Introduction

Three-dimensional reconstruction of medical imaging information is increasingly used to present anatomical structures and pathologies for the purposes of diagnosis and treatment planning. This trend is driven by (1) the availability of high-resolution 3D or 4D data sets from CT, MRI, and ultrasound; (2) the desire to consolidate the large amount of data and focus on the relevant information about the disease; and (3) the need to present the imaging information in a cognitively intuitive way to facilitate communication.

Currently, 3D reconstruction techniques, such as volume rendering, emulate how a 3D object would appear on a two-dimensional screen. This restriction limits the full use of our spatial senses, thereby introducing ambiguity and uncertainty (Fig. 1). To overcome this limitation, two approaches are being developed. One is 3D printing and the other is 3D virtual reality.

In this poster, we describe one implementation of 3D virtual reality, the True3D technology developed by EchoPixel, and explore its medical applications. We will also discuss the respective roles of 3D virtual reality and 3D printing.

True3D System and Sensory Cues

The True3D system (Fig. 2) consists of a pair of specially marked spectacles with two orthogonally polarized lenses. A set of cameras tracks the markings to determine the position and orientation of the observer’s head. A spatially tracked pointing device tells the hand interacts with the virtual world. A computer gathers these inputs and calculates the appropriate right and left eye images. These are displayed on a polarized monitor to be viewed through the polarized spectacles, completing the loop.

Diagnostic Radiology Applications

For a radiologist, much of his training is spent on correlating memorized 3D human anatomy with medical images of any source or presentation. The anatomy knowledge helps him predict what is not in view. This skill breaks down when the anatomy is variable or unexpected. It is in these cases that True3D is most helpful to the diagnostic imager (Figs. 6-7).

Interventional Planning and 3D Guidance

Most procedures performed by interventional radiologists, interventional neuroradiologists and interventional cardiologists are guided by fluoroscopic projectional images. True3D can help navigate complex vasculature for the purposes of embolization, stenting, and drug delivery (Fig. 9). Measurement tools assist in sizing of stent, stented valve, and other endovascular devices before the interventional procedures (Fig. 10).

Surgical Planning and Intraoperative Guidance

Deployment of the portable True3D system in the operating room allows intraoperative imaging consultation during surgery. Simulating surgical anatomy, the True3D presentation is effective conveying patient-specific information to the surgical team. At Stanford, the True3D system has been used for separation of conjoined twin, for complex pulmonary artery reconstruction, and for sternotomy planning before minimally invasive valve replacement surgery (Fig. 11).

True3D Visualization Versus 3D Printing

Virtual reality and 3D printing are two approaches that produce 3D cognitive experience. Each approach has its advantages and disadvantages, and in some applications, they complement each other. True3D allows immediate examination of a study without waiting for the model to be printed, and it does not require segmentation, a time consuming process. The cut plane, scale, color, and surface texture for a physical model are fixed once it is printed, while these factors can be changed at will and in real-time in True3D. Furthermore, a model can be produced to test fit a device physically, while this cannot be done with True3D.

The best approach may be to combine both. True3D can be used first to gather the data set and plan out the optimal cut planes and segmentations. The results can then be transferred electronically for 3D printing.