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INNOVATION IN EDUCATION THROUGH THE USE OF AUGMENTED REALITY:CASE OF TEACHING HUMAN ANATOMY IN MEDICINE

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ABSTRACT

The innovation in the methods of teaching is currently dictated by the evolution of the technological tools and the diversified and sophisticated environments of training. Augmented reality (AR) is a technology which increases reality with images of two or three dimensions generated by the computer with the objects and/or information, and makes it possible for users to interact with them. This is can be used too in technical and educational contexts. Indeed, the applications based on augmented reality are evolved by offering great potential in terms of training and teaching.

This article offers an outline of the AR and its applicability by examining the recent developments in this field and by exploring its social impact like its implications for education and training in particular while taking as example the human anatomy teaching within the scope of the medical training on the basis of study and the comparison of some existing solutions in the objective to propose an augmented prototype of a new solution.

KEYWORDS*: Education Technologies, Augmented Reality, Mobile Application, Holographic System, Medical Training/Teaching, Human Anatomy*

INTRODUCTION

In the last years, Augmented Reality (AR) experienced an increased development and it was integrated into several fields offering the opportunities to its users to interact with virtual objects generated by the computer or the mobile terminals in the real world. The augmented reality applications touched several technical fields. The educational world too did exploit this technology to introduce new immersive forms of teaching and training**. [1]**

Several research tasks treated technologies of AR as well as the advantages and the challenges of its use in the educational mediums. Analysis based on 68 research articles gave results which reveal an increase in the number of AR studies during the last years. The advantage more declared is that AR supports the improvement of the training. **[2]**

Some of the problems raised by AR are the problems of usability and the high frequency of technical problems. We did find many advantages of using AR in teaching context and training precisely for the medical field, which will be discussed in detail. Moreover, the current gaps in AR research applied to the medical training and the practical needs and problems will be identified and some suggestions will be proposed for future research. **[2]**

This paper is structured as follows: we will begin by the problematic of this study then in a first part we will present the basic fundamentals of AR like its applicability by presenting its stakes for education and training as well as various technologies which support it, then in a second part we will study and compare some existing solutions of the applications of medical learning relating to the human anatomy based on augmented reality to end up presenting the assessment of the study made as well as a conclusion and prospects for this research task.

Context and Problematic

AR is regarded as a new technology which offers new methods to teach in an effective and gravitational way **[3].** This technology is very much used in the medical training area by reason of its multiple advantages, indeed, the AR (Augmented Reality) technology gives to the student the possibility of improving the access to the subject. It mobilizes the environment of training independently of the site and time, by allowing flexibility in the higher education precisely in medical education. Indeed, with the functionalities of AR technology, it supports the students in the complex subjects of learning, in particular, the subject of anatomy. **[4]**

This subject implies the anatomy learning in the practical laboratory of dissection, where there is an exposition to the human body structure, the animals and the internal bodiesin order to facilitate the training of more complex parts of the human body. **[5]**

The problematic of this study consists, in general, of examining the opportunities offered by the augmented reality for the education in general and the medical learning in particular through the study of some existing solutions in order to propose a new prototype of teaching human anatomyin order to innovate and to develop student's motivation, work in group and collaboration between learners.

Augmented Reality in Education: Advantages, Challenges and Technologies

Definition of Augmented Reality and Applicability

The term augmented reality (AR) was presented and explained in several different manners. Some regard it as a technology which increases or superimposes a given image of the real world with objects in 2D or 3D generated by computer (CG objects) making it possible for the user to interact with them [**6**]. Others regard it as a tool of man-machine interaction, taking the information generated by computer, to complete the real world using some devices like a camera [7].

Another group of researchers presents it as an emergent form of experiment in which the real world is enriched by contents generated by the computer. **[8]**

A fourth group prefers that augmented reality is rather regarded as a concept than a type of technology. This could be, according to these researchers, more productive for teachers, researchers and creators. **[9]**

Indeed, the fact of restricting or limiting the augmented reality to a simple technology reduces the field of the possibilities that it offers. Consider, rather, AR as a concept makes it possible to leave the door open to more exploration of the horizons which can be generated and developed. In fact, AR can be the association of ideas, severalmaterial and software technologies, and the implementation to have a richer vision of the real world. For example, it is conceivable to have a system that makes possible the measurement and the display, on the windshield of a vehicle, of the distance separating to him from the vehicle in front. Augmented Reality (AR) can be applied in many

fields like: Marketing, Gaming, Education, Industry, Medicine, etc **[9]**

Stakes of the AR for Education and Training

There is a multitude of technologies and tools that can be used in AR and in particular in Augmented Reality dedicated to education and training. Consequently the learners (students), in the training environments based on augmented reality, may be overloaded by great quantities of information in some phases of the training/learning session, by the use of different technological devices and sometimes also by complex tasks that they have to do. The learner must thus be able to work in a multitasking context. In certain cases learners must take up the challenge to work in co-operation and collaboration in a multi-user mode. **[10]**

Because of the massive handling of the devices used in augmented reality, the number of breakdowns of these components can rise. Consequently some errors can be generated; such as the erroneous values coming from a defective system GPS. Therefore, a strategy of maintenance to guarantee good stability is essential. Even if progress carried out the last years in portable and wireless technologies as well as the evolution of last laptops and smart phones being able to integrate high developed cameras, a gps, a wireless receiver, a faster processor and a larger memory could minimize the number of the possible breakdowns**.[11]**

Among the problems of teaching is the non flexibility of contents being in an AR system dedicated to education and training. In certain cases the sequence of training is fixed. It is thus not possible, for teachers, to modify part of teaching to adapt it to the specific needs for their learners. This concern can be solved by the use of the "Authoring tools" (Bergig, Hagbi, El-sanatorium.) what allows the students and the teachers to be able to intervene to revise or create applications or AR activities. **[12]**

It should be also noted that the tasks envisaged in a sequence of training in an AR education environment may suppose that learner had a spirit of synthesis as well as a multitude of competences in various fields: space navigation, collaboration, resolution of problems, mathematical estimate etc. But this is not always the case.

Main Technologies of Augmented Reality

3D Technology

3D technology is not recent as one can imagine, and goes up, even, to the middle of the XIXth century. It was used to add relief to the old first photographs using the two-tone glasses called anaglyphs. The principle of anaglyph was described since 1857 by Rollman but it is Louis Ducos du Hauron who finished its development in 1891 and thus considered as its inventor. **[13]**

The 3D, also named stereoscopy, can be defined as the set of the techniques making possible the fact of having a meaning of relief for the objects through the recording of visual information in three dimensions.

There is a deep natural feeling of relief view of the human eye that the 3D image tries to reproduce. The human eyes, having a distance, which separates them, of 70 mm on average (called interpupillary distance), do not save the same image. It is, rather, the brain which superimposes them in order to reproduce the image in relief.

The principle of 3D technology is to give to the brain perception of two separated images, so that it reproduces the relief. The images are thus collected at the same time with two cameras, positioned with the same distance separating the eyes**.[13]**

The question is: how to differentiate the left side image and the right side one so that each eye sees only the corresponding image?

For that, several techniques can be adopted as the anaglyph (two-tone glasses), The passive 3D glasses (polarized projection), The active 3D glasses (alternate projection), etc

Holographic Technology

Holography was born following the initiative of Dennis GABOR who in 1947 had the idea to observe the atomic structure in its three dimensions. The principle was as follows: To record the phase of the waves having met an object, it "would be enough" to record the interferences between these waves and a simple wave of reference coming from the same source of the lighting of the object. The photography of these interferences illuminated using the wave of reference alone would make it possible, then, to restore the waves object. Thus optical holography had been born, but its use was not possible until the appearance of the first lasers in the years 1960. [16]

The 1970 years were remembered by the passage of optical holography towards the numerical holography which since the years 2000, did not cease developing profiting from technological progress as regards sensors of the camera, of a storage capacity of data and computing power. For this purpose, this new technique has the advantage of giving access to the size, to the form and to the space position of the concerned object and this, **[7]** while making it possible to project in space an object in three dimensions, around of which, without helmet or glasses, the spectators can turn to observe it under various angles. It is necessary that the image is projected against a screen or semi-reflective walls, which explains why the specialized companies market them in the form of the "holographic boxes".

In the beginning, the use of holograms was limited to the representation of an image in three dimensions. From now on, the AR applications do not cease developing and evolving: it is finally possible to control and feel a holographic image.

In fact, this innovative technology made it possible to add an interactive and tactile dimension to the traditional holograms. Consequently, the tactile hologram was born thanks to the combination of sensors resulting from wiimotes (being used for the detection of movements) and from a generator of ultrasounds (creating air volume displacements). The latter is fixed on the movements of projection (LCD video projector) and the unit generates a pressure which is connected with a tactile feeling on the hand of the user, without contact with a physical matter. **[14]**

This new technique is very useful in several fields like industry, medicine, safety and protection. We can find also holograms in the field of leisure, where holography is used in the museums for the restoration of works of art for example. For the people hoping to see holographic films, there still remains some work to be done, because data brought by holography is not being able to be dealt with by the current instruments of cinematography.

However, the general public holographic applications are still embryonic, and run up against several obstacles: the price, first of all, but also returned colors and impossibility of restoring complex scenes with several elements. **[15]**

Holography thus has a luminous future in our society; it will be obviously an engine of future innovations **[16]**

Comparative Table

Table 1

Criteria/Technology	Technology 3D	Holographic Technology
Principle	Illusion of perception of two separate images given to the human brain, in order to reproduce relief.	To record the interferences between the waves having met an object and a simple wave of reference coming from the same source of the lighting of the object.
Various Generations	- The anaglyph, - The 3D passivates, - 3D active	- 1960- Optical holography, - 1970- Numerical holography
Fields	Cinema, Plays, Education, Architecture, Industry, Medicine, Marketing and communications	Industry, Medicine, Safety and protection, Leisure, Museums.
Advantages	- The use of the 3D is captivating, - In the event of training by the 3D, information is easier to understand, - To exceed the real and physical barriers to present an animation	Access to the size, the form and the position in the space of the desired object
Modes of Possible Interaction	tactile	Interactive, tactile
Limits	- obligation to often put 3D glasses, - sometimes heavy and expensive glasses, - can cause headaches	Price, returned colors, difficult restitution of complex scenes
Prospects	possibilities of exploitation in various fields and various companies, 3D without glasses	Engine for future innovations

Study and Comparison of Applications of Augmented Reality in Medicine Relating to the Human Anatomy

Introduction

The human anatomy is a discipline having cardinal importance for the comprehension and the study of the components of the human body. Its illustration has a long history. In fact, it started with the drawings of the beginning of the 16th century then with the exposures of plastinated bodies and finally with those known as transparent solutions based on the technology of augmented reality which varies from a simple mobile application to a holographic system or a 3D workstation. **[17]**

Study of Some Existing Solutions Based on AR Classified by Category

The Mobile Applications

The mobile learning is becoming a new teaching tendency imposed by the increased use of the mobile terminals and the development of the mobile applications dedicated for the teaching presenting of the multiple advantages and offering new possibilities such as the training on the place of work, in education and at the house. The simplicity and the mobility of the mobile apparatus allow more effective training and conservation of knowledge. **[18]**

The mobile applications based on augmented reality and dedicated to the teaching of the human anatomy are able to generate virtual images and making it possible to explore the anatomy of the human body starting from a paper medium on which the 3D objects presented in the real world are superimposed.

They require: an aircraft equipped with a webcam (shelves, smart phones, portable computer,…), a marker (often paper) and an application which will make it possible to start an action, an 3D animation by pointing the marker paper and the Apk file of the mobile application making it possible to visualize the details of the human anatomy when it is superimposed on part of the body.

Like a mobile example of an application dedicated to the teaching of the human anatomy, we can present the prototype of HuMAR application which functions in the same way as an application based on a teachware which indicates educational software conceived for the training and teaching in class.

This prototype of application presents a certain number of functionalities, for example, buttons of navigation, information on the subject and of the hypertext links. These functionalities were added in HuMAR, to create interactivity with the system and to improve the training of one of the selected bones.

In order to visualize the augmented or superimposed object, HuMAR uses the screen of the shelf. The flow of the interaction starts with a marker, who can be specified like an image on any surface, where the camera of the shelf works as a scanner of the image.

In HuMAR, the image is detected like a marker, and is measured by the dimension width. Thereafter, the camera of the shelf detects and recognizes an assigned marker. Once a marker was recognized, an application installed on the shelf will post and superimpose the corresponding 3D object on the screen.

The application starts with the real environment by using the camera of the shelf using a marker in the handbook of the laboratory. Once the recognized marker, the 3D augmented model is posted and the apparatus is superimposed on the screen, so that the user can see the augmented object. A user can visualize a 3D model increased by a part of a bone when the user moves the camera of the device of the shelf in the zone of the marker. **[19]**

The Augmented Holographic Systems of Medical Training

These are holographic systems that allow users to explore the human body using augmented reality technology based on the use of HoloLens which is a headdress that overlays the 3d graphics generated by The computer on a person's field of vision, a mixture of reality with virtual reality. This headdress allows visualizing 3-dimensional holograms. These are devices based on Microsoft HoloLens technology allowing tovisualize the details of the human body in the form of holograms with the possibility of manipulating it by hand or by the voice.

As an example, we will introduce the application Holo Anatomy which allows the user to explore a virtual human body, to turn around him by looking at the details of the different systems of the body, and select a part of the body in order to zoom it. Some of the body sounds are reproduced, like the heartbeat**. [20]**

The application uses hand gestures and speech recognition for controls; it also uses graphic tags that are inserted to learn the different anatomical components.

Several other projects based on this technology are in development like **3D4Medical**, an editor, specialized in the field of anatomy learning and the project called **Esper**, which is a concept of application of anatomy in mixed reality, based on the use of the Microsoft Hololens headset with the use of hand gestures for manipulating virtual objects.

Simulators or 3d Workstations for Multiple Users

First Solution: the Use of an Augmented Reality Solution Based On the Use of a Scientific Visualization Screen As Well As Visualization Devices

These are devices allowing to explore the human body through an overlay of 3d graphics generated by the computer on a person's field of vision, a mixture of reality with virtual objects.

These devices use virtual work benches, these are large retro-screened screens, which form a symbol of an L. It is used with shutter glasses and allows several people to immerse themselves in the same virtual environment. They are mainly used for scientific visualization. **[17]**

The specificity of this solution is the use of a scientific visualization screen as well as visualization devices. The most necessary equipment are:

- Virtual work Plan: Screen
- Shutter bezel: Stereoscopic Vision to see embossed objects-camera
- Locating sensors or marker

Second Solution: the use of an Augmented Reality Solution Based on the "Spatial Augmented Reality", which can be Translated as "Augmented Space" :

For this solution, users do not wear visualization devices, but sensors and projectors are installed around them and they will react according to the user. The user will be able to use a tool to interact with the surrounding space. **[17]**

Spatial augmented Reality uses a retro-projector to increase an object and to provide additional information about it.

3D workstations or Personal Simulators

These are3D systems that allow users to explore the human body using augmented reality technology based on the use of some components soft and hard. **[17]**

These systems are: Anatomy simulator in the form of an augmented reality workstation, with the following components:

- Virtual reality Viewer-marker
- Eyeglasses
- Connected eyeglasses (SmartEyeGlass): These goggles are equipped with cameras, motion sensors, storage capacity of 32 GB, processor, etc
- These glasses are delivered with proprietary software
- -And a PC with keyboard and mouse or mobile terminal

Comparaison of Solutions

Comparison Criteria

Before beginning the comparison of the various configurations of existing solutions of immersive training of the human anatomy, it is necessary first of all to specify the comparison criteria which are detailed in the following table:

Table 2

Criteria	Description
Functionalities	It is about the whole of the cases of use of the application
Used technology	It is the technology on which the application is based which can be one of the technologies presented above.
Teaching interest	Corresponds to the degree of innovation and concretization as well as the ludic aspect of the treated solution.
Cost	It is the price of components as well as the necessary training for the development of the solution
Techniques and Models of interaction	The handling of virtual objects by using gestural hand and voice recognition
Patentable character of the application	**It is about the possibility of patenting the solution**

Comparative Table of the Solutions Classified by Category

Table 3

	Mobile Application	Holographic System	Simulator or 3d Workstation for Multiple Users	Personal Simulator 3D
Technical Functionalities	Limited: Basic functionalities	Very Rich	Rich	Rich
Used Technology	3D	Holographic technology	3D	3D technology
Teaching Interest	Limited	Very interesting	interesting	Interesting
Models of Interaction	tactile	Tactile and auditive	Tactile and auditive	Tactile
Cost	Non expensive	Expensive	Expensive	More or less expensive depends on the material used
Patentable Character of the Application	not possible	possible	possible	possible

Assessment of the Study and Discussion

Following this study, we can deduce that the applications of augmented reality vary from a simple mobile application to a simulator or workstation while offering varied functionalities. Indeed, we can summarize their characteristics as following : The functionalities are mainly oriented to recognize the anatomy of a virtual human body, by looking at the details of the various systems of the body, and to handle them with the use of gestural of the hand or the voice recognition, Also, each application has a model of precise interaction, these devices are not of same teaching interest

and they are intended for a variable number of people, the devices of AR have the same technological bases: smart glasses and hololens jointly with the SDK, CMS and AR frameworks and the cost varies according to the material used.

The contribution of these new devices can be helpful to:

- Associate 3D techniques, with those of augmented reality to be able to implement and exploit applications of immersive training,
- Conceive systems which are ergonomic, effective, easy to use or more generally adapted to their context of use,
- Develop devices or immersive simulators dedicated to the training,
- Improve the teaching performances and optimize environments of training by the introduction of the techniques of augmented reality.

CONCLUSIONS

The augmented reality in Medicine presents many stakes on several levels: technological level (mobile sensors, terminals, etc), methodological (techniques of localization 3D, generation of environment 3D, visualization and interaction 3D) and the industrial one. The implementation of such systems requires the resolution of the scientific problems with mobile AR, namely the localization, visualization and the 3D interaction.[17]

This research work aims to study the feasibility of a project of realization of a new system of augmented reality dedicated for the teaching of the human anatomy in order to explore and illustrate human anatomy beyond a physical examination of medical cadavers that it is in terms of technology but also of adoption by the final users.

As a prospect for this work, we will complete it in order to develop a new holographic training system based on augmented reality. We believe that our future application is an exploratory project adopting a very innovating technology which can have many prospects in the medical improvements in education

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