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The impact of Web3D technologies on medical education and training

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Abstract

This paper provides a survey of medical applications that make use of Web3D technologies, covering the period from 1995 to 2005. We assess the impact that Web3D has made on medical education and training during this time and highlight current and future trends. The applications identified are categorized into: general education tools; tools for diagnosis; procedures training; and collaborative training. A summary of work that has been carried out to validate these tools is also included in the survey.

Keywords: Applications in medicine; Virtual reality; Interactive learning environments; Simulations

1. Introduction

Web3D is the generic term commonly used to refer to any three dimensional (3D) graphics technology supported by the World Wide Web (WWW). The first ISO standard for Web3D was the Virtual Reality Modeling Language (VRML 97). This is still used, but is currently being replaced with X3D, an open standards XML-enabled 3D file format to enable real-time communication of 3D data across all applications and network applications. Java3D and other technologies such as Macromedia's proprietary Flash, can also be classified as Web3D. As all of these technologies mature, there is a significant opportunity for Web3D to make a real difference to

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medical practitioners. The use of the WWW for medical education offers inexpensive training opportunities at virtually any location and at any time. The web infrastructure also supports possibilities for collaborative working. This flexibility is ideal for the high pressured staff of a typical hospital.

This paper begins with an overview of the main techniques that are used to visualize and interact with medical data in three dimensions, and highlights how these techniques can be implemented using Web3D technologies. We then provide a survey of the current tools and applications developed for medical education and training using VRML, X3D, or Java3D, although some other technologies are also identified. The applications are categorized into: general education tools; tools for diagnosis; procedures training; and collaborative training. A summary of any work carried out to validate these tools is also included in the survey.

The paper concludes with a discussion of the limitations of Web3D as used for medical education applications, and suggests solutions and workarounds gained from our experience. Many of the problems are being addressed by the Web3D Consortium's Medical Working Group, and we provide an overview of this group, together with future directions.

2. Medical visualization techniques

Medical image scanners are common place in hospitals, including support for MRI, CT, and Ultrasound modalities. Typically, a scanner will produce a series of two dimensional (2D) images that are displayed directly onto a monitor or printed onto film for viewing on a light box. A standard called Digital Imaging and Communications in Medicine (DICOM) has been adopted to store the raw image data together with associated information, and to enable the images to be transferred between devices manufactured by different vendors. Medical scanner manufacturers also routinely provide workstations that support three dimensional (3D) visualizations of the patient data and such workstations are becoming faster and the software more sophisticated. They start with the stack of 2D image slices obtained from a medical scanner. This image stack is referred to as a *voxel* data set, a voxel is the 3D analogy of the 2D pixel. A voxel data set can be processed to provide a 3D visualization as described below. As accessibility to 3D software increases, then significant efficiency gains and benefits to patients has been predicted (Megibow, 2002). One way in which to improve accessibility is to deliver the visualization using Web technologies so that the user only requires the use of a Web browser running on a desktop PC or laptop. Such solutions will be the focus of this paper.

Typically, the first step in creating a 3D reconstruction is to segment the raw data to identify the volumes of interest, i.e., the internal organs, skeletal structure, tumour, etc. Well known segmentation approaches include thresholding, region growing, and pattern recognition. Pham, Xu, and Prince (2000) provide a survey of these and other common segmentation techniques. Most are only semi-automatic and require intervention from the user. It may also be desirable to combine data sets from different image modalities using image registration algorithms. This task is often time consuming and needs access to good computational resources. Most of the web based solutions described in the paper therefore require this stage to be carried out as a pre-processing step. Alternatively, some solutions make use of a central server to perform image registration on demand, or perhaps utilise a computational Grid infrastructure (e.g. Hill et al., 2002; Stefanescu,