Augmented Reality Techniques, Using Mobile Devices, for Learning Human Anatomy

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ABSTRACT
We present a technological tool we developed under a portable environment by taking a specific fixed image from an anatomy atlas and visualizing it as a three dimensional and dynamic model; an enrichment of the anatomical image and an important aid in the student learning process. The system consists of an augmented reality library called Vuforia. After the images were scanned, they were stored in a database. The three dimensional models seen are created with Unity3D and Maya. The system allows Android and iOS platforms. The use of these mobile devices will allow managing the knowledge for students, developing new ways of teaching innovation and improving the quality of the academic process. These applications encourage student learning, promoting a more interactive attention. There is no doubt that smartphones and tablets are an additional teaching resource nowadays, they enrich and facilitate the transmission of educational contents in health science, specifically in the field of Human Anatomy.

Categories and Subject Descriptors
H.1.2. [**User/Machine Systems**]: Human information processing; Software psychology

General Terms
Human Factors

Keywords
Augmented reality, mobile devices, medical training, Human Anatomy

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1. INTRODUCTION
During the last two decades, there has been an increase in the use of mobile devices. According to the last report of the International Telecommunications Union, there are 6.800 million people with a mobile line worldwide. In Europe, there is a mobile line penetration rate of 128% and of 68% with access to mobile broadband. We find ourselves in a society where more content is increasingly consumed from any device. If we delve in the data from Spain, it is the leading European country in smartphone use within the European Union frame, with a 66% penetration rate.

Portable electronic devices (smartphones and tablets) have become technological tools of widespread use in medical education. Mobile technology development is unstoppable. The massive use of these devices by university students is beginning to change the search and communication habits among users. These resources enrich and enable educational content transmission, favoring medical training. We present a technological tool developed under a portable environment, which takes a specific fixed image from an anatomy atlas and visualizes it as a three dimensional and dynamic model; an enrichment of the anatomical image and an important aid in the student learning process.

2. METHOD
Our system consisted of an augmented reality library called Vuforia, implemented by the company QUALCOMM Incorporated.

To achieve proper image recognition, the images were first scanned to obtain the most representative points that will later be detected by the mobile application. The data belonging to the patterns was stored in a local database within the device.

Additionally, the recognition patterns were uploaded in a dynamic way through a cloud service that stores different recognition patterns in a database, which can be downloaded to the final application in real time (Fig. 1). Currently, Vuforia gives us a complete API to work in a CLOUD environment.

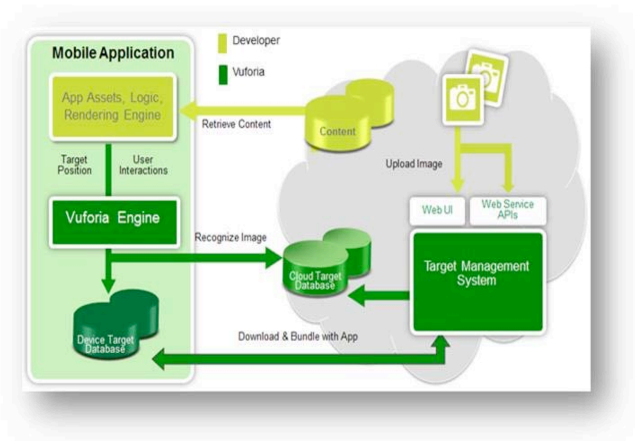

Figure 1. Diagram showing the development process, using Vuforia library and the ways to obtain the image recognition patterns.

2.1 Arquitecture

Vuforia´s SDK is based on the following components:

2.1.1 Camera.

The camera component ensures that every image is efficiently captured and sent to the tracker that identifies it. The application only needs to launch the camera to start and stop image recognition.

2.1.2 Image Converter

The pixel format converter transforms the camera format (for example, YUV12) into an adequate format for OpenGL ES (for example, RGB565) and for the internal follow-up (for example, luminance). This conversion also includes resolution reduction, so the camera image, given different resolutions, adapts to the system.

2.1.3 Tracker

The tracker component has the computer vision algorithms that identify and track real world objects in the video photograms of the camera. Based on the camera image, different algorithms are in charge of identifying images or new markers and evaluating virtual buttons. The results are stored in a state object that is used by the video processor and can be accessed from the application code. The tracker can upload several datasets at the same time and activate them.

2.1.4 Device database

The active images are uploaded in a database within the mobile device which has an XML configuration file allowing the developer to configure certain traceable characteristics and a binary file that has the image database. These files are assembled by the application developer in the installation package and runtime application used by the SDK Vuforia AR.

2.1.5 Cloud database

The cloud database can be created using the API service of Vuforia's website. The application uses the recognition function in the cloud and does a visual search of the images sent from the camera. Besides the target data, the uploaded images may have metadata that are incorporated into the query to add information.

2.1.6 Image recognition

Unlike traditional markers, data matrix codes and QR codes, the images used do not need special areas in black or white or codes in order to be recognized. Vuforia's SDK uses sophisticated algorithms to identify and track the natural characteristics found in the image itself (Fig. 2). Vuforia recognizes the image by comparing these natural characteristics with the records of the database created. Once the target image is identified, the system will do an image follow-up, provided it is at least partially within the camera's field of view.

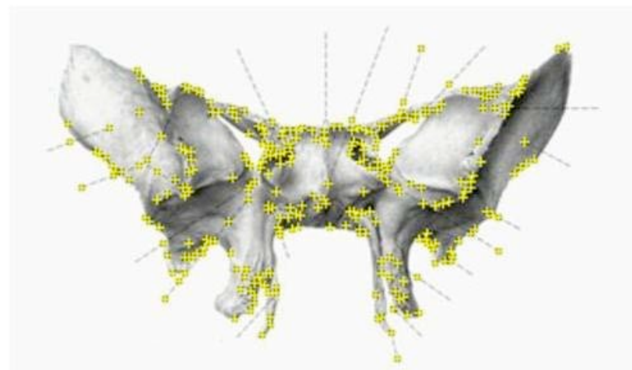

Figure 2. Image of the sphenoid bone with the representative image points recognized by Vuforia's algorithm.

2.2 Supported platforms

Currently, the system supports Android, iOS, and PC platforms in a native manner and the development can be done in Windows, Mac OS and Linux systems.

The library has been successfully tested in different terminals Android and iOS (Fig. 3) getting great results and adapting the device's screen resolution to optimize user experience.

Figure 3. Mobile devices for iOS (iPhone) and Android (Samsung) environments.

2.3 Description of the development environment

Native development applications can be done for the iOS platform through its development environment for Xcode as well as for the Android platform using a java IDE and the SDK.

The models seen are created with Unity3D and Maya, a complete integration between Vuforia and Unity (Fig. 4).

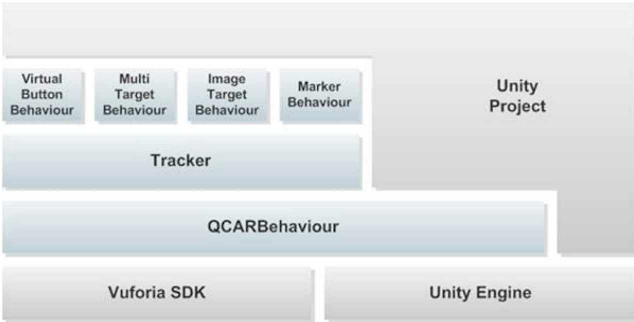

Figure 4. Diagram showing the integration between Vuforia's SDK and Unity3D.

Unity3D is a powerful multiplatform software that lets us export one same project to all mobile platforms (iOS and Android) with a very fast development (Fig. 5). It optimizes the construction work of scenarios and animations as well, since there are models and free resources on the Internet.

The following diagram shows the integration between Vuforia's SDK and Unity3D:

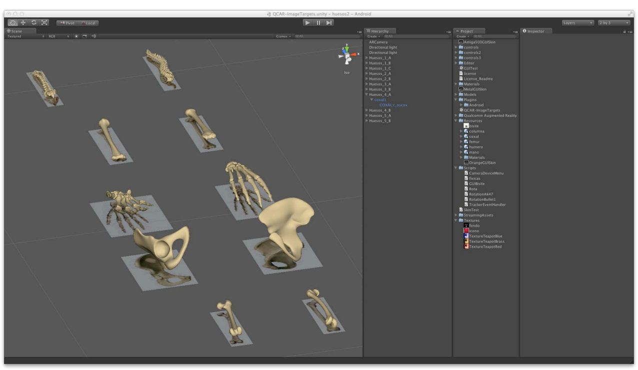

Figure 5. Interface of Unity3D software for the creation of three-dimensional anatomical models and their export to mobile platforms.

3. RESULTS

Anatomy atlases are important elements in Human Anatomy teaching, they are one of the resources that students most handle in any health science degree (Medicine, Occupational Therapy, Physiotherapy, Nursing and Dentistry). However, these books are passive elements in which students see a fixed image.

The technological tool developed by us for portable devices allows taking a specific fixed image from an anatomy atlas and visualizing it as a three dimensional and dynamic model (Figs. 6, 7 and 8); an enrichment of the anatomical image, and an important aid in the student learning process.

Figure 6. Identification of an anatomical atlas image to be transformed into a three-dimensional one using an iPad tablet.

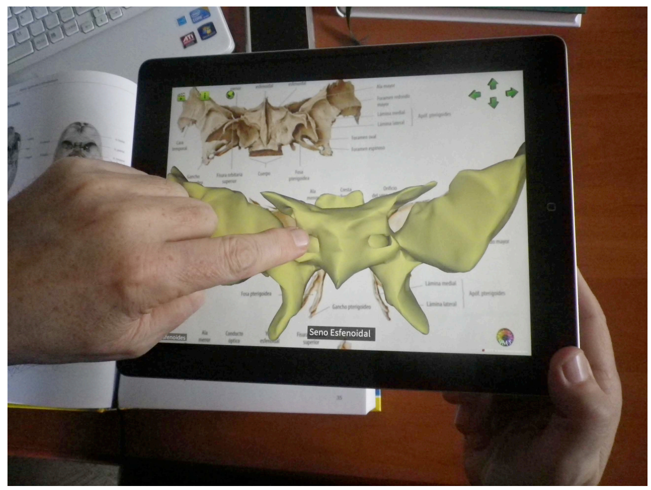

Figure 7. Manipulation of the three-dimensional image (sphenoid bone) for its assessment in any spatial position and for studying its different anatomical parts.

Figure 8. Video display of the sphenoid bone explanation, as an instructive audiovisual complement to the three-dimensional view.

4. DISCUSSION

According to an analysis on potential learning through mobile devices (m-learning), the main advantages from a functional standpoint are the possibility of learning anytime and anywhere, the immediate student-teacher interaction, cheaper technology (the cost of a mobile device is significantly lower than that of a PC), greater accessibility (increasingly common Internet access), greater portability and function, possibility of a more collaborative (creating groups, sharing answers, providing information, etc.) and explorative (learning about a topic or field, exploring, experimenting and applying while doing so) learning.

From a more pedagogical standpoint, m-learning can be used to motivate independent or group learning experiences, letting teachers send reminders to their students regarding activity deadlines or tasks as well as support and encouragement messages. This enriches the learning experience, makes it less formal and provides variety in content or in conventional courses.

On the other hand, we find some limitations or disadvantages of m-learning. They are the ones inherent to the mobile phones themselves: battery life, device size, screen resolution, cost of data access rate plan or low processing speed, to name the most common. We must also take into account the difficulty of adapting educational content to these types of devices. The offer of mobile learning applications is increasingly broader and varied. Regardless the field of knowledge, it is not difficult to find an application that is somewhat suitable to use. Mobile device stores, like Apple's App Store, Windows' Marketplace, Google's Android Market, Blackberry's App World or Nokia's Ovy have extensive resources and educational applications. Even Yahoo has included a tab exclusively dedicated to iPhone and Android application search, and plans to expand this mobile application index with tablets like the iPad or with those from other mobile stores like Samsung or Nokia.

Earlier this year, Apple announced that its application store had surpassed the download of 10.000 million apps by more than 160 million iPhone, iPod touch and iPad users worldwide. Although Apple currently leads the application market, Windows Phone 7 Marketplace is close and has reached 20.000 applications almost at the same rate than Apple store did at the time (8 months), while it took Android over a year with Android Market and Blackberry App World nearly two years.

Many educational projects have demonstrated the great potential of m-learning. More schools have taken notice of this new system to develop their own teaching programs. The characteristics of these devices encourage student implication in learning through direct content interaction, becoming an excellent platform for training in any health science discipline.

5. CONCLUSIONS

These resources enrich and enable educational content transmission, favoring medical training. The use of mobile devices enables managing the knowledge for students, by developing new ways of teaching innovation. These applications stimulate student learning, promoting a more interactive attention.

Mobile technology development is unstoppable. The massive use of these devices by university students is beginning to change the search and communication habits among users. It seems evident that smartphones and tablets are slowly making their way in university education. The characteristics of these mobile devices promote student implication in the learning process through direct contact with teaching content; becoming an excellent platform for university education.

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