Indoor and Outdoor Profiling of Users in Multimedia Installations

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ABSTRACT

We present a work-in-progress interactive exhibit for the museum of Onna (L'Aquila, Italy). The Onna Onlus and the citizens of Onna have the ambitious project to rebuild the town affected by the earthquake of April 2009 and to create a museum in memory of Onna. In addition to the traditional fruition tools for museums, we have been asked for an interactive system capable to communicate the past events and the efforts invested. We are working on a multi-modal system composed of an indoor environment in which visitors can interact with a natural interface system and an outdoor module based on a cross-platform mobile application. A profiling method is also exploited in order to extract a profile of interest of each visitor and then use it to suggest in-depth personalized and geo-located information about the disaster and the local history via multimedia contents.

Categories and Subject Descriptors

D.2.10 [**Design**]: Methodologies and Representation; H.5.2 [**User Interfaces**]: Graphical user interfaces (GUI), Input devices and strategies, Interaction styles, Prototyping, User-centered design.

General Terms

Design, Experimentation, Theory

Keywords

Natural Interaction; Interaction Design; Location Awareness; RFID; Real-time Location; User Interfaces; Interactive Museums; Multimedia Installations: Mobile Application;

1. INTRODUCTION

Our goal is to design and develop a multi-modal system involving both natural interaction principles [8] and mobile systems to present a large collection of information related to the Onna museum: video interviews with people directly involved in the disaster, images of the town before and after the earthquake, maps representing the alterations of the geography of some places in Onna. The idea is to make it happen according to the different interests of each visitor. Personalization is "a new communication strategy based on a continuous process of collaboration, learning and adaptation between the museum and its visitors" [9]. Strong personalization of all the information provided in a museum is an effort to ensure that each visitor is allowed to accommodate and interpret the visit according to his own pace and interests. The goal is to create a balance in terms of attention required from the visitor, allowing time to also be spent enjoying the "romance" of the exhibit and preventing the visitor from being overwhelmed by an infinite amount of information, even if wonderfully presented. These and other challenges come into play when designing a system for the entertainment and edutainment of museum visitors, moving the user experience from one of simple consultation (commonly achieved with audio guides, multimedia kiosks or web-sites) to an immersion into a rich informative environment. The solution is to provide in-depth personalized contents exploiting the visitors interest profile. The remainder of this paper is organized as follows. In section 2 we present related works in the field of interactive museums, personalization and mobile applications for cultural heritage. In section 3 we propose the work in progress system explaining the architecture focusing on its three main parts. Finally, a scenario is proposed in section 4.

2. PREVIOUS WORK

Recent advances in IT affect our everyday life in various aspects, providing access to different informative, educational, scientific or even entertaining resources in a new manner. Such technologies can be exploited even by museum curators who want to enhance visitors' museum experiences in a more personalized, intensive and engaging way both on a virtual and physical level. This is why, in recent years, the purpose of museums has shifted from merely providing static information of collections to providing personalized services to various visitors worldwide, in a way suiting visitors' personal characteristics, goals, tasks and behaviours [9]. Since its early roots in the WebLouvre by Nicolas Pioch in 1994 [3], the state-of-the-art in interactive multimedia has being enhancing museum experiences. In the San Francisco Museum of Modern Art (SFMOMA) website [4] users are able to browse an extensive virtual catalog of works of their

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collection, whilst Google StreetView technology is exploited to build an interactive, virtual and explorable 3D model of a physical museum exhibit in the Google Art Project [2].

Furthermore, the continuos spread of multi-sensor solutions and advanced technologies for mobile communication, capable of linking each visitor with the surrounding objects, feeds the so-called Internet of things [7]. There are interesting experiments exploiting proximity-based interaction in order to analyze the user physical behavior near an object. A visitor equipped with a mobile device can receive - in a completely automated way - flows of multimedia information, simply approaching one of the works of art [12] [11].

The theme of personalization enjoys a long history in multimedia information analysis, and in particular in the context of interactive multimedia museums [15]. The affirmation of social networks (web 2.0) makes available a large amount of personal information regarding the interests of individuals and the relationships between different profiles of interest: such data can be merged with those extracted by monitoring the visitor's behaviours inside a museum in order to refine his/her profile of interest.

Many museums provide natural user interfaces both exploiting interactive surfaces for large audience (e.g. multi-touch tables, walls or floor) and personal mobile devices such as smart-phones or tablets. These devices improve the quality of the exhibition experience by providing visitors more informed enjoyment and knowledge, hence greater engagement with the artworks [10].

Several research projects and prototypes developed over the last years aim to improve cultural heritage experiences also through mobile devices. Previous works [6] [14] [13] suggest that such mobile solutions for cultural heritage should focus on three different aspects: the personalized information provided, the physical environment around the user and the social interaction.

3. THE SYSTEM

As shown in fig. 1, the indoor and outdoor part of the system communicate through the profiling layer.
The **indoor system** is an immersive space in which a large interactive screen allows multiple users to have a multi-sensorial experience by seamlessly interacting with multimedia contents (videos, images and audio).
The **profiling layer** collects and analyzes all the data coming from:

- the natural interaction module;
- the position detection module;
- users on-line profiles.

The personal bag of information extracted is then used in the **outdoor system** through mobile devices to exchange data with geo-location systems (i.e. GPS) in order to propose recommended points of interest of Onna and related in-depth contents.

3.1 Indoor system

The Natural Interaction module exploits Computer Vision solutions in order to recognize and analyze user gestures and make the interface able to respond to their requests. The installation is composed by a central interactive rear-projected screen and two lateral screens used for displaying non-interactive multimedia contents (see fig. 2).
A short throw projector is positioned behind the central screen in order to display the main user interface. Furthermore, an infrared camera and IR illuminators are positioned behind the screen. User gestures in front of the central screen are captured by the infrared camera and then processed by the Computer Vision module based on diffuse illumination technique [8] in order to understand the interactions. The installation is positioned in a room of the exhibit that has been darkened and made soundproof, in order to prevent issues due to light changing conditions and external sounds.

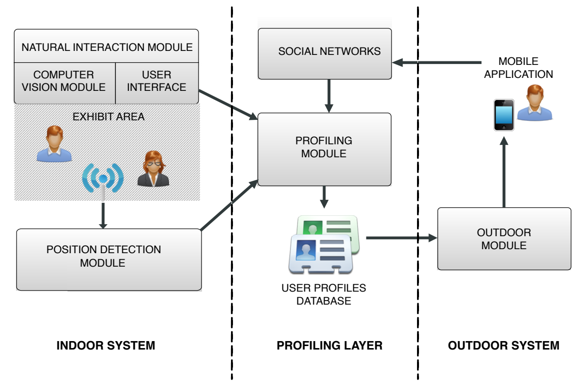

Figure 1: System architecture.

The user interface is inspired by an educational game-book published in the seventies about the devastation of the town of Pompei caused by the eruption of Vesuvius in 79 B.C. It presents an aerial view of the town of Onna after the earthquake: users can interact with a particular area of the map and then visualize the pre-earthquake status.

In addition for each area the interface shows multimedia assets about history, architecture and life of the town, like video interviews, images and maps. Such contents are showed in the lateral audio-video displays in order to avoid information overload on the main screen (see fig. 3).
The position detection module provides a solution for identifying every person interacting with the natural interaction system. Each visitor is equipped with an RFID tag in order to have a unique identifier exploited by the system to associate to it personal data extracted during the interactive session. We divided the installation environment in two areas of identification, allowing two visitors to interact simultaneously. The idea is to read the Received Signal Strength Indicator (RSSI) [16] from two antennae pointing toward the area where users equipped with RFID tags stand during their interaction. An SVM classifier has been used in order to determinate if the tag is located in the left or right area.

3.2 Profiling layer

The minimization of feedback requests is usually desirable in personalization systems, since this reduces intrusiveness and, as a consequence, helps to avoid the visitors' irritation: this is why we aimed at learning user preferences and providing recommendations automatically. Recommendation systems enhance user access to relevant information by using techniques such as collaborative filtering, content-based filtering, and hybrid approaches (see for example [5] for the re-

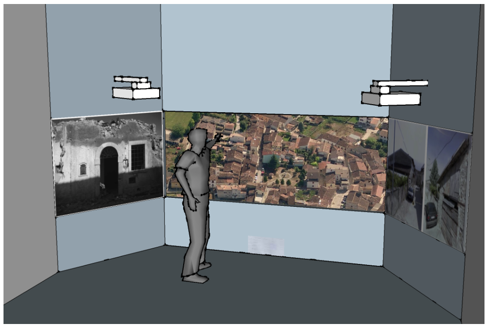

Figure 2: The installation setup.

Figure 3: A user interface testing session.

cent survey of the state-of-the-art). *Content-based methods* analyze the common features among the contents selected by a visitor and recommend those contents that have similar features. *Collaborative-based methods* search for peers of a visitor that have similar known preferences and then recommend those contents that were most fruited by the peers. We are leaning toward an *hybrid approach*, which combines collaborative and content-based methods in order to exploit the benefits of each separate solution.

Information about the users can be implicitly inferred by observing their behavior in the museum during their interaction with the user interface, and also through the explicit interest profile provided by the visitor himself through social network tools (e.g. Facebook, Twitter and so on). The profiling module processes these data in order to populate a database containing the history of all the visitors' activities thus building a profile of his/her interests. *User profiles* are exploited by the outdoor system in the process of content generation to describe or recommend potentially relevant multimedia contents and real-world points of interest to people using the mobile application. Collaborative filtering is performed comparing the user profile to those with similar features and extracting common interests using both information coming from the indoor system and data extracted from on-line profiles. The recommendation system can extract information directly from the user's Facebook profile through the Open Graph API.

3.3 Outdoor system

The outdoor module is a location-based service [15] that uses geographical information from mobile devices via GPS. In order to enhance the visitors' experience during their out-

Figure 4: Screenshots of the mobile application.

door visit to the town, we developed a cross-platform mobile application using the Titanium Appcelerator framework and Javascript programming language. After his/her interactive session with the virtual exhibit, a user can download the application on his/her device associating it with the provided ID (using the code printed on his RFID badge).

In this way the system can use the interaction history of the user in order to create and suggest itineraries through the town. When the user registers an ID, the application retrieves from a web server a list of geo-referenced points of interest based on the user profile. Then, using the Google Maps API direction service, a personalized walking itinerary is proposed to the user together with in-depth related multimedia contents.

The GPS module of the modern smart-phones [17] allows the application to detect the user's latitude and longitude with a certain accuracy, that may change due to the device capabilities or the strength of the signal received.

Given the coordinates of a point of interest in the town, defined by his latitude and longitude in radians (ϕ_{poi}, ψ_{poi}) and the coordinates obtained from the GPS module (ϕ_{gps}, ψ_{gps}), we can calculate the distance between these two points using the Haversine formula [1]. The distance d, in kilometers, is therefore obtained using the formula

$$d = 2r \arcsin\left(\sqrt{\sin^2\left(\frac{\Delta_\phi}{2}\right) + \cos(\phi_{poi})\cos(\phi_{gps})\sin^2\left(\frac{\Delta_\psi}{2}\right)}\right)$$

where $\Delta_\phi = \phi_{gps} - \phi_{poi}$, $\Delta_\psi = \psi_{gps} - \psi_{poi}$ and r is the radius of the Earth.

If d is less then a threshold distance of 200 meters, the application notifies the user that a point of interest of the city is in the nearby vicinity. Since modern smart-phones allow multitasking, we have also implemented the GPS module to read the position when the application is in background mode. In this way, users won't need to keep the application active while visiting the town.

Using the mobile application, user can also use a third-party login in order to link to an existing profile on a social network. For instance, a user can login with a Facebook account feeding the profiling module with his/her explicit interests. By accessing the Facebook profile the application will also be able to retrieve the list of the user's friends that have already visited the town: the extracted data can be useful to enrich the recommendation service. Some screenshots of the mobile application can be seen in fig. 4

4. USE CASE SCENARIO

Let us consider the following scenario describing the actions that are required for visitors in the museum of Onna to perform the complete indoor-outdoor experience. The first stage is at the entrance of the indoor system: the visitor receives a personal badge (equipped with a hidden RFID tag) and then installs the Onna mobile app on the smartphone. After associating the badge with the personal profile on the mobile app via a unique identification number, the visitor is able to interact with the immersive installation. Whenever an area on the map of the central screen is triggered and related multimedia assets are played on the lateral screens, the system monitors which asset is played and how much time the visitor focuses his attention on a particular content. Such information are then stored in a database. Thus a personal profile of interest is built in the indoor system and then linked to the visitor via the ID on the RFID tag.

In the meantime another visitor can receive the badge and enter the exhibit. The user interface of the interactive installation reacts to the actions of this further visitor showing the multimedia assets on the other half-side of the screen. The system records his activities in a new personal profile of interest, which will be stored in the same database with a different ID.

A second stage of the experience is when visitors leave the exhibit and go outdoor into the town. While they are visiting the various areas of Onna, they can activate the app on their smartphone, which connects to the indoor system database via an Internet connection, showing information based on the actions performed during the indoor session. The app provides two different modes of operation. The former can be activated at the beginning of the visit and consists of proposing a path through the areas of the town, in order to visit all the places related to the multimedia assets that were mostly interesting for the visitor during the indoor session. The latter option could be useful when a visitor is already in a particular area and desires in-depth information. In this case the mobile app detects the location of the visitor via GPS and proposes the multimedia assets showed in the indoor system, eventually ordered according to a ranking based of the mostly interesting ones.

5. CONCLUSION

This paper presents a prototype of an indoor-outdoor solution for providing a multimedia experience in artistic exhibitions. Tourists and citizens of Onna (Italy) can visit for first the interactive installation and navigate multimedia assets about history, architecture and life of the town. The sessions of interaction are recorded by a CV system and then associated with visitors' smartphones. All the collected data are then analyzed when people leave the exhibit, in order to propose paths of interests and multimedia enriched information via the smartphone based on their location. Future work will address an extended experimental evaluation of the indoor system in order to record efficiently the activities of many users at the same time, as well as a test to estimate the outdoor user experience.

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