ABSTRACT

This study reviews the latest innovations in medical informatics based on digital and technological applications. In particular, we focus on the contributions developed by VisualMed System (Medical Visualization Systems) Group. Applications are presented in four categories: first, development of digital anatomical viewers; second, development of augmented reality applications; third, development of simulator applications; and finally, examples of developed applications for portable devices such as smartphones and tablets are also presented. Every application shares multiple interactivity features and rich visual medical content. Finally, implications for teaching and learning in health sciences are discussed. In particular, the key role of these applications in order to enhance autonomous learning and to visually support traditional teaching methods.

Keywords: 3D Software, Augmented Reality, Image Processing, Information Technology, Medical Informatics

INTRODUCTION

In recent years, the development of technological advancements has experienced exponential growth, in the health sciences field in general and particularly in medicine, transforming the teaching-learning process and supporting a new domain known as educational technology (Carmichael & Pawlin, 2000; Chariker, Naaz & Pani, 2011; Clark & Mayer, 2007).

One of the most representative examples in this area has been the development of new three-dimensional (3D) visualization content systems, which offer a more complete and realistic content representation than traditional learning material on paper (Venail, Deveze, Llallermant, Guevara & Mondain, 2010; Temkin, Acosta, Hatfield, Onal & Tong, 2002; Petersson, Sinkvist, Wang & Smedby, 2009; Estévez, Lindgren & Bergethon, 2010; Silén, Wirell, Kvist, Nylander & Smedby, 2008). In the medical imaging field, these developments have been mainly based on the use of two well-known open source libraries, VTK (Visualiza-
tion Toolkit) and ITK (Insight Segmentation and Registration Toolkit). These applications constitute true learning environments directed towards maximizing the student’s independent work outside the classroom and the interaction with contents considered traditionally complex. Therefore, they represent a powerful support or complement to more expository and unidirectional traditional teaching systems.

Parallel to this, the development of technological advancements with teaching purposes in the health field is paying increasing attention to mobile phones, smartphones and tablets, given their greater portability, economic accessibility and optimal integration with the internet, which maximize the diffusion and mobile use of the applications developed. The recent development of Osirix MD™ versions, an advanced and complete DICOM image viewer for iPhone and iPad is a representative example of these applications.

All these changes in health science teaching pose a challenge for teachers and institutions when it comes to designing, developing and implementing these technological applications, as well as a student effort to adapt.

The effectiveness evaluation of these applications is receiving increasing attention through more sophisticated studies, whose encouraging results contribute to strengthen this line of work (Chariker, Naaz & Pani, 2011; Ruisoto, Juanes & Prats, 2013; Ruisoto, Juanes, Contador, Mayoral, & Prats, 2012; Nicholson, Chalk, Funnell & Daniel, 2006).

The objective of this study is to present a summary of the most recent contributions to the educational technology field in the medical training area, developed by the recognized research group from Salamanca University, VisualMed System).

**METHODOLOGY**

For this study, the applications developed by the VisualMed System research group between 2000 and 2013, were assembled and revised, including peer review journal articles, contributions to national and international congresses and applications still under development.

In order to facilitate its presentation and reader analysis, the applications were classified in the following categories: first, anatomical and functional viewers; second; virtual simulation environments for training purposes; and third, augmented reality applications for portable devices.

We will attempt to present a brief description of each application illustrating the most relevant characteristics through iconographic representations. The aim is to reduce the text extension and facilitate its comprehension. For a more complete presentation we recommend consulting the references included in the corresponding section of the paper.

Anatomical and functional viewers were developed as follows: fist, anatomical, radiological and nuclear medicine images were acquired. All participants gave their informed consent to participate in the study, which was approved by the local ethics committee following the principles established in the Declaration of Helsinki. Then, Amira™ software program, version 5.3 (Mercury Computer Systems/TGS, San Diego, CA) was used for the image segmentation and 3D model reconstruction of acquired images. Finally, Visual C++ and Active X controls for Windows™ were used to create the general user interface (GUI). All viewers have been developed for Windows™ although open source options and other platforms may be developed in the near future.

Virtual simulation environments were developed using chromakey technology. It consist on the combination of output signals of two or more cameras together and/or with other external sources and masks, namely, images with opaque and transparent areas that allow viewing or hiding the background alternatively until reaching the final composition. Autodesk Maya™ version 13 was used for object modeling in these scenarios. It allows 3D animation and delivers a comprehensive set of tools for modeling, simulation and rendering that met our requirements. The 64-bit version of Maya 2013 was used in an iMac OS X 10.7 operating system. Autodesk Maya is an application
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