

A Modular, Multi-modality Integrative Pipeline for Neurosurgery Simulation and Visualization Anthony Beardsworth Costa PhD; Joshua B. Bederson MD Department of Neurosurgery, Icahn School of Medicine at Mount Sinai



Introduction

The practice of pre- and intraoperative interactive visualization and modeling continues to grow as its value to clinical practice is augmented by new technologies, such as virtual and augmented reality, or 3D printing. Current tools which extract the necessary structural information from medical imaging modalities and allow virtual or other interrogation of the data are either difficult to use in a practical clinical setting, or sufficiently simple as to limit the knowledge available to the operator. Nonetheless, the broader medical visualization and simulation communities have invented tools which enable automated segmentation and interrogation of structures critical to the success of surgery, such as cranial nerves, vasculature, and cortical and subcortical parcellations.

Learning Objectives

Pre-operative planning using virtual, augmented, and structural modeling.

Methods

We leverage these tools as inputs to a novel pipeline for neurosurgery simulation. Our pipeline is compatible with ATLAS-based subcortical volumetric segmentation (e.g., Freesurfer, ANTS), or any structural input in mesh- or voxelbased formats, together with volumetric data. The visualizer, based on VTK7's OpenGL3x rendering backend, is efficient enough to display an arbitrary number of input structures or volumes at interactive refresh rates. Structures can be manipulated by adjusting parameters for each structure independently (e.g., color, opacity). Standard ATLAS-based and ITK/VTK-based tools are included in the pipeline directly. Also included is a novel volumetric shiftbased segmentation tool, allowing an operating scientist to easily include information detailing aberrant pathologies rapidly and with minimal semantic information.

Results

We demonstrate these tools for a variety of cases, including tumor, vascular, hemorrhagic stroke, and spine. Its performance sufficient to run and be used on a laptop computer and capabilities for preoperative planning through 3D printing the generated structures.

Input data set for analysis



Input MR and CT scan to integrated pipeline for expert-driven and ATLASbased segmentation.

Visualization of pre-operative plan for transnasal endoscopic resection.



3-part visualization of expert-driven pathology segmentation in the integrative pipeline. Each component of the simulation may be included as ray-cast volume or polygon data, and individually enabled/disabled, cropped, or respect other modification of underlying transfer function.

Expert-driven segmentation



3-part expert-driven pathology segmentation for transnasal endoscopic planning, superimposed on MR and CT base imaging sets.

Visualization of Freesurfer data



Integrated visualization of 11 subcortical structures simultaneously from the standard Freesurfer 5.3.0 pipeline, implemented in our novel pipeline.