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Collocated learning experience within collaborative augmented environment (Anatomy course)

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Abstract— **Nowadays, collaborative systems and applications are widely used to allow multiple users to work together in order to achieve one same goal. In the field of virtual and augmented realities, such collaboration is often sought to effectuate complex activities in some relevant experiences. Users can share virtual objects, but most importantly, they use collaborative 3D interaction, visualize their objects manipulation in real time and communicate with each other to coordinate their actions efficiently. These users will, therefore, be able to work together in a shared virtual environment to carry out different tasks.**

In this paper, we present our work related to the design and implementation of a collaborative augmented system, our application introduces a multi-users experience in a face-to-face configuration and can be used by the students in anatomy course.

Augmented reality; Collaborative environment; Learning application; Anatomy course.

I. INTRODUCTION

Over the past decade, we have observed a growing evolution of the digital world, smart phones and 3D visualization devices. This evolution is more and more visible with the emergence of virtual and augmented reality (VR, AR) [1][2] where the user can be completely or partially emerged in a 3D world. This world offers the possibility to navigate around 3D objects and also to manipulate them in an interactive way. The combination of software and hardware tools in this domain has enabled the emergence of virtual and augmented reality, essentially, in industry [3][4], health and medicine [5][6][7] as well as in training and education [8][9][10].

Moreover, with the evolution of new information and telecommunication (NITC) technologies, it has become possible for several users to share a 3D world in real environment and thus, collaborate by co-manipulating 3D objects. This concept is called Collaborative Augmented Reality [2][11]. The main objective of this work is to elaborate a collaborative augmented reality system for medical learning.

II. RELATED WORK

Several works have been proposed to design collaborative augmented reality applications. Earlier work [12] presented, in first part, a collaborative AR application for painting, in which different users are implicated. The interaction is done with a stylus. Each user selects the color to paint using a table of colors and then he paints the desired area with the chosen color. the second part was consacred for an application developed to play a chess game. In this case, two users can play by visualizing 3D chessboard on a 3D tabletop. The manipulation of each element of the chessboard is done by a stylus. The project presented in [13] consists in displaying an augmented city on a table. The 3D model is viewed by several architects. This allows them to solve problems related to urban buildings planning. In [14], augmented reality for mobile gaming is developed where two players are in face-to- face. Each one uses his phone to play a game (AR Tennis). This application is implemented on a Symbian mobile phone that uses Artoolkit library for AR. The developed platform is based on peer-to-peer network architecture. CMAR [15] is a platform developed for interactive collaborative face-to-face augmented reality on mobile phones. This platform allows several users to interact and manipulate objects in a shared scene, the goal is to design a room together. The application is implemented in C++ and uses Artoolkit library for AR. Each device has its own copy of the scene and the actions are synchronized via a server. More recently, [16] developed a system called Second Surface, which is a multi-users system based on augmented reality and allows spatial collaboration. The content creation in the shared spatial canvas is possible with co-located users in real-time, each user can also situate the objects on the spatial canvas with natural interaction based on hand gesture. Finally, [17] develops a serious game named Table Mystery which represents, an educational game aiming to encourage collaboration within teams, in order to accomplish a common educational goal. It also uses handheld augmented reality and examines the efficiency of AR in creating an engaging and motivating educational environment.

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III. PROBLEMATIC AND MOTIVATION

We interviewed medical students and professors at an Algerian university, and noticed the several difficulties they face in learning anatomy course, heart and brain in particular, which both represent a semester of studying for new medical students. This problem of comprehension, according to some students and professors, is due to the nature of course supports based mainly on paper documentation difficult to assimilate. As a result, the students are not able to fully grasp the form and structure concepts of human organs. Certainly, there are real artificial models of human organs, but it is impossible to provide these models to all the students, considering the costs. In this context, the aim of this work is to design and implement a low-cost learning system that supports multi-users 3D interaction for anatomy course.

IV. PROPOSED APPROACH

In view of that, we proposed a solution : change 2D models to 3D models that students can see, inspect, move, rotate and manipulate at their convenience. We propose this solution by using augmented reality technology, this choice is motivated by a number of advantages well known in the education, learning and training based on augmented reality, we can briefly cite some of them [10][18][19][20]:

- Increased Motivation for the treated subject
- Increased Attention by using 3D contents and interaction tasks
- Increased Student-centered Learning, the teacher becoming more facilitator and students more self-responsible in their learning
- Improved Collaborative Learning by providing new ways of communication and cooperation
- Increased details, information accessibility and interactivity
- Reduced Costs, by using Low-cost applications which can be also used collaboratively in the same place or remotely

In our case, we are interested in designing a collaborative augmented reality system for medical training that we named: "e-learning by augmented reality". The advantage is to allow teachers and students to visualize the course contents in 3D (3D heart, 3D spine, 3D brain ...). This visualization facilitates the comprehension of the course, instead of doing it using paper documentation and/or a classic PowerPoint presentation. Further, both the teacher and the students can manipulate these 3D organs and visualize their internal components.

Our purpose is also to present a solution that is easily integrative in real anatomy course, in this way we need to propose a low-cost system. The hardware requirements are simple, a laptop, a tablet or a phone, these are frequently used in student daily life. We need also a marker (a printed sheet), stick at the plastic human torso (for our first prototype, see figure 1). The real materials from anatomy laboratories can be used in future.

Figure 1. Plastic human torso in the real environment

The teacher and the students will be able to connect via the local network with the Wi-Fi of the university for example, all participants are located in the same class. In face-to-face collaborative AR, the participants can naturally communicate with each other and move around the shared objects to capture more information, the different points of view participate to enhance the collaborative experience.
To make a design which allows us to extend our solution in future and be able, for example, to have another kind of experiences with a distant teacher (from another university) or have remote students who want to join the course, some choices have been made related to the network architecture and communication protocols in such a way that we can have a functional system, even if the number of students augments or their location changes. The following scheme summarizes our system.

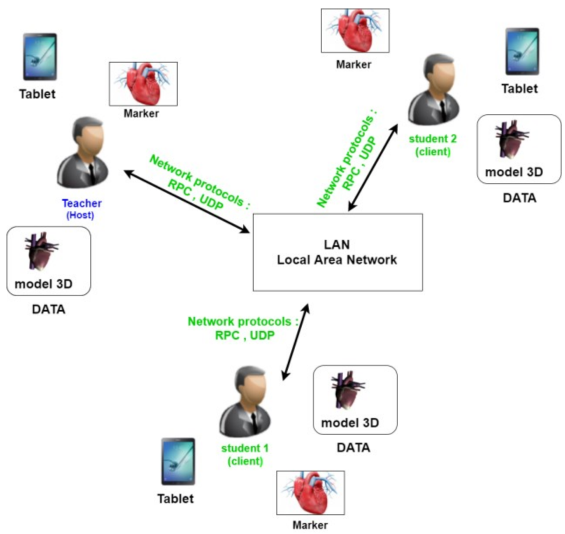

Figure 2. Global System Scheme

In order to make efficient choices for our system, we considered some important points, synchronization of users' actions must be guaranteed by the system and have to make the less network traffic to minimize the latency and augment the responsiveness of the application. In such collaborative interactive experiences, each user needs to see the reaction of the system in real time for his actions and also for the actions of others. Without this, the system can be inconsistent and introduces ambiguities for users, the collaboration could completely fail in this case.

We explain briefly some orientations for our system:

<u>Network architecture:</u>

We have adopted a client/server architecture where the server is considered as a Host (a server and a client at the same time). The latter is attributed to the professor who is considered as the pivot of the system. In fact, he engages the session, he gives a maximum information, he coordinates verbally the session...

<u>Communication protocols:</u>

We used two types of protocols depending on their membership in the OSI model:
The RPC protocol in the layers "Presentation" and "Session" and the UDP protocol in the "Transport" layer. The first one is used to call functions on remote machines and we used the UDP protocol in order to reduce the latency, as reported in [21], UDP sends data in a non-connected mode, there is no way to verify the correct reception and the correct order of the packets. Although this protocol does not send acknowledgments when sending/receiving packets, it insures a fast data transfer to several users.

<u>Data storage</u>:

The 3D data is stored at the level of a local database located in the hard disk of each node (client and host). This is justified by the fact that these data are large and that it is not interesting to send them via the network (the drawback is the saturation of the bandwidth, the increase of the latency/response time and the effect of the bottleneck). Thus, we are in the case of the homogeneous mode replicated data.

V. EXPERIMENTATION AND RESULTS

As explained earlier, our setup is composed of mobile devices with integrated camera, touchscreen and Wi-Fi connection, and a table with a plastic human torso and finally image patterns for tracking. In our implementation, the first device acts as a Host (Server + Client), to which the other devices will connect as Clients. The software was developed using the elements above, this section explains the details of the conducted experimentation :

- Third party Plug-in, Vuforia [22] which is an augmented reality software development kit (AR-SDK), it enables and facilitates AR experiments especially with mobile devices.

- Unity3D and C#, Unity3D [23] is a development software created by Unity Technologies, one of its main uses is game engine-oriented, and there are two languages that Unity3D accepts, JavaScript and C#, use of the latter is more recommended because the C# is basic object-oriented language and the growing community of Unity uses mostly this one, so it is easier to find tutorials or aids on forums and websites.

- UNET: Unity3D developers have developed Unity networking, which succeeded Raknet, this one was a network engine presented as a C ++ and C# library. Unity Networking works only with Unity3D, it is a system based on the Client/Server architecture, usable with a dedicated server or Host.

Our experiment introduces three users, one professor and two students. All of them use handheld devices (a tablet and two phones Samsung).

<u>The teacher</u>: It will be the first user to log in to the system; he will be automatically connected as Host, and then he waits for the different students to connect.

<u>The students</u>: They are clients differentiated by their name and their color (random), they can only connect if the teacher has already launched the application.

Steps of our scenario are described below:

1- The Teacher and students will connect through the following interface (Figure 3)

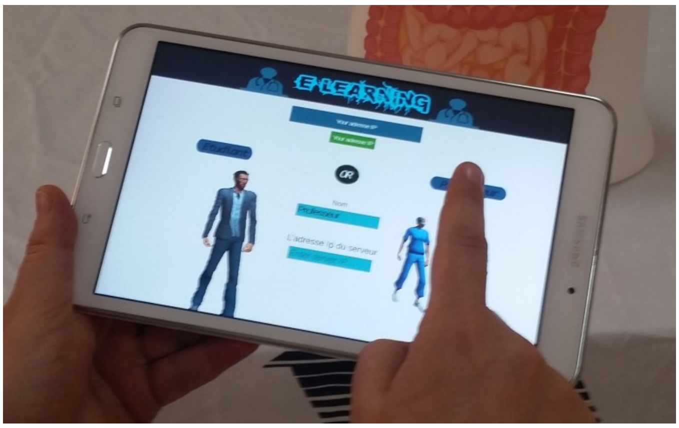

Figure 3. The same user interface for each participant with two possibility connections (Professor, student)

2- The teacher and the students visualize the same objects that are the organ in 3D and its different parts; each user has its own point of view. The users can manipulate the objects via a simple proposed interface.

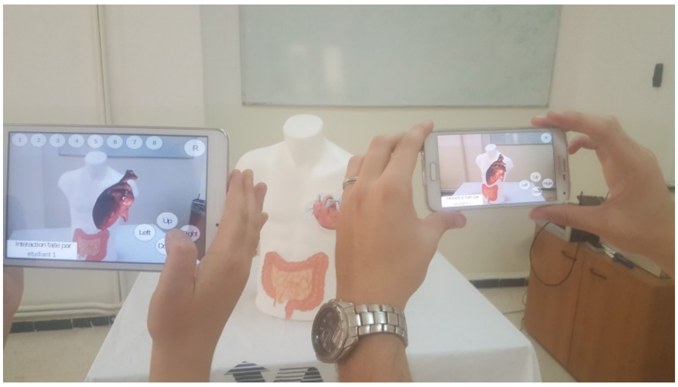

Figure 4. Two users (Professor and student) visualize 3D human heart and manipulate the object in real time

3- The complete experience with the “Professor” (the woman) and the two "students".

Figure 5. Three users sharing and manipulating the same object

With this experimentation, we have completed the scenario successfully without any observed inconsistency. We envisage conducting other tests with more students to augment the number of actions and test the performance of our system. We also plan to extend this work to support remote participants and finally working with medical students to ameliorate the user interface and medical information about the 3D models.

VI. CONCLUSION :

Augmented environments are very useful to support different sciences such as medicine, mechanics, etc. Collaborative applications in augmented reality facilitate certain tasks that are difficult to carry out by a single person and thus provide users with a mean of sharing certain information and interacting with the 3D objects to achieve the final objective. In the aim to support learning activities, the AR/VR technologies are more and more used, our work is into this axe, and treats some complex aspects related to communication, network and consistency issues.

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