An Interactive Tool for Fitting Surfaces to Volume Data

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Problem

▶ Currently, fitting smooth, parameterized surface models to specific anatomy elements in medical image data is a time-consuming problem involving a great deal of manual intervention. Can we reduce the manual component of this process?

Motivation

▶ MRI and CT scanners have long been used to produce three-dimensional samplings of anatomy elements for use in medical visualization and analysis.

▶ Smooth, parameterized surface models of such datasets are useful not only for visualization, but also as finite element models on which simulations and further processing can be performed.

▶ A common approach to surface reconstruction from medical image data is "contour stitching". In this process, a surface is reconstructed by connecting the vertices of adjacent contours in order to generate a mesh that passes through all contours. Such methods all assume that a series of parallel contours on the input data are given.

▶ Unfortunately, the act of marking contours on the input data is currently a time-consuming process, in which an experienced scientist or physician must manually segment the original volume dataset by going through the two-dimensional slices of the data individually, in order to mark a series of parallel contours that outline the object of interest.

Our Approach

▶ We propose a tool that allows the user to generate a surface from just a few contours drawn on arbitrarily oriented planes. The user can then edit the model globally and interactively, rather than marking many parallel contours on a slice-by-slice basis.
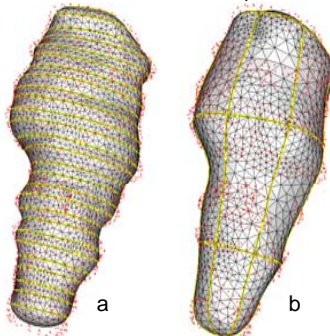
Initial Results

▶ Contours defined on benchmark brainstem volumes. Red dots represent portions of the benchmark that are not well represented by the surface.

a) 27 transverse contours

b) 6 oblique contours

The use of oblique contours yielded a more accurate reconstruction with the use of fewer contours.


1. The Input Data

▶ We begin with a volume dataset. In this example, we have a CT scan of a human prostate. There are 256 slices. The figure to the right shows one input slice, along with rectangles that outline the locations of every 10th slice.
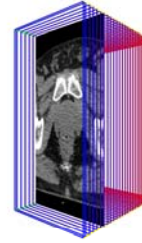

2. Arbitrarily Oriented Image Planes

▶ We perform linear interpolation between each slice in the input dataset, and now we can render arbitrarily oriented image planes. The figure to the right shows one such plane.
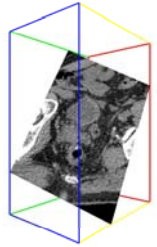

3. Drawing Contours

▶ The user can draw contours on any plane, having any location and angle. Below we give an example of segmenting the bladder with oblique contours. Here we show close-ups of three of the five user-drawn contours. Each close-up image is accompanied by a reference image showing exactly where the corresponding image is located in the volume.
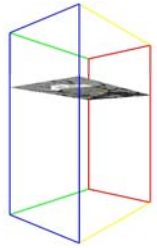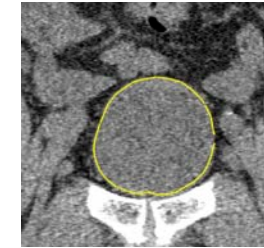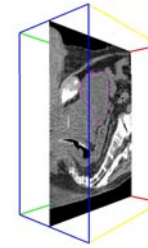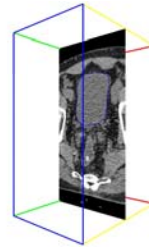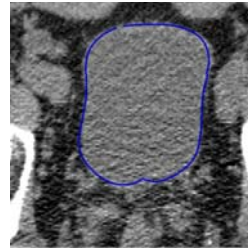
4. Surface Reconstruction

▶ After a set of contours have been drawn, we can reconstruct a surface using the technique of [Liu et al. 2008].
a) Generate the medial axis (MA) of the sub-space. b) Project curve networks onto MA sheets. c) Triangulate regions on MA sheets projected from different materials. d) Connect curve networks with their projection on the MA.

▶ Below is the result of our reconstruction. Sagittal (top) and transverse (bottom) views are provided.
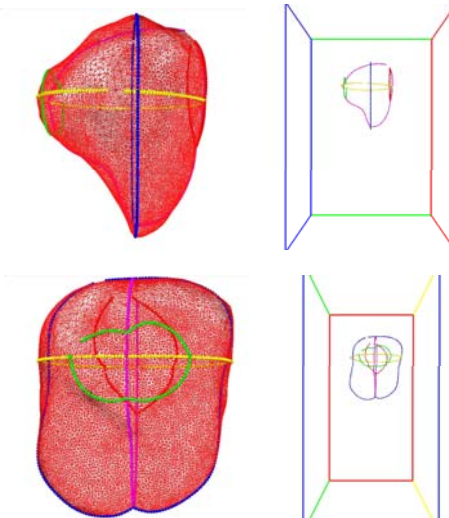
5. Viewing and Editing the Surface

▶ Once an initial surface is reconstructed, it can be viewed simultaneously with the volume data for evaluation. We intend to provide many tools for editing the surface directly, rather than simply editing the contours. The user can edit a single contour, and nearby parts of the surface will automatically adjust accordingly. The interface will also provide the user with tools to snap the surface to local thresholds, and provide the user control over the region of influence for editing.
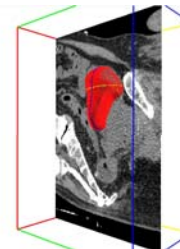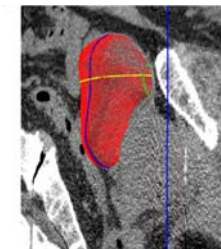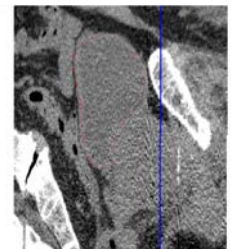

Image and Surface   Close-up   With Clipping Plane