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Interactive Mobile Assistants for Added-value Cultural Contents

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Abstract

Multimedia technologies provide new opportunities for museums to enhance their visitors' experience. However, its use brings new challenges for presentation preparation, among which are how to enrich the visit while not diverting the visitors' attention from the actual objects in the museum, which should remain the focus of the visit; and how to provide a rich information space suitable for a wide variety of visitors. These challenges need to be addressed during planning and preparation of information presentations for mobile, multimedia museum visitors' guides.
This paper describes the design and implementation of the AMICo prototype to an exhibition room for visitors who are equipped with wirelessly connected handheld devices. The prototype has been implemented on an exhibition showing a set of architectural scale models from the famous Spanish architect Rafael Moneo hold in the Kubo exhibition centre of the Kutxa Foundation in Donostia-San Sebastian during September and October 2005. The architectural scale models were augmented with information in the form of multimedia content. Users were able to access those contents in a personalized way when in the proximity of the artwork.

Categories and Subject Descriptors (according to ACM CCS): I.3.6 [Computer Graphics]: Methodologies and Techniques

1. Introduction

Museums and exhibitions do not communicate. These places are often only a collection of objects, standing deaf in front of the visitors. In many cases, objects are enhanced with textual descriptions, usually too short or too long to be useful for the visitor. In the last decade, progress in multimedia has allowed for new, experimental forms of communication in public spaces using computer technologies.

Implementations range from simply using standard PCs with multimedia applications to large theatres that immerse users in virtual worlds or reproduce and display 3D models of masterpieces. Content generators often just transfer the available technology to traditional museum schemes, without paying much attention to the ways they expect users to interact with the system or to the cognitive and aesthetic factors involved.

During the last decades, a large number of projects related to the application of innovative technologies to Cultural Heritage has been implemented. Several European projects have assessed some of the most outstanding technologies: 3D digitalization and scanning techniques have been used for the reconstruction of historical objects (3D-MURALE); Virtual and Augmented Reality technologies allow new interaction ways for users and experts (ARCHEOGUIDE, RENAISSANCE, CHARISMATIC); and mobile devices and multimodal interfaces provide intuitive and personalized access to scientific information from museums and archaeological sites.

Concerning multimedia mobile guides, they must support important personalization of the content owned by a cultural institution in order to provide users with an enjoyable visit in accordance with his/her background. At the same time, a guide for a museum or exhibition room should encourage learning and personal enrichment. Therefore, information should be displayed taking into account the physical location of the visitor and the position of the artworks in their natural environment. The overall experience can be optimized connecting the information of the exhibition and the presentation to the visitor in a coherent way depending on the location.

This paper describes the design and implementation of a prototype for visitors to an exhibition equipped with wirelessly connected handheld devices. Section II of the paper presents a brief state of the art about current applications concerning electronic guides in cultural environments. Within Section III, the project is described, including the main requirements and objectives, the design and implementation of the AMICo prototype and the validation scenario.

Section IV presents the modules of the prototype: the relational database for the existing information about the exhibition, the author and the artworks; the Authoring Tool implemented for the generation of multimedia personalized added-value contents; the tracking system based on wireless technologies; the visualization device and the tools for the assessment of the behaviour of the visitor. Finally, some conclusions are provided.

2. State of the art

The growing availability of portable devices with increasing computational and interactive resources in terms of power and capacity has raised research issues regarding the design of user interfaces for applications with such devices. Currently, museums and cultural institutions are becoming an attractive application area for such interactive mobile devices.

Museum visitors can be assisted in several ways. One possibility is the use of Audio Tours: visitors can use a sort of large telephone receivers. They can select the work of interest typing its code through a numeric keypad. Audio Tours are useful precursors of electronic guides, although they have limited visual channel.

Museums have used portable electronic guides or eBooks since the 50s. Although they have already had a long history, these guides are still raising research issues regarding the use of portable computers. Electronic books allow displaying information and disseminating content during the interaction with different objects of an exhibition. Currently, multimedia guides display static images or pre-recorded videos describing the artworks of an exhibition.

One of the first fully operating systems in a museum setting was implemented at the Marble Museum of Carrara [CP04]. The managers of the museum decided to provide their visitors with additional information to that available in traditional formats such as leaflets or audioguides. The system stores the information locally in the memory of the PDA, uses a map to guide the visitors around the museum and presents content of different abstraction levels (room, section and exhibit).

The Sotto Voce system implemented by Xerox analysed the use of mobile technologies in exhibitions [AGH*02]. The project was validated in different exhibition rooms of Filoli, an historical house in Woodside, California. Each visitor carried a Compaq iPAQ device with a tactile screen, a wireless card with Internet protocols and a single-earphone. The evaluation of the prototype has been positive, because a balance expenditure of the time of the visit between the electronic books and the real artworks was achieved.

Zancanaro, Alfaro and Stock [ZAS03] have implemented kinematics techniques for the visualization of some details of the frescos at Torre Aquila, a tower of the Castle in Trento. The multimedia guide, implemented with Macromedia Flash on a PDA, detects the position of the visitor by means of infrared emitters placed in front of each panel. The multimedia presentation is composed of an audio commentary accompanied by a sequence of images that appears on the PDA display and helps the visitor quickly identifying the details of the fresco mentioned in the commentary.

Headquartered at the Exploratorium in San Francisco, the Electronic Guidebook project [RS02] is a study of visitors for the evaluation of the use of wireless network technologies in order to "bridge the physical and virtual worlds". Visitors to the science museum were equipped with wirelessly connected handheld devices. The museum exhibits were augmented with information and services based on Web technology, so that users could access the proper contents when in proximity of the exhibits.

Sponsored by Bloomberg, the Tate Modern's Multimedia Tour Pilot was open to the public from July to September 2002 [Wil04]. Developed by Antenna Audio in collaboration with Tate Modern, the multimedia tour was a 45-minute tour of the Still Life/Object/ Real Life galleries, in which visitors could experience audio, video, still images and a variety of interactive applications on handheld iPAQ computers loaned by HP. The content of the multimedia tour was delivered to the visitor through the wireless network of the museum, using location-based technologies.

With the technological support of Sun Microsystems, the J.Paul Getty museum has developed the GettyGuide project in order to supplement its network of information kiosks. The project is based on Palms as the mobile platform, and uses Flash to display the multimedia content received from the museum central server via its wireless network. Moreover, visitors can search for artworks by queries using several criteria such as artist or genre.

Finally, the main goal of the MoMo system is the design of a user interface for multimedia applications on small devices such as PocketPCs [JEMC05]. The key issue faced by this system is the way information must be displayed so that it is assimilated by the user in the most adequate way. The project introduces a new type of browsing graphical control in the framework to explore collections of arbitrary related information.

For further information, the reader is referred to [RTA05], where a detailed review of mobile applications in museum environments is provided, focusing on the notion of context.

3. Description of the AMICo project

The AMICo project analyses the use of wireless technologies in the implementation of interactive mobile assistants based on Virtual Reality and storytelling technologies. The availability of portable devices with wireless capabilities has a great potential in the Cultural Heritage application domain. Using the wireless networks, mobile devices can detect the position of the visitor and stream multimedia content in real time.

The project relies on a high-bandwidth wireless infrastructure to download information about artworks as visitors walk through the exhibition. This enables supporting them with interactive services and highly dynamic information. In addition, the same network infrastructure provides location information to the system.

The AMICo prototype focuses on three simultaneous areas of research: information technology infrastructure (network components delivering the information and tracking the user); human computer interface issues (usability, interfaces); and content development (design, formatting). The project has been designed as a proof of concept study to explore potential areas for further research and development.

Finally, one of the main objectives of this project was the evaluation of the behaviour of the visitor when new technologies are introduced in cultural and artistic environments. A deeper knowledge about human behaviour in cultural institutions in relation to concrete technologies approaches has been generated. The results of the usability study will be published in further scientific papers.

3.1. Requirements of the prototype

The AMICo prototype includes two different components: the mobile device that is carried by the user and the server that provides multimedia content. The multimedia mobile device is the interaction interface between the user and the system. Its main requirements include wireless connectivity with IEEE 802.11 networks, portability (weight) and support for multimedia presentations (size, colours, resolution).

The server is responsible for collecting and processing queries from the mobile devices; determining the location of the mobile guides on the basis of the data coming from the tracking system; managing and rendering the personalized added-value content; and storing the results of the evaluation process.

Wireless communication technologies are a key issue within the project due to the different available mobile devices and solutions (colours, size and weight, processing capacity). Another important aspect is the ability of the mobile devices to be tracked by an accurate system for indoor applications (RFID, WLAN, Bluetooth). Moreover, the wireless network should be designed in order to support the simultaneous performance of several mobile devices with the proper bandwidth.

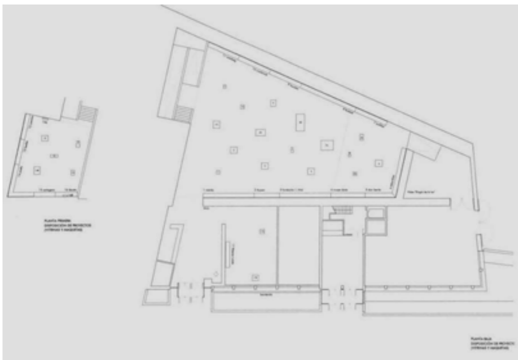

Figure 1: *Layout of the 17 architectural scale models.*

Regarding the contents available for the user, while traditional golden rules for interface design are a basic reference in the field of Human-Computer Interaction, there are no equivalent guidelines for mobile devices. The main requirements that have to be fulfilled by those contents are:

- Functionality. Graphical user interfaces should not require long learning curves, avoiding approximations that may not be intuitive for the user. By doing so, we contribute to relieve efforts of the users when interacting with the prototype and make their experience more attractive.
- Simplicity. The information provided to the user must be multimedia in nature. Multimedia information is very familiar to the human perception and, consequently, very attractive. It should be taken into account that although there could be large amounts of information to be potentially accessed, this process should be transparent to the user.
- Flexibility. The solution should be adaptable to the range of domains in which it might potentially be used: museums, monuments or exhibition rooms.

3.2. The AMICo prototype

The AMICo prototype has been implemented on an exhibition showing a set of architectural scale models from the famous Spanish architect Rafael Moneo hold in the Kubo exhibition centre of the Kutxa Foundation in Donostia-San Sebastian during September and October 2005. As a curiosity, it must be mentioned that the exhibition centre itself is placed inside one of the buildings designed by Moneo. The exhibition included 17 architecture scale models distributed in three exhibition rooms as shown in Figure 1.

Visitors carry the prototype with them as they walk

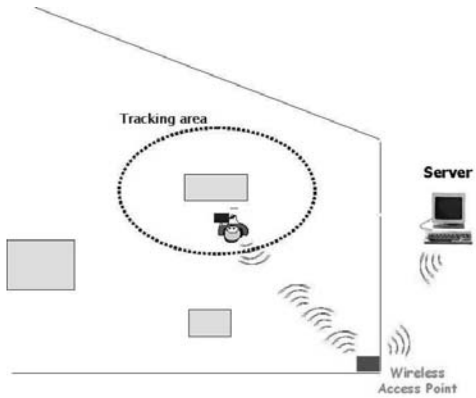

Figure 2: *Performance of the AMICo prototype.*

through the exhibition. When the mobile multimedia guide detects that a visitor is in the nearby of a specific scale model, general information about the scale model is displayed, including its main characteristics, texts and additional images (Figure 2). Furthermore, the system provides further information about specific topics, such as architectural details or materials of the real building.

For example, one of the most outstanding scale models was the future Church of Riberas de Loyola, a new district that is being built in San Sebastian. When approaching the scale model, visitors could visualize multimedia content on their handheld guidebook, so that they could perceive the future visual impact of the Church within its environment.

The multimedia presentation consists of an audio commentary combined with a sequence of images that are streamed and rendered in real time in order to help visitors quickly identifying the scale model and the real building. At any given moment, the user is free to pause or even stop the presentation by clicking on the appropriate control panel button.

As it has been mentioned, one of the aims of the project has been the usability study of interactive mobile assistant devices in real exhibitions. Therefore, the visualization application traces and records the selections of the visitors, the concepts that have been visualized, the time spent on each information piece and the concepts required for more information. At the end of the visit, a short questionnaire is provided to the user in order to gain information about further improvements of the system.

4. Technological components

4.1. Overview of the system

The prototype includes five main components: storage of the existing multimedia information about the buildings and the author using relational databases; generation, storage and management of added-value content with an Authoring Tool; tracking of the user based on wireless technologies; visualization of the multimedia content and evaluation of the behaviour of the visitor.

4.2. Storage of existing information

Within six months, multimedia information about the scale models has been collected, including technical and aesthetical aspects of the real buildings, biographic data about Moneo, audiovisual material about the building process and additional contents.

We have analysed the different existing approaches for the storage of the information, including relational databases, where all the available data is organised in value tables; object-oriented databases; and information repositories, where the information is not structured due to its high dynamism.

After a deep study of the requirements of the system, a relational database has been implemented in order to take advantage of the associated Data Base Management System (DBMS) that helps managing the database. A DBMS is a group of programmes, procedures and languages that allows working on a database without accessing the programming language.

MySQL has been selected to implement the relational database. The final structure of the database has been compiled from the requirements and the proposed schema from the content generators. Main value tables include data about Rafael Moneo (complete name, place and date of birth), his academic studies (undergraduate studies, postgraduate, masters, PhD) and his outstanding buildings (name and place, objective of the building, technical and aesthetical aspects, materials, illumination).

4.3. Generation, storage and management of personalized added-value contents

The content generator uses the available information to generate the personalized added-value contents that are presented during the exhibition using an Authoring Tool. The generation process using the Tool consists of two main phases: the definition of concepts or contents, and the implementation of the associated web pages for each concept. The AMICo concepts are related to the architectural scale models of the exhibition.

Concepts are only created once and can be classified into two main categories: general and specific. The former includes generic information about the content. On the other hand, the latter is used when content generators want to offer specific information about some pieces of the content. When visualizing the information, the visitor is allowed to choose between both possibilities.

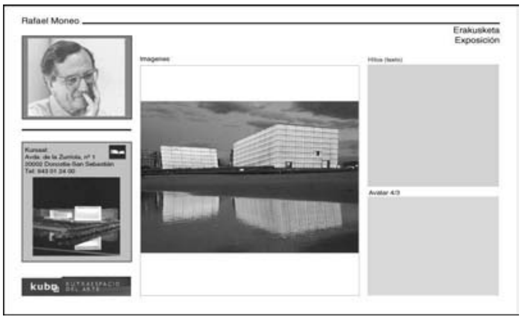

Figure 3: *Example of the template for the content of a scale model.*

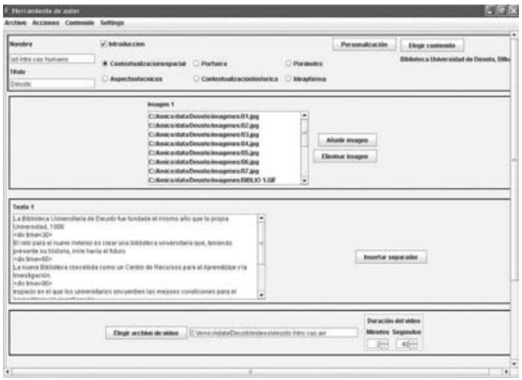

Figure 4: *Generation of added-value content using the AMICo Authoring Tool.*

Firstly, the appearance of the output is selected on the basis of some previously defined templates (Figure 3). These templates are dynamically created, allowing changing the distribution of the different types of content for visualization on the final web site. For instance, one template can include a field for text information and two fields for graphical information. Content generators determine the final choice of the template and the content.

Each content includes different types of information: images, texts, videos and audio files. Most of those types can be stored in sequences. This means, for example, that the content generator can specify a sequence of images to appear synchronized with the spoken text.

As content is personalized to the visitors, the same information must be presented to different profiles of users. Therefore, a profile is attached to the content during the generation process with the Authoring Tool. Although each concept includes different pieces of information, each of them is classified according to the user profile.

Once the added-value content has been created, it is stored in a second database for personalized contents, independent from the information database. This second database is owned by the Kubo exhibition centre as well as the added-value multimedia content that is visualized on the mobile device.

The second database has been filled by the content generators. The main advantage of storing the content in a database is that the output can have any format. Using an intermediate application, the information could be exported to different formats (a web site, audio). Another advantage is the possibility of adapting the content to different visualization devices.

The output of the storage and management system has a web site format. All the scale models have a main page whose URL is stored in the server, as well as several subpages. When the main page gets downloaded by the browser once the tracking system has detected the position, the visitor can click on some parts of the image to get further information about some of the related contents.

4.4. Tracking of the user

Location awareness is seen as a key issue within the AMICo project. Information about their position is not interesting for the users in most of the cases. However, if a system is aware of the current location of the user, it can infer what the most interesting contents are.

Within the project, we have selected the Ekahau software, a cost-effective solution for indoor location systems based on a Wi-Fi based location estimation system using the existing IEEE 802.11 network infrastructure. The selected approach can provide meter-level accuracy, which was assumed as acceptable for the AMICo validation scenario.

4.4.1. Selection of the tracking system

We have taken advantage of the high features of the visualization device, which is sensible to the use of wireless connections, in order to track the position of the user by means of the Ekahau software. The software including three components (Ekahau Client, Ekahau Positioning Engine (EPE) and Ekahau Manager) allows implementing location based applications for mobile devices working over a IEEE 802.11 network.

One of the main advantages of the Ekahau software is that there is no additional need for specific Access Points, because the existing ones can be used. The Kubo exhibition centre is composed of three exposition rooms, with a total area of 739.6 m2 distributed among three different exhibition rooms of 489, 146.6 and 104 m2 each. In order to cover the mentioned area, five Access Points have been installed, three on the main room and one on each of the remaining rooms (Figure 5).

The selection of the software was mainly based on the existing successful application scenarios. Even through the learning curve is quite complex, the installation process was quite simple.

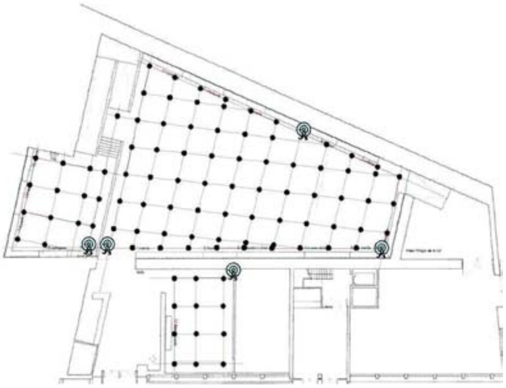

Figure 5: *Distribution of the Access Points.*

Figure 6: *Graphical interface of the implemented YAX application.*

4.4.2. Detection of the scale models

The Ekahau Positioning Engine (EPE) includes a standalone application with two different ways for detecting the position of the user: the Ekahau SDK for Java developers and the YAX protocol for any programming language supporting TCP sockets.

The YAX protocol has been implemented using the C++ object-oriented language, as the application for position tracking is independent from the content-supply application developed in Java. In addition, the YAX API has been completed with a plain graphic interface so as to help the personnel from the exhibition centre with the position tracking task.

The implemented YAK application allows selecting the desired scale model from the database, its position in the room, and the area around the artwork where the user should receive the information as shown in Figure 6.

Once all these data have been inserted, the program automatically detects which of the visitors should be provided with the proper information.

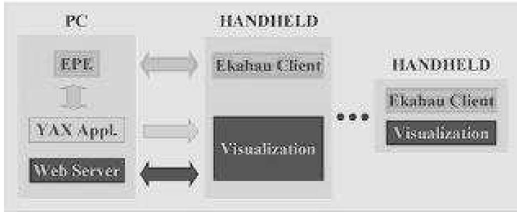

Figure 7: *Communication among the components of the tracking system.*

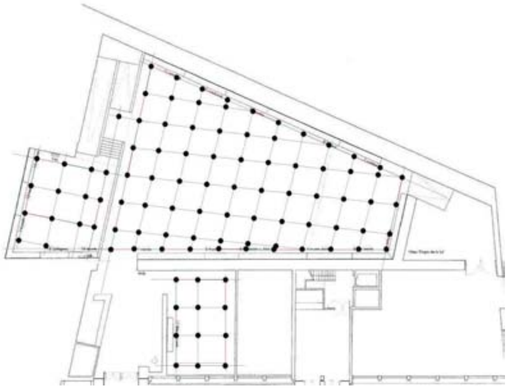

Figure 8: *AMICo and the grid of the WLAN tracking.*

4.4.3. Performance of the tracking system

For a robust tracking, several aspects must be fulfilled: the EPE has to be installed in a computer, the Ekahau client should run on each handheld and a Wi-Fi net equipped with enough Access Points must be available. Figure 7 shows the modules of the prototype and the communication flow between them.

Two different phases are required for a correct calibration of the tracking system. Phase I can be called the offline training phase, in which we have performed a site survey by measuring the received signal strength indicator from different Access Points (APs) at some fixed sampled points of the exhibition room. Figure 8 shows the selected grid for the exhibition room. The measurements are recorded onto a radio map that depicts the strength indicator values of APs at different sampled points.

Phase II is known as the online estimation phase, in which the location of the scale models is calculated in real time by matching sampled points on the radio map with the closest strength indicator values to the target.

Figure 9: *The OQO as the visualization device.*

Figure 10: *Use of the prototype within the exhibition.*

Once the calibration process has been successfully achieved, the system performs as follows. The EPE is constantly tracking the position of the handhelds via the wireless LAN. The tracking data is retrieved by the YAX application, which calculates if users are inside the areas where information should be provided. If so, the identifier of the architectural scale model is sent to the Java application running on the handheld, which in turn asks the web server for the information relative to the mentioned identifier.

4.5. Visualization of the content

In order to implement a light, wireless and compact prototype, we have selected the OQO handheld computer as the visualization interface. Due to its high performance, this device allows not only the streaming of the personalized multimedia content to visitors, but also the tracking of their position.

The OQO is a compact unit measuring 4.9" x 3.4" x .9", based on a 1GHz Transmeta Crusoe processor that weights approximately 400 g (Figure 9). We found the unit to have a battery life nearly one hour and 45 minutes while requesting web information via wireless LAN, and to be relatively resistant to rough treatment.

Preferences, previous knowledge, interests and movements of the user within the exhibition room have been modelled to achieve a better match between the content and the current context of the user. As content is personalized, visitors must first fill out some simple questionnaires in order to collect some personal details, such as their interests and preferred language.

As mentioned before, when the visitor gets close to a scale model, the visualization application receives the identification of the scale model in front of the visitor. Based on the profile of the visitor, the application makes a query to the server to decide which piece of information is the most appropriate.

Once the piece of information to be shown is determined, the visualization device makes a query to the content database, so that it can create the web site "on-the-fly" and send it to the handheld device. All the multimedia files are stored in the server. Therefore, the only thing that must be installed in the handheld device is the visualization application. This provides the system with high flexibility in order to update contents.

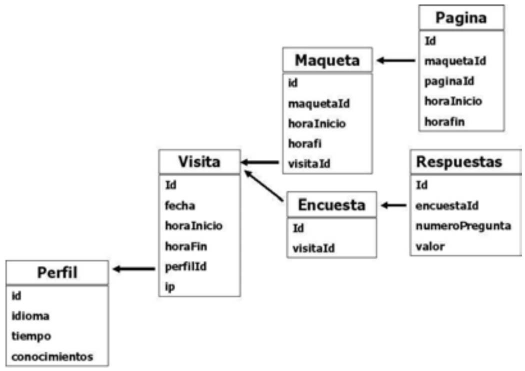

Figure 11: *Schema of the database for the evaluation of the behaviour of the visitor.*

4.6. Evaluation of the behaviour of the visitor

As an additional tool to support the usability study of the AMICo project, the implemented client-server platform stores all the choices made by the user. In order to manage all the information, a third database has been implemented (Figure 11), independent from the information database and the database with the added-value contents generated with the Authoring Tool.

The database stores the profile of the visitor; general data about the visit (data and timetable); the scale models that have been visualized and the visualization time for each content; and the answers to the questionnaires that are filled after the visit.

5. Conclusions and further work

A multimedia information system has been implemented in order to allow users to access specific information related to their immediate surroundings using mobile computing devices. The system has been implemented to provide information about the exhibition of architectural scale models of the famous Spanish architect Rafael Moneo in the Kubo exhibition centre in San Sebatian, Spain. The system allowed the user visualizing images, listening to audio and reading textual information while standing in front of the scale models.

The implemented infrastructure consists of five Access Points (APs) distributed properly so that the whole exhibition room is covered. Each AP communicates with the user's mobile device using Wi-Fi networks. The proposed prototype includes different components, such as a tracking system based on wireless LAN, real time multimedia content streaming via the wireless LAN and personalization of the content due to the definition of different profiles for the users.

Several problems were found regarding the implementation of the tracking system based on the Wi-Fi network, mainly due to the layout of the exhibition room. One problem of the Wi-Fi based location system was the amount of manual calibration effort needed to build the radio map during the offline training phase. It was necessary to compile a fairly dense radio map to compromise a large amount of measurements at different sampled points to attain reasonable position accuracy.

Another issue was that the central exhibition room of the Kubo exhibition centre is too open, so that signal levels were too similar in order to calibrate the system properly. Therefore, the provision of information was limited to three scale models, physically enough far away from each other in the exhibition room to avoid interference, namely the future Church of Riberas of Loyola, the Congress and Exhibition Centre Kursaal, and the Library of the Deusto University.

Further difficulties were found concerning the streaming of the contents in real time. The roaming among the five APs was developed on the basis of existing algorithms to manage the connectivity using the Windows XP driver of the OQOs. In the algorithm, there is no disconnection from one AP even though there could be another AP in the nearby with better coverage of the area. This caused several problems in the efficiency of the streaming of contents in real time, as the signal was lost in some areas of the exhibition room.

Regarding the content, the usability study showed that traditional approaches that have been applied to the design of contents are no longer feasible for current interactive multimedia applications. Therefore, several aspects were highlighted by the users, such as the layout and design of the templates, or the quantity of information provided. However, although different aspects should be improved, users have perceived an added-value in the use of advance mobile guides within the exhibition centre and they would be even willing to rent the guide during their visit for a couple of euros.

Finally, we can conclude that the optimal multimedia guide should support strong personalization of all the information provided in a museum in order to ensure that each visitor is allowed to accommodate and interpret the visit according to his/her own pace and interests. At the same time, a museum guide should foster learning and self-development so as to create a richer and more meaningful experience.

6. Acknowledgement

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