A System for Real-Time 3D Neurosurgical Planning

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ABSTRACT

We see two major barriers which limit clinical use of 3D surgical planning software. First, images must be automatically segmented. Second, the planning software must be easy for physicians to use. We describe a prototype system which addresses these problems, making computer-guided neurosurgical planning feasible in the real world.

INTRODUCTION

Complex 3D visualization and planning software must address the surgeon's real-world needs. The surgeon wishes to view detailed images of the individual patient. The surgeon wishes to view these images immediately after the patient is scanned, and the surgeon wishes to manipulate these images to diagnose the patient's condition and plan a surgical intervention, *without having to work through a technical assistant*. A surgical planning system which cannot meet these criteria is therefore of limited utility in the clinical routine.

To address the neurosurgeon's real-world needs, two major barriers must be surmounted. First, we must achieve rapid and robust segmentation of the individual patient's data. Second, we must make the 3D visualization software itself usable to the neurosurgeon. Surmounting either of these barriers in isolation does not address the neurosurgeon's overall problem: both automatic segmentation and easy-to-use software must exist before a system can go into clinical use. We believe that other barriers, such as volume-rendering segmented data and archiving results in a patient database, are more amenable to solution using published techniques. Thus the present work focuses on the segmentation and user interface problems, which we perceive to be key bottlenecks.

The task of segmenting objects from the background and each other is a necessary step for quantitative image measurement and visualization. It is not feasible to have days or even hours separating imaging of the patient from the potential start of surgery, but rather this turn-around time should be measured in minutes. As a result, labor-intensive approaches such as slice-by-slice hand segmentation of volume data are completely infeasible: the time taken to produce the segmentation makes the result effectively useless in clinical routine. An automatic segmentation algorithm which requires hours of computation is equally impractical. Thus, the neurosurgeon's tasks require robust segmentation techniques which require only minimal user interaction and produce their results within minutes.
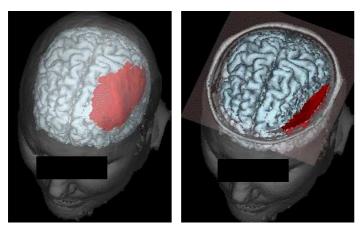

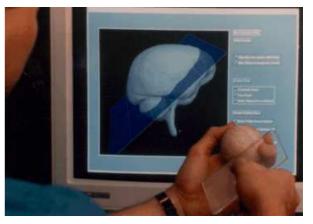**Figure 1:** Visualization of segmented MRI data from patient with a hematoma.

Figure 2: User specifying a cutting plane using 3D interface tools.