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WEARABLE PERSONAL ASSISTANTS FOR THE MANAGEMENT OF HISTORICAL CENTRES

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ABSTRACT:

One of the main tasks facing the manager of a historical centre is to avoid degradation while retaining the historical value. For this reason, any intervention which takes place on the environment, should be carefully managed. Only when performing a proper diagnosis of the environment and its reality is possible to follow a high quality intervention. The integration of new information technologies has been crucial to the improvement of these processes providing new tools. Within the project called RASMAP, we have designed and implemented a mobile augmented reality platform based on a service oriented architecture. This project introduces the concept of Wearable Personal Assistant (WPA). WPA in the RASMAP platform represents an innovative wearable tool, which provides support to professionals in their daily activities (mechanical engineer, safety responsible person, diagnosis expert, etc.). This tool is based on augmented reality technologies, mobile devices and communication infrastructures. The development of the platform for the WPAs implies addressing several technological challenges: a) to overcome the limitations inherent in the mobile devices: speed, capacity of memory, capacity of storage, graphical features and others, b) to obtain tracking systems that they do not need to alter or to adapt the environment, c) to optimize for the transmission and reproduction of multimedia contents through wireless networks on mobile devices. In this article, we describe the RASMAP platform, as a basis for the development of WPA and the extension of its use for the management of historical centres. The quality and usefulness of the scientific-technological results provided by the WPA have been validated developing a demonstrator for the diagnosis of the conservation status of the historical centre of a small town in the Basque Country. The advantages to be gained by using WPA in the proposed scenario are among others: more efficient processes, improved communication between users, and local and distributed multimedia content records.

1. INTRODUCTION

Three technological factors can be identified in the favourable transformation of many of our daily activities, including process and habits of behaviour. These three factors are the reduced size and cost of the portable devices, the potential of the multimedia in mobile devices and the wide wireless connectivity of these devices. Today it does not seem strange to use mobile phones or PDAs to take a picture, send an e-mail or take notes in a meeting.

Mobile devices can become the key element to transform and improve various kinds of activities such as the visit to a museum, attend school or repair industrial equipment. They are being introduced in all areas of daily life. But the success of these applications lies not only in the technological evolution and their low cost, but also in the design and implementation of systems that support new mobile applications, which provide the user with support in his activities. Based on the evolution of technologies previously mentioned in this article, we introduce the concept of Wearable Personal Assistant (WPA) as a lightweight and versatile tool to support the daily activities of non-professional and professional users. WPA presented in this paper has been developed based on the mobile augmented reality platform implemented in the project RASMAP.

In the field of Cultural Heritage, one of the main tasks facing the manager of a historical centre is to avoid degradation while retaining the historical value. For this reason, any intervention which takes place on the environment should be carefully managed. Only when performing a proper diagnosis of the environment and its reality, is possible to follow a high quality intervention. The integration of new information technologies has been crucial to the improvement of these processes providing new tools.

The diagnostic processes require the participation of various experts from different fields of knowledge (architecture, history, environment, social sciences, etc.). This requirement makes it necessary to move all of them in the study area with a consequent cost. For the fieldwork user relies only on their knowledge, experience and ability to interpret the information it perceives. For this reason, the diagnostic procedure is very different depending on the expert who performs it. There is currently a shortage and a demand for standardization of these procedures. The concept of WPA represents a suitable solution for support to the users responsible for carrying out these tasks and standardizes its procedures. Besides it allows reducing the number of people who must move to place the diagnosis as well as their level of knowledge of different areas.

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2. RELATED WORK

Integrating mobile devices together with other information technologies can help to improve the effectiveness and convenience of information flow in various kinds of activities, for both professional and non-professional users. Thus, the mobile phone becomes the guide to the museum (Bruns, 2007) using its camera for the recognition of objects in combination with an extensive tracking system. The PDA (Wagner, 2006) could be the device to teach art history through an educational game based on collaborative augmented reality technologies Also the MIT Teacher Education Program (MIT, 2008) used the PDA technology in combination with GPS and Wi-Fi for the creation of simulation games that combine real-world experiences with additional information supplied to students by mobile devices.

2.1 Wearable computing and Mobile Augmented Reality

The concepts of wearable computing and augmented reality are well known and the system (Feiner, 1993) can be considered one of the first synergies of both technologies. The mobility requirements of users require abandoning systems based on desktop computer for mobile devices and then the first prototype applications of augmented reality-based mobile devices appear with Head Mounted Display (HMD) connected to a laptop, which carries out all processing, placed in a knapsack on their back (Höllerer, 1999; Piekarski, 2001; Piekarski, 2004). The following prototypes are starting to use PDAs (Wagner, 2003) or mobile phone (Möhring, 2004) as processing devices, and the displays devices are both video-through devices and see-through devices. Many technologies have been used to obtain a precise positioning application in augmented reality, all of them are complementary and there is no perfect solution (Izkara, 2007).

The projects that stand out in this area are MARS (Feiner, 1997), ARCHEOGUIDE (Project Archeoguide, 2008), Signposted (Wagner, 2003), client-server architecture for an application of augmented reality on PDA (Pasman, 2003), MR Virtuoso (Project Mr Virtuoso, 2008), Large Scale Mobile Phones Museum Guidance (Bruns, 2007) and ULTRA (Project Ultra, 2008) among others.

In (Weiser, 1991) Weiser defines the concept of "ubiquitous computing" as an environment in which computing technology is embedded into all kinds of everyday physical objects (such as appliances, doors, windows or desks). Recently miniaturized mobile devices have extended their capabilities from simple communication devices to wearable, networked computational platforms. Mobile AR can be viewed as the meeting point between AR and ubiquitous and wearable computing (Papagiannakis, 2008).

2.2 Mobile assistants for the management of historic centres

The idea to create mobile assistants is not new, it is running for many years and currently it has an important impulse due the potential benefits in many areas. The report (Freitas, 2003) resumes a comprehensive study about the development of wearable devices and personal data assistants where it can highlight the Xybernaut Mobile Assistant (Xybernaut, 2008) a commercial product widely available multi-purpose wearable device, educational applications such as 3COM Learning Assistant (3COM, 2008) and IBM web lectures delivering learning content to the learner through the mobile devices such as PDAs or mobile phones, or tools such as CyberTracker (CyberTracker, 2008) a software system developed for a PDA which enables trackers to record all the significant observations they make in the field, and the Electronic Guide (Electronic Guide Research Project, 2008), a tool for recording museum visits that use handheld devices to enrich learning experience for museum visitors. Also there are research projects oriented in this direction such as wearIT@work project (Project WearIT@atwork, 2008) which will develop a set of new solutions to support the workers of the future. WearIT@Work aims to develop a mobile computing platform that can empower professionals to higher levels of productivity by providing more seamless and effective forms of access to knowledge at the point of work, collaboration and communication, i.e. the aeronautic maintenance showcase (Giancarlo, 2006).

In the area of the management of historic urban centres the book (Pickard, 1997) examines key themes for the management of historic urban centres and also presents a variety of approaches utilised to face the different problems of the centres including management and regeneration action, environmental management and tourism and heritage management. A particular wearable solution for the cultural heritage sector (WearIT@CH, 2008) proposes a wrist wearable wireless computer addressing the needs of visitors will use the wearable device as a personalized multimedia guide, the needs of site guardians to support their routine on-site inspections and the needs of site managers and researchers will be able to gather all kind of data about visitors on-site behaviour.

Multimedia contents, interactive elements, audio-guides, etc. all of them are nowadays elements that have been incorporated, in a natural way, for the diffusion of cultural heritage and especially in museums. However the use of such technologies is poorly introduced in other activities in the world of cultural heritage and the potential of the technologies is quite high.

3. WEARABLE PERSONAL ASSISTANT (WPA)

3.1 What is a WPA?

We call Wearable Personal Assistant (WPA) a tool that provides user-support for the development of daily activities. A WPA has the following main features:

- Physically it is a lightweight device, easily manageable and with high quality visualization and audio playback devices.
- It provides support and assistance to professional users and non-professionals in their daily activities.
- It is a versatile tool, applicable to many different environments (education, industrial maintenance, cultural tourism, etc.).
- The type of information that provides a WPA is multimedia, quite visual and user friendly, with content specifically designed to assist the user in carrying out its tasks.
- The interaction with the tool is intuitive and limited in order to facilitate its handling by any type of user.
- WPA is an innovative tool that incorporates new technologies such as augmented reality, position tracking, image processing, wireless remote connectivity and multimedia content management services.
- WPA incorporates information personalized to the type of user (user profile, level of experience, etc.), contextualized to the activity being implemented as well as the user physical location (using positioning technologies).

3.2 RASMAP Platform

The implementation of the WPA is based on the mobile augmented reality platform developed in the RASMAP project (RASMAP, 2008). The RASMAP platform is based on a service-oriented architecture (SOA), where the final application is implemented from the services provided by different processes. For the definition of the required services we have analyzed comprehensively and systematically augmented reality (AR) scenarios in different sectors (cultural heritage, construction, maintenance and m-learning). For each scenario, first we identified the relevant group of services and functionalities required. On a second phase we established the integration of all identified services in the complete set of AR scenarios. These services were structured and organized in the following six large types: Interaction, Tracking, 3D Rendering, Multimedia presentation, Information management and Context-aware information.

A common interface or language has been defined for the request of the service and each process requesting this service will use it. In the case of the tracking service, for example, the information requested will be the position and orientation at a certain time. Tracking service will manage its resources and use the more appropriate technologies and devices to handle this request. The final application will receive the information about the position and orientation without being aware of the method used (WiFi-based, image processing, GPS, etc.) or even if it has been processed locally or remotely.

In the proposed approach, we present a mixed architecture, in which some of the detected services are executed directly in the mobile device, some others are remotely processed and some others will be processed locally or remotely depending on the context. The following figure shows the configuration of the architecture and services for the proposed platform.

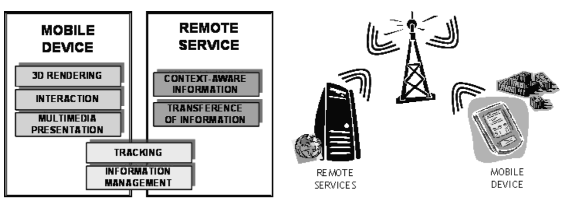

Figure 1: RASMAP platform

3.3 Software Components

The proposed design of the RASMAP platform has required developments in different research areas which include among others, graphics libraries for mobile devices, tracking libraries on 3D environments, image recognition algorithms based on 3D representations and multimedia transmission for mobile environments. The objectives proposed for these developments include the display of augmented reality applications on mobile devices such as PDAs, 3D positioning markerless on mobile devices, positioning the camera within the 3D environment, and the transmission of multimedia content.

The following sections describe various software components that perform several tasks including the augmented reality engine, robust positioning with occlusions in translations and rotations, and the creation and distribution of multimedia content in mobile environments. All the software components have designed for mobile devices based on Windows Mobile 5.0 and .NET Compact Framework.

3.3.1 Augmented Reality Rendering Engine: One of the main components of an augmented reality system apart from the image capture and the positioning/tracking is the 3D rendering. We have developed an engine for 3D visualization based on Vincent and PowerVR implementations of OpenGL ES; the first one is a software implementation and the second one is a hardware implementation.

Our selection is based on a low-lewel specification library such as OpenGL ES (OpenGL ES, 2008) (it is a subset of the OpenGL API for desktop environment), which describe the specifications for 2D and 3D graphics, and avoiding the high level rendering libraries available for mobile platforms due to the delay introduced in debugging and execution of applications on mobile devices and their incompatibility with the graphics standards. All the alternatives have in common that they use a scene graph to manage the 3D content.

We have developed a 3D visualization engine that incorporates interaction through buttons and touch screen, also displays complex 3D models generated using high-level 3D modelling tools and incorporates the text display using OpenGL ES techniques.

The image capturing module provides information to define the context to the system. In an augmented reality system real information is used to set the background of the augmented reality scene. For the implementation of this module we used both the Windows API and the SDK of the camera manufacturer. Figure 2 shows simple augmented reality scenes using the implemented 3D engine and the image capturing.

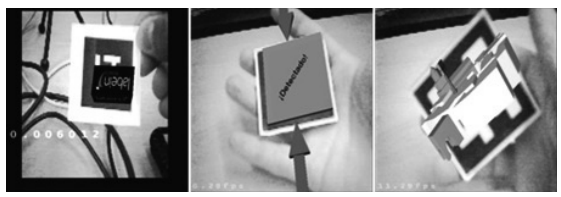

Figure 2: Augmented reality scenes

3.3.2 Tracking/Positioning: One of the major challenges of an augmented reality system is to achieve a good positioning of the user in the environment, providing both orientation and position with a high degree of accuracy (Kato, 1999). In order to make a robust 3D tracking, usually it is needed three main steps: a) camera calibration and initialization of the tracking system, b) initial camera pose (position and orientation) and c) tracking of the user movements relative to the initial or reference position.

For our developments, we have modified the ARToolkitPlus library (Wagner, 2007) for allowing partial occlusion of the markers, thereby improving the robustness of the system without adding markers (from now on, we will call the modified library as ARToolkitPlus'). Our implementation allows translation in the three axes (x, y, z) and rotation in z even when the marker is partially occluded. Apart from the processing algorithms mentioned, in order to soften the augmented model transformations we used a Kalman filter which avoid uncomfortable flickering for the rendering of the 3D scene. The following figure shows some screenshots of the achieved results.

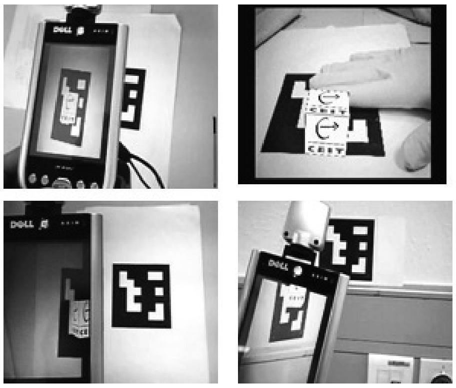

Figure 3: Using ARToolkitPlus'

3.3.3 Multimedia Management: This software component provides the user with a multimedia management service that lets her/him record video and audio, take pictures and draw or write over the photographs manually, and also write text notes. All these tasks are performed on a single screen with intuitive menus and organized in four tabs corresponding to text, audio, images and video management respectively. In addition, users can share their multimedia content or content from other users, sent or received via wireless (Wi-Fi or 3G) using the send/receive options enabled on all the menus of the multimedia management. The option send/receive is used in a mode transparent to the user to load and download multimedia content by web services located on a server that can be in the same building or thousands of miles away.

An additional functionality of the multimedia management component is the capacity to construct multimedia presentations based on the multiple data created or previously stored. This kind of service allows creating multimedia user's guides to assist the users in a rich media way. It uses an SMIL-2.0 player that presents all the multimedia contents (text, audio, pictures and video) in an integrated and synchronized form.

The advantages offered by this developed multimedia management with respect to other business applications such as windows mobile notes (text and audio), proprietary software camera (video and images), and utilities sending content via email are among others the following: a) integration into a single application. b) standard file formats (txt, wav, mp3, avi, mp4, wmv). c) multimedia content records: local storage and remote storage. d) collaborative content (send & receive). e) rich media presentation. Figure 4 illustrates different instants of taking a picture or making manual annotations, and the server hosting the web services of the collaborative mode.

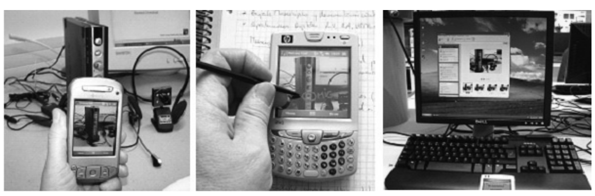

Figure 4: Multimedia management system

The case study (Basogain, 2008) has been implemented in an university environment to demonstrate the suitability of this multimedia management in education, and has served as a testing ground for this software component. Any other scenario where the PDA becomes a real wearable personal assistant could have selected as a test ground, for example a visit to a museum or a cultural heritage site, a tour guide or a visit to an industrial exhibition, etc.

3.3.4 Remote Communication: The transfer of video and audio information in real time between two distant locations allows communication between two users who are in remote locations.

In our developments in the RASMAP platform we have integrated a video conference system for the remote communication. The system provides full duplex communication and it is based on either WiFi or 3G communication networks.

3.4 Hardware Devices

An augmented reality system consists of a group of devices with complementary functionalities connected and integrated through a software platform. From the hardware point of view the three main elements of the system are: The processing device, the visualization device and the positioning device. Alternatives for the three of them will be presented next.

The hardware device selected for the developments described in this article is the PDA Dell Axim x51v, mainly because its processing power, graphics card and screen resolution. For image capture, cameras Spectec SDC-001A and Spectec SDC-003A have been used. The only difference between both cameras is the resolution, 300KPixels and 1,3MPixeles respectively. The camera is attached to the PDA through the SD slot. The PDA has microphone and audio output to which are plugged conventional headphones to allow using the system in noisy environments. To give freedom the user to use his/her hands during the inspection, the PDA hangs on the user's neck through a band. The PDA screen itself, providing VGA resolution, is used as a display device. For the positioning, the system is based on marker-based optical tracking. Figure 5 shows a picture of the hardware components used in the described application.

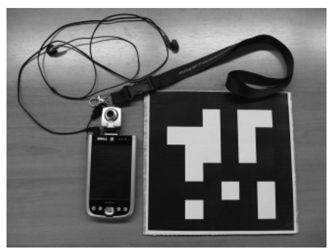

Figure 5: Hardware devices

4. PROTOTYPE FOR THE DIAGNOSIS OF BUILT HERITAGE

4.1 Scenario Description

For the development of a first prototype of the WPA, we choose the task of diagnosing state of preservation and accessibility of buildings and public spaces of a historic centre, as one of the key tasks for the management of the historic centre of a village or city.

A user moves to the historic centre selected to make the diagnosis, in our case a small town in the north of Spain called

Labraza (see figure 6). The user is equipped with the WPA. The WPA includes a data sheet to be completed during the inspection.

Figure 6: User in Labraza

The task focuses on the diagnosis of three different elements of historic centre selected: A residential building that is attached to the wall (number 1034), a building of historic interest (El Portal Sur) and a public space (La Plaza Alta).

4.2 Methodology

Examples of the sequence of actions to be taken during the inspection are detailed below:

- The user arrives to the first element to inspect.
- Turns on the WPA, identifies himself on the system, selects the element and the system shows on the screen its corresponding diagnosis procedure.
- The system provides instructions prior to diagnosis such as how to place the marker, informs that it must take a photograph of the facade and presents the sheet to be completed to establish the diagnosis.
- During the diagnosis, the system provides additional information for each of the sections in the sheet:
    - Accessibility: Based on the marker position, when the user asks for additional information to diagnose the accessibility of the building, 3D information relative to the accessibility normative in buildings will be shown.
    - Vaults: An interactive 3D model library of the most common types of vaults will be shown.
    - Facade preservation status: In this case it comes to detecting if the facade suffers any kind of pathology. For this purpose there are presented to the user a photo and a brief textual and oral description with the most common pathologies.
    - Covers: With the objective to detect the kind of cover of the building, visual information of the most common types of covers is presented to the user.
- During the diagnostic process the user can download multimedia information about other inspections carried out previously. This information includes photographs and audio files. The user can make notes on the photographs for review in subsequent inspections.
- The user may request the assistance of a remote expert by using the video conference system included in the application.
- When the user has completed the inspection of the building he will have to move to the next item to inspect. The system will provide information on the route to the next inspection element with a 3D arrow accompanied by a three-dimensional reconstruction of the historic centre indicating the most relevant environment elements to help the user in his orientation.

4.3 Application Development

For the diagnostic procedure, we defined three main diagnostic elements: a residential building attached to the wall, a building of historical interest and a public area. On the other hand, we defined two different types of user: an expert user, and a non-expert user. For each of the elements and for each type of user a diagnosis procedure is defined. Table I shows an example of the procedure of diagnosis. In particular, the one corresponding to a non-expert user who is in front of a building of monumental interest:

ACTION	DESCRIPTION	TYPE
Place marker	Instructions to place the marker on the building to inspect	Multimedia Information
Initial instructions	Initial instructions for the diagnosis	Multimedia Information
Accessibility	Information about accessibility	Augmented Reality
Vaults	3D model library of different kinds of vaults	3D Model Library
Covers	Information about kinds of covers	Multimedia Library
Pathologies	Information about the facade preservation status	Multimedia Library
Route to next	Information about the route to the next inspection point	Augmented Reality

Table I. Procedure actions

Concerning the contents, several types of information have been used in order to define the contents shown to the user. The main functionalities provided by the system are described below:

- *Multimedia information reproduction*: This is a reproduction of a single media file, which consists of a picture, text and audio.
- *Multimedia Library reproduction*: It corresponds with the reproduction of a multimedia file consisting of a sequence of photos, text and audio associated with each picture.
- *Augmented Reality visualization*: This functionality displays the image captured by the camera in real time, augmented with a virtual 3D scene in a position and orientation relative to the position of the detected marker. This type of content is mainly used for routing the user between the inspection points and for assistance in the accessibility diagnosis. Figure 7 shows how the WPA assists the user in the diagnosis of the accessibility in the building entrance.

Figure 7: Augmented reality for accessibility diagnosis

- *3D Models Library visualization and interaction*: This system allows the visualization of 3D interactive models. The interaction implemented allows rotation of the model, as well as zoom in and out of the camera.

- *Remote Expert Assistance*: The WPA includes a video-conference system which allows the user making the diagnosis contact with a remote expert for assistance during the inspection. Figure 8 shows the user and expert during the remote assistance of the diagnosis.

Figure 8: Remote expert assistance

- *Multimedia recording, downloading and annotation*: The WPA provides the user with the multimedia management system. A repository of multimedia content allows the user access to the recorded actions undertaken during previous diagnoses, and also the user can add new multimedia records as it is illustrated in figure 9.

Figure 9: Multimedia files annotation

4.4 Test

The prototype has not been validated yet, however we have performed a first test with one external user. In this section we provide some information about the test done. This test allows us to detect some advantages and disadvantages of the developed prototype.

In order to perform the test we moved to Labraza. There were three people involved in the test session: The responsible person of the WPA, the WPA developer, and the user, who is an architect with long experience in diagnostics conservation status of historic buildings and environments.

Prior to the start the session, the user is informed about the tool and the objectives of the session, informing that he will be observed and his actions and comments will be recorded with a video camera.

The main advantages detected by the user were:

- The manageability of devices exceeds expectations, as it can hang the PDA on the neck that gave freedom of hands movement to the user.
- The interaction with the application was simple and intuitive.
- Information provided was adequate and very interesting.
- The information presented using 3D models provided enough help and was of great interest for the user.
- The inclusion of the marker corresponding to the diagnosis element in the diagnosis sheet was very interesting and useful.
- Information given using 3D models with the aim of guiding the user in the environment was really useful.

The contents of augmented reality shown are very useful in the tasks of accessibility diagnosis and guidance to the next element. In the first case, the system allows the user to visually access the accessibility rules and make a diagnosis without measure. For guidance to the next point, visual information provided allows the user to orient easily within an unknown environment, as well as to reach the next inspection point in a simple way.

The tool for managing multimedia content provides apart from a mean of presentation of rich multimedia content that help during the diagnosis, other features like taking pictures, annotations over them, recovery of photographs taken during previous inspections, upload photographs for upcoming inspections and so on. These actions are also possible with other types of multimedia content such as video, text or audio.

Remote communication with an expert facilitates the diagnosis by non-expert users since the system allows accessing experts during the performance of the task.

However, problems were detected; for example:

- Light intensity on the screen of the PDA under conditions of high brightness outdoors is a bit poor.
- Battery life of the PDA during the assessment session was about 1 hour and 45 minutes, which is not enough to make the diagnosis of a complete historic centre.
- The user requests for the possibility to have the diagnosis sheet integrated in the WPA, which is not yet implemented.

5. CONCLUSIONS AND FUTURE WORK

In this paper we present the concept of Wearable Personal Assistant as an innovative tool for the assistance to professional and non-professional users in their daily activities. The concept of WPA has been defined in the context of a project called RASMAP in which we have developed a mobile augmented reality platform based on a service-oriented architecture.

Several software components have been developed for the implementation of the RASMAP platform. We have implemented an augmented reality rendering engine for mobile devices based on software and hardware implementations of OpenGL ES. Based on ARToolKitPlus, we implemented several algorithms to improve the robustness of such marker based tracking library using mobile devices. We have implemented also a multimedia management tool; this tool it is based on a set of web services and provides functionalities to record, edit, download and upload multimedia contents. In the RASMAP platform we have also integrated existing tools such as a video conferencing system for the remote communication between users remotely located.

The RASMAP platform is the technological support for the development of WPA. We have developed a prototype for the diagnosis of the built heritage. The tool has been tested on site by an architect with long experience in the diagnosis activities. Regarding the usability of the tool, although several problems were detected, the user perceived an added-value in the use of such tool for their daily activities. Among others, the standardization in the diagnosis processes, the reduction of time and the number of experts needed to be moved to the site to make the diagnosis are some of the most important benefits of such tool.

The use of tools such as WPA based on new technologies is not only a instrument for the diagnosis of the conservation status of the built heritage, but also can be very useful for many other tasks in the management of cultural heritage sites, for example: as a supporting tool for the visualization and selection of alternatives in the revitalization processes of the historical sites, also in the phase of maintenance of building or infrastructures etc. For non-professionals the concept of WPA could be applied to aid the user in the visit to a museum or other cultural places. As previously mentioned cultural heritage is not the only sector to apply such novel technologies. We are starting to develop a new prototype for professionals in the areas of mechanical maintenance.

In the near future we plan to extend the services of the RASMAP platform, developing new technologies for improving the tracking. We will develop new algorithms for the vision based tracking and combine it with other different technologies (GPS, WiFi, etc.). We plan also to development of new services for context awareness, considering both contexts: the user and the environment. These services will allow the system to provide personalized information to the user.

For the prototype in the diagnosis of the built heritage we will include minor changes in the application according to the feedback provided by the user during the test and we will validate the tool using the developed WPA for the diagnosis of a historical centre comparing the results with the traditional methods.

REFERENCES

Basogain, X. 2008. Olabe, M., Espinosa, K., Rouèche, C. and Olabe, J.C. Collaborative Multimedia Mobile Tool for Teaching Laboratories. *8th International Conference Developing Innovative Video Resources for Students Everywhere*, Diverse' 2008. July 2008, Haarlem, INHOLLAND University, The Netherlands. (Accepted)

Bruns, E. 2007. Brombach, B., Zeidler, T. and Bimber, O. Enabling Mobile Phones To Support Large-Scale Museum Guidance. In *IEEE Multimedia*, vol. 14, no. 2, pp. 16-25.

CyberTracker 2008. www.cybertracker.org (accessed 16 June 2008)

Electronic Guidebook Reseach Project 2008. http://www.exploratorium.edu/guidebook/ (accessed 16 June 2008)

Feiner, S., 1993. Macintyre, B., Seligmann, D. Knowledge-based augmented reality. *Communications of the ACM archive.*Volume 36, Issue 7, Special issue on computer augmented environments: back to the real world. pp 53-62.

Feiner, S. 1997. B. MacIntyre, T. Höllerer, and T. Webster. A touring machine: Prototyping 3D mobile augmented reality systems for exploring the urban environment. *Proc. ISWC '97, October 13-14*, Cambridge, MA.

Freitas, S. 2003. and Levene, Mark. Evaluating the development of wearable devices, personal data assistants and the use of other mobile devices in further and higher education institutions. JISC Technology and Standards Watch Report (TSW0305), pp. 1-21.

Giancarlo, B. 2006. Andrea Lorenzon, Nicolas Chevassus, Valerie Blondel. Wearable Computing and Mobile Workers: The Aeronautic Maintenance Showcase in the WearIT@Work Project. *Third International Forum on Applied Wearable Computing* IFAWC2006 March 15-16, Mobile Research Center, TZI Universität Bremen, Germany.

Höllerer, T. 1999. Feiner, S.; Terauchi, T.; Rashid, G.; and Hallaway, D.: Exploring MARS: Developing Indoor and Outdoor User Interfaces to a Mobile Augmented Reality System. Computers and Graphics, 23(6), pp. 779-785.

Izkara, J.L. 2007. Pérez, J.; Basogain, X.; Borro. Mobile Augmented Reality, an Advanced Tool for the Construction Sector. *D. Bringing ICT knowledge to work: Proceedings of CIB 24th W78 Conference* in Maribor 2007, pp. 453-460.

Kato, H. 1999. and Billinghurst, M.: Marker Tracking and HMD Calibration for a Video Based Augmented Reality Conferencing System. Proceeding of the 2nd Internation Workshop on Augmented Reality, pp 85-93.

MIT 2008 Handheld Augmented Reality Simulations. http://education.mit.edu/ar (accessed 16 June 2008)

Möhring, M. 2004. ; Lessig, C.; and Bimber O. Optical Tracking and Video See-through AR on Consumer Cell-Phones. In: *International Symposium in Mixed and Augmented Reality*, Arlington, USA, pp. 252-253.

OpenGL ES 2008. http://www.khronos.org/opengles (accessed 16 June 2008)

Papagiannakis, G. 2008. Singh, G.; Magnenat-Thalmann, N.; A survey of mobile and wireless technologies for augmented reality systems; Computer Animation and Virtual Worlds, Volume 19, pp 3-22.

Pasman, W., 2003.. and Woodward, C.: Implementation of an augmented reality system on a PDA. Poster article in *Proceedings of International Symposium of Mixed and Augmented Reality*. ISMAR 2003, Tokio, Japan.

Pickard, R. 1997. *Management of Historic Centres*. Edited by Robert Pickard ISBN: 978-0-419-23290-2

Piekarski, W. 2001. and Thomas, B.: Tinmith evo5 – An Architecture for Supporting Mobile Augmented Reality Environments. *Proceedings of the International Symposium on Augmented Reality* ISAR01. New York, USA.

Piekarski, W. 2004. and Smith, R.; and Thomas, B. H.: Designing Backpacks for High Fidelity Mobile Outdoor Augmented Reality. *Proceedings of International Symposium on Mixed and Augmented Reality* ISMAR04, Arlington.USA.

Project ARCHEOGUIDE 2008. http://archeoguide.intranet.gr (accessed 16 June 2008)

Project Mr Virtuoso 2008. http://studierstube.icg.tu-graz.ac.at/handheld_ar/virtuoso.php (accessed 16 June 2008)

Project ULTRA 2008. ULTRA Light-weight Augmented Reality Mobile System. http://ist-ultra.org/publications.shtml (accessed 16 June 2008)

Project WearIT@work 2008. http://www.wearitatwork.com/ (accessed 16 June 2008)

RASMAP 2008. RASMAP Project. http://www.labein.es/rasmap (accessed 16 June 2008)

Wagner, D. 2003. and Schmalstieg, D.: First Steps towards handheld augmented reality. *Proceedings of International Symposium of Wearable Computers* ISWC03, New York, USA.

Wagner, D. 2006. Handheld AR for Collaborative Edutainment. Lecture Notes in Computer Science, Springer Berlin / Heidelberg. ISBN 978-3-540-4977-9. pp. 85-96.

Wagner, D. 2007. and Schmalstieg, D.: ARToolkitPlus for Pose Tracking on Mobile Devices. *Proceedings of 12th Computer Vision Winter Workshop (CVWW'07)*.

WearIT@CH 2008 Wearable Solutions for the Cultural Heritage Sector. http://www.wearitatwork.com/wearIT-CH.259.0.html?&0= (accessed 16 June 2008)

Weiser, M. 1991. The computer for the 21st century. Scientific American, 265(3). pp. 94-104.

Xybernaut Mobile Assistant 2008. http://www.xybernaut.com/ (accessed 16 June 2008)

3COM Learning Assistant 2008. The 3Com University http://www.3com.com/support/en_US/training/ (accessed 16 June 2008)

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