSRiM) at the University of Leeds. Kia is involved in several research domains including gestural interfaces, interactive multimedia, multimodal, computer vision, document imaging and computer music, in collaboration with many European and international organisations and individuals in the field. Large-scale projects include i-Maestro on technology-enhanced learning (coordinator), CASPAR on digital preservation and AXMEDIS on cross-media with over 20M Euro research funding. Kia has over 200 publications and presented keynotes and invited lectures in over 33 countries. **www.kcng.org**

Prof. Jonathan P. Bowen, MA Oxon, FBCS, FRSA, is Professor of Computer Science at Birmingham City University, Chair of Museophile Limited, a museum and IT consultancy company that he founded in 2002, and Emeritus Professor of Computing at London South Bank University. In recent years, he has been a visiting professor at East China Normal University (Shanghai, China), the Pratt Institute (New York, USA) where he taught a masters course on museum informatics, the University of Waikato (New Zealand), the University of Westminster, and King's College London. Previously he has held posts at the University of Reading, the Oxford University Computing Laboratory and Imperial College, London. He contributes to Wikipedia on cultural and computing-related topics. **www.jpbowen.com**

Dr Nick Lambert, DPhil Oxon, MBCS, is Lecturer in Digital Art and Culture at the School of Arts, Birkbeck, University of London, and Director of the Vasari Centre for Visual Technologies in the Arts. His research interests include art and technology, contemporary digital art and the use of digital technologies in the history of art. He is Chair of the Computer Arts Society and Exhibition Chair of the EVA Conference. Nick also develops digital art projects, including Fulldome projections and installations, that have been exhibited in the UK, USA, and elsewhere.
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