EDUCATIONAL MOBILE ENVIRONMENT WITH AUGMENTED REALITY TECHNOLOGY

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Abstract

Augmented Reality (AR) is a technology which is progressively being introduced in new areas of application including the construction sector, reconstruction of historic legacy, training of workers in industrial processes, marketing tasks, interior design, multimedia museum guides, and others. The academic world has not remained unaffected by these initiatives and has started to incorporate augmented reality technology in some of its disciplines such as mechanical engineering, mathematics, geometry, geology and others.

The new demands of mobility and ubiquitous access of the users/students are being incorporated progressively in the mobile educational environments. For example, currently a large number of universities provide e-learning access to a wide range of multimedia (text, images, audio and video) content related to courses and course materials. This access is provided with services such as iTunes or similar programs, which allow students easy and organized download mechanisms of these materials in mobile devices. However, at the present time the majority of the applications based in augmented technology are still oriented to the desktop frameworks and environments.

In this paper we present the augmented reality technology as an innovative tool for the educational mobile environment. First we describe some of the results of the RASMAP research project and present the current status of the augmented reality technologies using mobile devices. Then we describe the benefits provided by these technologies, the most recent goals achieved, the novel applications developed, and finally the problems not yet solved. In the final section of the paper we describe a scenario in the education mobile environment in which the development of mobile computing solutions help improve the efficiency of current e-learning methods.

Keywords
Augmented reality, m-learning, mobile communication, e-learning, education, multimedia.

1. INTRODUCTION

Higher Education is constantly being transformed with new possibilities offered by the technologies of information and communication. Until recently, higher education and online systems followed largely separate tracks. Currently however the institutions of higher learning are increasingly being associated with infrastructures and services offering platforms of e-learning and m-learning.

Another important aspect of higher education is its permanent assimilation of new pedagogical methodologies in order to improve the teaching learning process. The academic materials of traditional courses have also been transformed with the use of new products and services: the course documentation and materials are offered in diverse electronic formats, incorporating new technologies such as video, virtual reality and augmented reality.

1.1 E-Learning Environments

There is a large set of content management systems CMS (or Virtual Learning Environment (VLE)) that provide easy-to-use web interfaces to share course material, facilitate communications and to access related course tools. Some of them are OpenSource such as Moodle and Typo3, and others are commercial such as Blackboard, WebCT.

Recently in a movement which is gaining strength rapidly, initially in the US, a large number of universities provide their students with portable and mobile devices where they can download specially formatted versions of lectures. In this sense, one of the authors belonging to the Grupo Multimedia of EHU has added to other mobile initiatives. The group was developing the Mediamovil project [1] in the areas of content generation, .3gp files, compatible codec, encoding settings, streaming server, internet browser and plug-in based on Java applications. The group has been working in the area of on line higher education for the last years, focusing in the creation of video/multimedia as an integral element of the teaching process and its integration in elearning platforms.

Also the development of CMS is applying mobile technology to current CMS, obtaining the Mobile CMS. The first steps in this direction are that the original web pages can be transferred to mobile screen and also incorporating new modules such as feedback and quiz for mobile devices.

1.2 Augmented Reality

AR is an emerging technology in the area of virtual reality and it is increasingly acquiring greater relevance as a research and development area [2]. In virtual technology the user is immersed in a world completely virtual, without any contact with the surrounding real world. However AR allows the user to see the real world augmented with additional information created by the computer. This added environment includes virtual objects incorporated into the surrounding physical space or non geometric information related to existing objects. Ideally the user perceives the real and virtual objects as coexisting in the same space.

These augmented systems combine the virtual and the real. They are interactive in real time, and integrate three-dimensional objects in the scene. AR extends the perception capabilities of the user in the real world and his or her interaction with its objects, providing information that the user cannot detect personally and directly. To obtain these results one could use special devices such as video-through lenses allowing to over impose computer generated information on the real world view. The main problem confronting AR is the precise alignment of computer generated data and real world data.

The figure below shows a conceptual diagram of an AR system with a video see-through [3]. The video camera captures information from the real world. The positioning system determines the location and orientation of the user in each moment. With this information a virtual computer scene is created and mixed with the real world video signal, creating an augmented scene. The combined scene including real and virtual information is presented to the user through a visualisation device. On the right image we see a system of AR based on mobile devices, PDA and portable image visor.

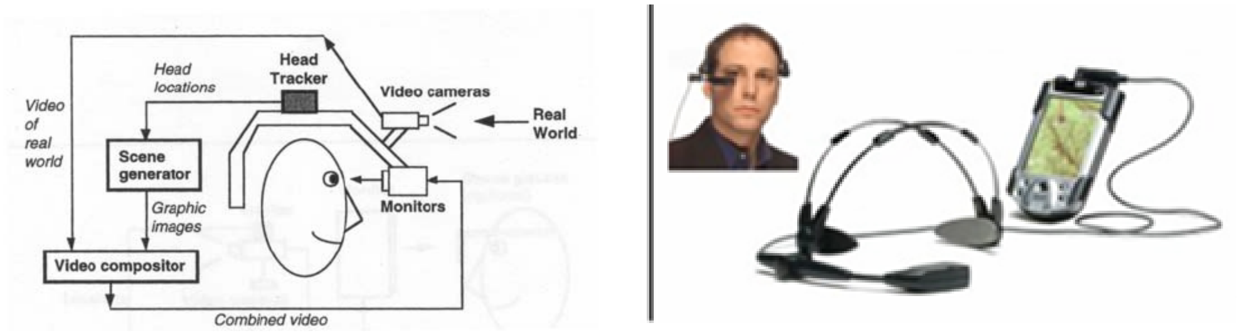

Figure 1.- Conceptual diagram of an Augmented Reality system

2. AR MOBILE

In the last few years the interest in the area of AR in environments of personal computers as well as the results obtained by these systems is increasing. Several platforms based on different architectures have been developed for these applications. One example is AMIRE, developed in a project in which participated one of the research groups of the current project [4].

However there is a marked tendency to move to environments requiring mobility for the user in the areas of application of these AR technologies. These applications demand access to services regardless of place or time. This new concept of mobile AR requires the design and development of new technologies, new architectures and new mobile devices.

As a starting point in this new area of research several studies have been implemented to determine the state of the art in the world of mobile AR in the development of RASMAP [5] in which the authors participate. The following section describe and organize some of the most important and significant aspects of this topic.

2.1 Technologies

The technologies integrated in mobile AR constitute a heterogeneous and extensive group which includes: 3D modelling and positioning; image recognition; wireless communications; video compression; and client-server architectures.

The first group, 3D positioning, consist in determining the position of the camera with six degrees of freedom with respect to a reference system. The system must have the information required to know the environment in which it will operate, for example a 3D model of the surrounding space, or a photographic map of it, or both. For that purpose there are tracking techniques used with different types of sensors, such as inertial sensors, gps systems, etc. There are also graphic libraries used for positioning tasks based on markers such as ARToolKitPlus [6] which determine the position and orientation of the camera using the information provided by markers and references present in the real environment.

The recognition of images or reference is applied with success in controlled applications. This success is more limited in changing three dimensional environments or references where the shape can be altered or deformed. The AR systems require system of vision that allows determining the position and orientation of real physical objects placed in real 3D environments: tracking of the eyes and head of the user, tracking of the motions and gestures of the hands, fingers, etc. or determining the location of cameras and the scenes.

One of the basic elements for the implementation of mobile AR systems is the communication of data allowing the free mobility of the user and the special/geographical flexibility of the application. In this area wireless networks constitute the optimum solution, and in particular those networks based on radio transmission (WiFi, WiMAX, UMTS) provide successfully all the requirements of the applications.

The process of video compression in these applications plays an important role, whether is using standard protocols such as H.262 and MPEG-4 or other private protocols. All protocols aim at the creation of a digital codec with high compression ratio that will provide good image quality, and at the same time adapting to the bandwidth and computational limitation of the communication channels.

Another important aspect to consider is the design of the architecture of the client-server. There are several experiences reported in the development of applications of mobile AR with different degrees of autonomy of the mobile devices. The most common implementation, and at the same time the lightest, includes a mobile device as an input/output element of visualisation and interaction with the user, since all the data processing and composition of the augmented image is implemented in a server [7], [8]. This architecture generates a flow of client-server information of great magnitude that is not suited for many environments of use. An architecture supported completely of almost in its totality by the mobile device produces in turn severe problems of performance given the hardware limitations of this type of devices. The architecture of the server could integrate in addition other services such as streaming on demand and video-conferencing over IP.

2.2 Devices

The hardware devices used in mobile AR applications are mainly, not including the positioning tasks, devices to implement tasks of visualization or data processing required by the applications. The processing devices used in the beginning were general purpose portable PCs, however their weight and size did not meet the requirements for a system of mixed reality that was comfortable.

Currently there are portable computers of reduce weight and size, including the Dell Latitude X1 and the Oqo 01. Recently in Cebit 2006, in Hannover, Microsoft presented their prototype for ultra-portable PCs, the new Origami.

Figure 2.- Dell Latitude X1, Oqo 01 and Origami

The PDAs originally designed as an evolution of the pocket agendas, are now presenting functionalities typical of portable PCs. These characteristics make them, each day more, the ideal device for this type of applications given the combination of computational power and size. Among these devices we can name the Dell Axim x51v. which includes the following main characteristics: Processor Intel XScale a 624MHz, Screen VGA 480X640, graphic accelerator Intel Marathon 2700G with 16MB of RAM, 195MB of RAM for applications, Wi-Fi and Bluetooth. Another good device in the market, which also incorporates a video camera is the model MyPal A730W from Asus.

Figure 3.- Dell Axim x51v and Asus MyPal A730W

The mobile telephones are also processing devices suitable for these applications. Currently these devices implement functionalities typical of PDA. Some of these devices include: Motorola A1000 and Sony Ericsson P910i. New developments beyond the Sony Ericsson P910i are the Sony Ericsson P990i running under Symbian or the Palm Treo 700w running under Windows Mobile.

Figure 4.- Sony Ericsson P990i and Palm Treo 700w

However the differences between mobile telephones and PDAs are becoming insignificant, and there are currently devices such as the Treo 700w which are referred to as PDA/SmartPhone or new mobile PDA phone devices HTC TYTN with a 3G internet connection of high bandwidth (HSDPA/UMTS) and complete connectivity with UMTS 3-band, EDGE 4-band, Bluetooth and WiFi [9].

Figure 5.- PDA-Phone HTC TYTN

It is also appropriate to consider the new devices that have been recently introduced into the market such as the ARCHOS WiFi presenting the functionalities of tactile LCD color screen - 4.2 inches – which provides easy navigation with a pointing device or the tip of the finger, integrated wireless systems 802.11g offering a complete connectivity web and LAN, camera for video recording in MPEG-4 format and VGA (640x48) resolution, in addition to reproducing video, music and photographs [10]. There are also other devices to consider as well, the PMPs (Portable Multimedia Players) such as Zune and Iphone of Microsoft and Apple respectively, which integrate multimedia payers and connectivity.

The devices of visualization, responsible for providing the mixing of reality and virtual elements can be classified into two groups: video-through, and see-through.

The devices video-through are not transparent and require a video camera to capture the images of the physical surroundings. Over these images the system overlays the virtual information forming an image composed of reality and virtual data. Generally these devices are used as type HMD devices, as illustrated in the figure below.

Figure 6.- Examples of commercial HMD devices

The devices see-through include semi transparent screens through which the user can view the surrounding environment. These screens project the digital content, and the human system of vision implements the task of integrating both real and virtual worlds of information. The figure below illustrates an HMD device of visualization.

Figure 7.- Carl Zeiss HMD

2.3 Applications

In studying the state of the art of mobile AR we need to include as well the analysis of applications developed by the most relevant research groups in the areas of technological applications of augmented reality in mobile devices. The comprehensive description of these groups and their recent developments falls outside the scope of this paper, however, we can highlight some of the most important aspects of this area.

The study and of prototypes and applications implemented by these research groups will help provide a better global perspective of the field of mobile AR.

The project MARS [11] developed between 1996 and 1999 represents one of the first important events in the evolution of systems of mobile mixed reality; this systems includes a portable PC equipped with a graphics accelerator card for 3D mounted on the back of the user, a GPS system, a pair of visualization glasses of the type see-through HMD, a tracking systems for determining the orientation of the head, and a wireless connection for the communication of the different components with the PC, where all the data processing is implemented.

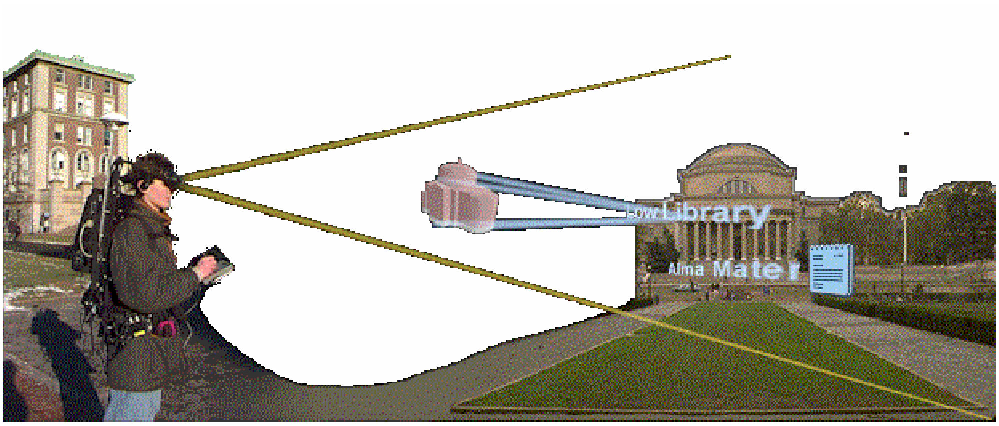

Figure 8.- MARS Mobile Augmented Reality System

The first utilization of a PDA as a system for AR where all the processing was implemented in the same device was presented in the project SingnPost of Daniel Wagner [12]. It consists of a system of AR video-through, where the image of the real world is captured by a camera and the image is augmented with the digital information. It uses a processing system based on the recognition of images using markers, which demands the previous configuration of the environment and lighting requirements to maintain constant light levels.

Figure 9.- SignPost Project

Other systems of importance include those developed by the University of Graz and the University of Wieibar. Among other projects they include the MR Virtuoso and the Mobile Phones Large Scale Museum Guidance, respectively. The first project consist of a collaborative educational game based on technologies of AR over devices type PDA designed to teach the history of art through technology [13], while the second project includes the development of a guided museum visit system over telephone equipped with camera [14].

Figure 10.- MR Virtuoso

Figure 11.- Mobile Phones for Large-Scale Museum Guidance

The list of active and relevant groups in this area is extensive, and among many others we can name the following: Virtual Reality Laboratory EPFL, Fraunhofer IGD, VTT Finland, Active Vision Group Oxford, Universidad British Columbia, Imperial Collage London.

Finally, it is of interest to note that currently there are several European groups belonging to the FP6 actively working in areas of AR. These projects include: ARIS*ER: Augmented Reality in Surgery, Research Training Network for Minimally Invasive Therapy technologies, VAR-TRAINER: Versatile Augmented Reality simulator for training in the safe use of construction machinery, LEMATCH: Crossmedia programming of sports. Enhanced format provisioning and streamlined cross-platform production of live and additional user information, INMAS: Intelligent Networked Manufacturing System, MATRIS: Markless Real-time Tracking for Augmented Reality Image Synthesis, ULTRA: Ultra portable Augmented Reality for industrial maintenance applications and S2S^2: Sound to Sense, Sense to Sound.

3. EDUCATIONAL AR MOBILE: ACADEMIC LABORATORIES

The current characteristics of m-learning offer new forms of implementing tasks of teaching learning. M-learning students have access to new possibilities including: access on demand to remote multimedia content and information; creation, processing and storing of information in digital form; communication with students and faculty. With these premises, areas such as laboratories of technical subjects and laboratories of languages can be addressed with new paradigms that can substitute classic methodologies.

The proposed scenario is a learning environment of Academic Laboratories based on augmented reality oriented to mobile students. The academic laboratories would include both technical subjects and areas of languages.

In the case of laboratories of technical subjects, such as laboratories of telematics and automatics, the incorporation of AR will provide a better understanding of the physical and logic concepts of the operation of equipment in the areas of telematics and automatization.

In the area of language laboratories, such as foreign language laboratories, the incorporation of AR will provide information relating to the country, culture, traditions, literature, etc.

The implementation of the system of AR will require the equipment of the classroom-laboratories with connectivity to an e-learning platform such as Moodle. The students will use their own mobile devices, PDAs or mobile phones to access the laboratories integrated in the e-learning platform.

The mobile devices used by the students will include a camera, microphone, speakers and user interface of easy use with menus accessible in a tactile screen of click wheel. The student will navigate using the menus the learning environment in order to select the study materials. As an alternative mode, image recognition techniques using the camera will provide the student the appropriate materials (according to materials studied earlier). The augmented information offered to the user will present different formats including among others images, 2D and 3D, video, audio, text, pdf, etc.

One of the first areas of application of this environment could include laboratories of courses taught in Engineering Schools. In these laboratories the students experiment for the first time with real devices of electric or mechanic nature such as electric machines, electronic circuits, models, pneumatic actuators, hydraulic actuators, motors, etc.

The mobile AR will serve as a bridge between theoretic concepts and the physical implementation of experiments with real devices. The students will access the tutored exercises via their mobile devices; during the experiments the student will capture with the mobile device the real device (for example an electronic circuit) and will observe in the screen the real device with additional information provide by the mobile AR. Depending on the type of laboratory the augmented information will include formats in 2D, 3D, video, audio, text, etc. related with the theoretical concepts of the real device.

Figure 12.- Mobile AR Academic Laboratory: electronic circuit of a sound external card

This environment proposed for the implementation of academic laboratories has been detailed in the project RASMAP along with other environments with different applications of mobile AR. This project will implement the architecture of mobile AR in several reference demonstration models including a demonstrator model for m-learning in academic laboratories.

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