Developing Innovative Models for Learning in Social Isolation Environments: Exemplifying it for the Bone Anatomy Study

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Anatomy knowledge is essential for many professionals, such as: doctors, nurses, biologists, biochemical, physiotherapists and any professional in physical education. Over the years, the main anatomical teaching method, the dissection of cadavers becomes less common due to issues related to high costs associated with the maintenance of laboratories, ethical aspects and health risks related to exposure to formaldehyde vapor. This factor was maximized with the Covid-19 pandemic, since presentials accesses to laboratories have become unviable. In order to offer a complementary tool for the teaching of bone anatomy, we propose in this work a serious game in augmented reality, based on controls by analysis of manual gestures, to assist the learning of this discipline.

CCS CONCEPTS • Applied computing • Game for Health

Additional Keywords and Phrases: Augmented Reality, Anatomy, Game for Health, Manual Gestures

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1 INTRODUCTION

Understanding the spatial context of human anatomy constitutes an important teaching aspect in the curriculum of several courses in the health and physical education (PE) areas. There is much debate about the appropriate methods of delivering anatomical knowledge. In the literature there are the definition of six categories of teaching tools: 1) dissection of cadavers, 2) inspection of examined specimens, 3) didactic teaching, 4) use of models, 5) computer-based learning (CBL) and 6) teaching of living and radiological anatomy [4]. Knowledge of anatomy is essential for the safe exercise of activities in the field of health and PE. A recent study indicates that a significant number of deaths in the United States occur due to anatomical errors and medical incompetence in it [5], and despite the importance of this subject, less than a 1/3 of new residents have sufficient anatomical knowledge [16]. Furthermore, a large portion of anatomists argue that in order to obtain an accurate understanding of anatomy, the student must be exposed to the “real” 3D formats

as much as possible, that is, they must experience the study based on dissection of cadavers [5] . However, despite of this way of study being the most usual in the last 400 years [2], nowadays it is almost impractical due to: (a) the high costs associated with the acquirement and maintenance of dead body parts in laboratories, (b) the health risks related to the exposure to formaldehyde vapor used in corpses, and (c) ethical and religious issues. All such aspects make this learning method less common, now being reserved almost entirely for medical students, and not for those who are training for related occupations [14] [12] [7].

Moreover, this tendency of gradually reducing contact with cadaver dissections was maximized with the outbreak of the COVID-19 pandemic when presentials access to those labs is no longer feasible [9]. In this scenario, it is necessary to use alternative tools for the anatomy learning. A possibility is the improvement of the learning by anatomic atlas (i.e. draws and images) on the aspect where students present more difficulty: the 2D images found in these books cannot accurately represent the 3D correspondent body parts and theirs relations among the neighbors on movements and functionalities [11]. Bearing in mind all this aspects regarding the learning of anatomy, we propose in this work an Augmented Reality (AR) solution by using a serious game approach for the study of this so important aspect in the training of health professional [6]. The prototype presented here helps on self-learning of bone anatomy through concepts such as: rewards, competition and progress feedback.

2 THE AUGMENTED REALITY PROTOTYPE

The literature presents some augmented reality solutions for anatomical teaching, in general these implementations allow only the display of overlapping multimedia objects so that students can interact with these [10] [11] [8] [1]. The augmented reality addressed in this work is based on incorporating the real and virtual world [13] to expand the experiences that one is living. The information of the virtual world is text data, images, audios or videos [3] [15]. In the implementation an augmented reality game is proposed that not only provides the display of multimedia objects, but presents concepts of gamification in order to increase the degree of satisfaction and motivation of students of bone anatomy.

The solution presented here was designed to provide a pleasant and motivating experience for teaching bone anatomy [6], in an accessible cost, since the only necessary requirement is the installation of the software on an Android smartphone with an operating system higher than 7.0 and with a rear camera for the capture and real-time recognition of the user's gestures. The application currently makes use of the Application Programming Interface – APIs, ARFoundation and ARCore. These APIs together provide the necessary architecture to work with augmented reality, through which it was possible to simulate the 3D model of a human skeleton in a real environment, maintaining all its proportions and characteristics. Furthermore, it was also necessary to use the Devkit Manomoton, Unity Engine, to provide a structure for analyzing 3D gestures in real time; and the environment for developing the game. Currently, the project has 20 (twenty) bones of the human body for interaction. It is important to emphasize that the application is still in its initial phase and that in the future the idea is to interact with all the bones of the body. The 3D model can be seen in Figure 1, the image shows the virtual object of the human skeleton superimposed on a sandy beach.

Figure 1: Image of the game running in a real sandy beach setting and manual gestures recognized in the application

In its game play, the prototype makes use of controls based on the players hand gestures, which we believe provides a more intuitive, immersive and stimulating experience. At the moment, the application recognizes for the interaction two non-continuous gestures, they are: pinch and grab (respectively, shown in at the end of Figure 1). Gestures are recognized by combining hand locations in the users previous and current hand positions. The system understand what type of activity the user is currently performing and thus activate the desired functionality based on the input data.

The game features simple concepts and mechanics in order to make it understandable even for those unfamiliar with applications in augmented reality. During the game, questions with the name of any of the interactive bones are drawn at random and then the player must indicate on the 3D model which bone corresponds to the question. Each bone has an id that will be compared with the id of the question drawn by the system. In sequence, a new bone is drawn and the user receives points if he has correctly indicated the bone. Furthermore, simple game concepts were implemented in order to increase the motivation of the users to play. That way, the game features are: a) scoring elements to increase competitiveness among students; b) the concept of combos, giving a bonus in the score when hitting three or more questions in a row; c) the time challenge, in which the player has only 1 minute to try to get the highest score possible in this interval.

3 RESULTS

This initial version of the prototype was tested for six volunteers to allow us to reach conclusions about aspects related to its usability. The volunteers are male and female, all university students or graduated from health-related areas that have the study of human anatomy in their didactic curriculum. All participants freely played the game and then answered a total of 15 questions, all of them subjective, divided into two types of questionnaires: about the interface and about learning. The answers should obey a scale from 1 to 5, with grade 1 represents the lowest level of approval and grade 5 is for the highest level of approval possible. Table 1 shows the questions and the respective averages grades.

4 CONCLUSION

Although the prototype is in an embryonic state, the feedbacks related to the system interface and its effectiveness in learning about bones were very positive. All volunteers were able to use the application intuitively, without monitoring or guidance. However, with the tests it became evident that there is a need for improvement regarding the system feedback on the users progress, as a portion of the volunteers reported not being able to accurately understand their progress within the game. The results so far are optimistic, the

project in its initial phase complies with the proposal to offer a cheap and accessible tool to students. We believe in the potential of the presented solution to add value to the teaching of anatomy.

Table 1: Questions and average grades of the questionnaire responses

About the interface	Grades	About the learning	Grades
Is it object easy to handle?	4.17	Are you satisfied with is it?	4.83
Is control compatible with movement?	4.83	Do you believe that the app is relevance?	5.00
Are the texts clear?	4.50	Did you find is it fun?	4.67
Is the sound feedback clear?	4.83	Is it better for learning than conventional tools?	5.00
Is it response time appropriate?	4.00	Would you recommend it to a friend?	4.83
Is it easy to start the application?	4.83	Is it possible to notice that the objects are in 3D?	5.00
Are mistakes difficult to do in the app?	4.00	Is it easy to start?	4.83
Is clear the reports of your progress?	3.67		

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