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Editorial for Volume 7 Number 3
Recent ADvances in Augmented Reality (RADAR)

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1 Introduction

With the arrival of the information age, which exploits mainly the use of digital computers, huge quantities of information about the real world can be generated, processed and manipulated. Consequently, human beings are experimenting an increase of the knowledge about the environment surrounding them. However, every day, there exists a necessity to obtain more knowledge, which typically leads to the creation of new technologies from the scientific community. An important part of the acceleration of economic growth and structural change in developed countries is mainly due to the increase in using the so called Information and communication Technologies (ICT). ICTs are a set of services, networking, software and devices aiming to enhance the knowledge and the people quality of life inside a particular environment. ICTs include all kinds of visual, aural, printed and written technological tools providing rapid flow of information and knowledge [1-2].

Virtual Reality (VR) has become an increasingly important representation of an ICT, and it is defined as a computer created an environment in which the users can experience and explore interactively [3]. However, the possibility of user interaction with a complete virtual world can derive in several drawbacks such as the hardware high costs, hardware accessibility, large effort required for creating the virtual content, the necessity of high programming and modelling abilities, and non-real interaction, among others.

In order to overcome the VR drawbacks, augmented Reality (AR) is emerging. Unlike VR, AR does not simulate the reality, instead it superimposed contextual data without altering the reality. AR is a technology which allows users to see the real world, with virtual objects superimposed, the virtual objects are computer graphic objects that exist in essence or effect, but not formally [4-5]. Thomas Caudell coined the term in 1990, referring to a head-mounted display (HMD) that guided workers through assembling electrical wires in aircrafts [6].

Since AR dissemination, many research works have been presented in several fields such as military, education, maintenance, medicine, entertainment, among others. AR technology has become increasingly accessible to a wider public mainly due to, the explosion of the use of mobiles and wearable eyewear devices, which include powerful processors, high resolution cameras and sensors such as GPS, accelerometers, digital compasses and gyroscopes. AR interfaces have demonstrated how a person can interact with the real world in ways never before possible. Moreover, the Mobile AR (MAR) allows having the augmented experiences anywhere; also it promotes and enhances the collaborative work.

At least four elements are necessary to build an AR system: 1) a device to capture the real world scenes, which is typically a camera; 2) a display to project in a joint way the captured images and the virtual models, which can be the display of a computer or smartphone; 3) a processor to interpret and recognize the information of the interest objects, and to perform the pose estimation and tracking processes; and 4) an object to activate the AR, here it is important to distinguish between marker based (uses an obvious mark surrounded by a contour) and markerless (the place where the information is superimposed can be any object inside the acquired scene).

Even when AR is not a very new technology, its potential in real life activities is beginning to be explored. Most AR-applications are still limited to simple visualization of virtual objects onto spatially limited scenes. Besides, today is still difficult to determine: what are the ideal applications in which AR can be successfully used? Therefore, the proposal of a lot AR research in the next years is expected. In the following sections a brief explanation about MAR and its advances in education and medicine is presented.

2 Mobile Augmented Reality

In the past, AR applications were created for executing in personal computers. However, with the explosive development of powerful mobile devices (i.e., smartphones and tablets), it has become convenient platforms for deploying AR applications. Mobile devices include a camera for capturing the real world view, wireless communication, powerful processors to recognize and track the objects of interest, and the capability of rendering and displaying 3D graphics and video. This new area is known as MAR [7].

MAR proposes a novel way of interaction between user and systems, in which the user pointing out the camera of the device to a specific object or mark, and in the display the scene is represented by adding enriched information about the environment. MAR systems are frequently classified into two types: a) location-aware and b) vision-based. The former, presents digital media to users as they move through a physical area with a GPS-enabled mobile device. The latter, presents the digital media (i.e., text, graphics, audio, video, 3D models) to users when they point the camera of a mobile device to certain objects (e.g., QR codes, images) [8].

According to [9], the main components of a MAR system are: 1) a processor to perform the tracking and 3D registration of real scenes; 2) a display for mixing the virtual objects with the real world scenes; 3) the portable device in order to interact with the augmented world; 4) wireless capability to establish communication with the system infrastructure; and 5) data storage technology to store and retrieve data as necessary.

Besides portability, one of the main advantages of MAR, is that it could provide a natural way to promote collaborative work between users. The collaborative feature of MAR allows that multiple devices intuitively discover and connect to each other in order to share information and to interact with the elements of the scene with the goal of creating a more natural and compelling environment especially useful for teaching and training purposes. In collaborative MAR, multiple users must to share at least one common place inside the augmented environment. According to [10], users can collaborate face to face, remotely or by a combination of both. Each user has its own view of the objects that are private or shared in the augmented application.

One of the main challenges to solve in MAR is the proper use of computer vision techniques, since most of the processes must be performed in an active fashion. Active vision implies that the point of view of a camera is manipulated in order to observe the environment and obtain as a result a richer kind of information, as it is naturally performed by the human biological vision system. An efficient way of processing is critical in terms of power consumption, memory limitations, delays, and display requirements.

In the literature, several works that show successful MAR applications mainly oriented to medicine and education can be found. In the following subsections, some applications in the mentioned fields are briefly discussed.

3 Mobile Augmented Reality in Education

New Media Consortiums 2011 Horizon Report has reported AR as a technical trend in higher education for making technology blend with virtual and real worlds, and it is expected to reach mainstream use in education [11]. MAR for educational purposes, offers an innovative learning space by mixing digital learning materials in the format of media with tools or objects, which are direct parts of the physical space. MAR is well aligned with constructivist paradigm of education where learners control their own learning through the active interactions with the real and virtual environments.

Using MAR the students are free to explore wide open spaces, to learn through success and failure, and they can arrive at multiple possible outcomes. Therefore, MAR is now revolutionizing the way to teach and to learn, making these experiences more entertaining and rewarding [12]. Educational researchers have recognized AR as a technology with great potential to impact affective and cognitive learning outcomes. The key benefits obtained with MAR learning are that it is easy and inexpensive to setup, and there are no costs for making mistakes, as they are not real [13].

A collaborative MAR system for learning physics was presented in the work of [14]. The project tries to involve a total of 43 6-8 years old students in a series of scientific investigations about Newtonian force and motion. Their results show that students were able to develop a conceptual understanding of force, net force, friction and two-dimensional motion after participating in the use of the system. The proposal demonstrated that young students are able to learn force and motion concepts at an earlier age than thought possible. Finally, results show that young children need not be limited to memorization of science facts or unstructured explorations just because they cannot design controlled experiments for inquiry.

The survey performed by Wu et al. [15], discusses more than 50 research works focus on MAR and related to educational issues. The paper presents three categories of instructional approaches that emphasize the roles, tasks, and locations and discuss what and how different categories of AR approaches may help students learning process. The main idea is that viewing AR as a concept rather than a type of technology would be more productive for educators, researchers, and designers.

The work presented in [16], discusses the results obtained with the application of an MAR system in a chemistry course. The application targeted the composition of substances, where students could control, combine and interact with a 3D model of micro-particles using markers. The AR tool was tested in practice with 29 junior high school students in Shenzhen, China. With the results obtained, the authors asseverate that MAR has a significant supplemental learning effect as learning tool; that is more effective for low-achieving students than high-achieving ones; that students generally have positive attitudes toward MAR and the learning attitudes of students are positively correlated with their evaluation of the software.

An application called pARabola to learn the fundamental concepts of quadratic equations was presented in the work of [17]. A pilot study was conducted with 59 students in a Mexican undergraduate school to obtain feasibility insights on how MAR could support the teaching-learning process and to observe the reaction of students to the technology and the particular application. Comments expressed by the users after the AR experience was positive, supporting the premise that AR can be, in the future, a valuable complimentary teaching tool for topics that benefit from the contextual learning experience and multipoint visualization, such as the quadratic equation. An example of the students performing the pARabola experiment is shown in Figure 1.

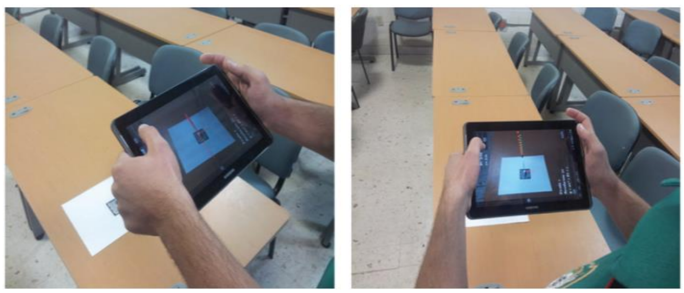

Fig. 1. Students performing the pilot study with the pARabola plotting application [17].

A MAR system to support of preschoolers in the task of lecture learning was presented in the work of [18]. The main goal was to create an application to arouse the interest and love for reading with students since the early stages. The system uses as base the history written by Hans Christian Andersen called "The Ugly Duckling". Children enjoy a lot the history, because it presents a character who went through several adversities but at the end, he could fulfill the dream of everyone to be happy. The application allows children to interact with a mobile device while reading the history, in each page the child point the device to a marker and a 3D model regarding the part of history that is reading is displayed. As a result, it was observed that by using the application, the children were very engaged for the reading activity. Figure 2 shows an example of a student using the application.

Fig. 2. Preschooler student using the application called "The Ugly Duckling" [18].

In summary, MAR can be a new way of learning which uses the unique capabilities of mobile devices (flexibility, mobility, and efficiency) in order to offer to students the opportunity to continue the learning process inside and outside the classroom. AR can be adopted as an educational medium increasingly accessible mainly to young users.

4 Mobile Augmented Reality in Medicine

Nowadays, and as never, the technology and medicine are very interrelated. MAR systems allow that the physician's labour can be enhanced; and in the field of medicine and healthcare it is presenting huge advances. The use of MAR in medicine is mainly motivated by the necessity of representing and visualizing medical data. Applications go from improving medical training, monitoring body temperature and heart rate, treating small animal phobias, until helping in a computer aided surgery (a computer generated organ is superimposed onto the surgeon's view of the patient). According to Navab et al. [19], the use of MAR in the medical field still faces three main challenges: the correct perception of virtual data in the real world; the integration of AR in complex medical workflows; and implementing the required change in culture.

A MAR system that can be used in the treatment of renal stones was developed in [20]. Percutaneous nephrolithotomy (PCNL) is a minimally invasive procedure to remove kidney stones from the body and it plays an important role in the renal stones treatment. The most important step of the procedure, is the creation of a percutaneous renal incision. Therefore, a novel MAR system was created to support this step [20]. The camera of the mobile device is positioned pointing the field of intervention, after that, the images acquired are registered with the computer tomography (CT) image using fiducial markers. As a result, the structures of interest were superimposed in a semitransparent way on the image sequences. In order to evaluate the system, two experts and one trainee performed 53 incisions on kidney phantoms. By using the system, the trainee performed best in terms of incision time, the same occurs with the experts. Additionally, with the use of the MAR system, the radiation exposure was reduced by a factor of three for the trainee and by a factor of 1.8 for the experts.

A system for the remote monitoring of the body temperature and heart rate of a patient by means of a wireless sensor network (WSN) and MAR was presented in [21]. The combination of a WSN and MAR provided a novel alternative to remotely measure body temperature and heart rate in real time during patient care. The system was composed of hardware such as Arduino microcontrollers (in the patient nodes), personal computers (for the nurse server), smartphones (for the mobile nurse monitor and the virtual patient file), and sensors (to measure body temperature and heart rate), a network layer using WiFly technology, and software such as LabView, Android SDK, and DroidAR. Results obtained from tests showed that the system could perform effectively within a range of 20 m and it required ten minutes to stabilize the temperature sensor to detect hyperthermia, hypothermia or normal body temperature conditions. Additionally, the heart rate sensor could detect conditions of tachycardia and bradycardia. In Figure 3, an example of the MAR interface for monitoring body temperature and heart rate is presented.

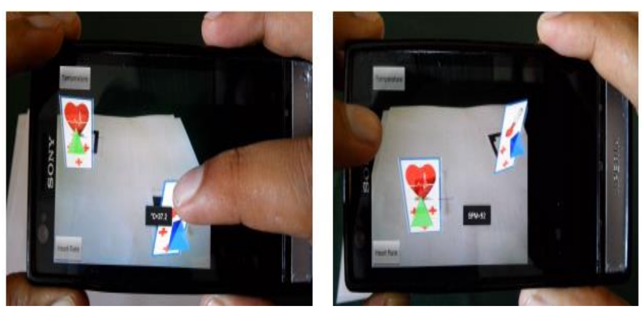

Fig. 3. The use of the monitoring system for measuring body temperature and heart rate of a patient [21].

A prototype to learn the topic of anatomy of the human skeletal structure called human anatomy in MAR (HuMAR) was shown in the work of [22]. The pilot test used the experimental method with 30 science students from three different universities. The objectives of the pilot test were to consolidate the user experience from a didactic and technical point of view. Based on the results of the pilot test, it was concluded that students were satisfied with HuMAR in terms of its usability and features; which in turn could have a positive impact in their learning process. With use of the prototype, students should be able to enhance their learning environments and to improve their ability to retain information related to skeletal anatomy.

Approximately a 5% of the people all over the world suffer a phobia to small animals, blood or a particular situation. A phobia is a persistent, excessive and irrational fear triggered by the presence of a specific situation or object. There are several therapies to overcome phobias; however, the most effective is the so called in vivo exposure, which confront the patient to his fear in a systematically and deliberately way. Even when phobias can be cured, most people avoid treatment because of denial and ignorance of the therapeutic procedures. The research proposed in [23], present a MAR system to support in vivo therapy to treat Arachnophobia. The system faces the patient to his fear without any risk of sting, and it was validated in a real environment during Arachnophobia therapy presenting promising results. An example of a real therapy using the MAR system with a little boy is shown in Figure 4.

Fig. 4. The use of the MAR system for Arachnophobia therapy [23].

As aforementioned, MAR systems can support medical procedures. The simulation of medical situations such as surgeries and therapies offers an opportunity to create controlled and safe environments for professional education and training. Although, several successful medical systems have been presented, several drawbacks are still necessary to be addressed. One of the main challenges to overcome in MAR medical systems is the accuracy offered by the system, which mainly depends on the camera calibration procedures. Additionally, the realism and quality of the models presented most be enhanced, and this can be carried out by adding powerful graphical processor abilities and visual cues in the real environment.

5 Conclusions

A brief panorama about MAR advances in education and medicine has been presented. MAR is a young technology that offers users a great sensation of presence that you can take with you wherever you go. MAR systems use the camera and the display of a mobile device to overlaying digital information onto the real world. When MAR is used, the people are experiencing a totally immersive environment in such a way that can confuse the real objects with the virtual ones. Particularly, in the field of education and medicine, a lot of successful MAR systems have been presented in the literature. The future of MAR is encouraging, mainly due to the cost decrement and rapidly advancing that are experiencing the technological devices.

Although the concept of AR was proposed more than 20 years ago, most applications are still limited to simple visualization of virtual objects onto spatially limited scenes. The barrier can be passed by overcoming the ergonomic and hardware limitations that frequently are experienced in MAR devices. Therefore, it is clear that there are benefits and drawbacks about the use of MAR in education and medicine. MAR provides a combination of real and virtual environments that is almost impossible with the use of other technologies. MAR can engage, stimulate and motivate users to explore materials everywhere and from different angles. Frequently, the cost of MAR systems has been low compared to special purpose technologies. Moreover, one of the main advantages of MAR is that can help to motivate user collaboration.

On the other hand, MAR systems present several drawbacks. The resources of most devices are limited. The users can put a lot of attention in the system and ignore important parts of the experience, which is known as an attention tunneling effect. In several occasions, MAR systems can be rated more difficult to use compared with classical approaches. Additionally, sometimes people need to change its culture about technology avoidance. Finally, it is important to mention that the programming abilities (mainly computer vision techniques) and time needed to design and implement the MAR content are frequently high.

In the following years, it is expected that MAR interfaces will experiment its consolidation stage and continuing integrating into a number of educational and medical applications. The final question is: are you ready for experimenting with augmented reality? If you do, we promise you will be conducting a fascinating experience.

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