Contour Guided Surface Deformation For Volumetric Segmentation

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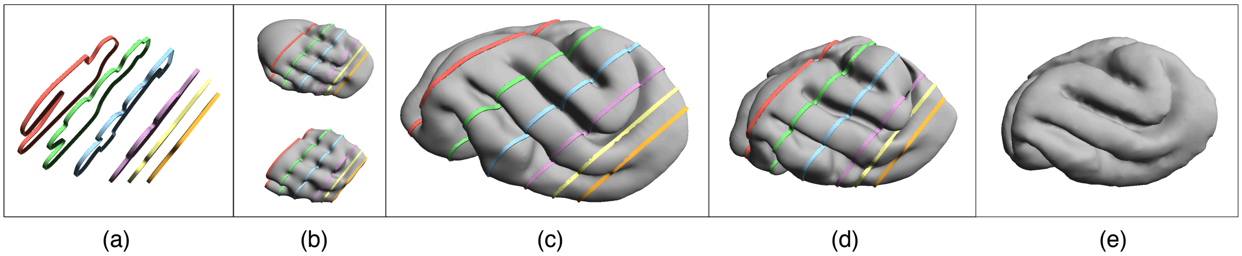

Figure 1: *The goal is to find the best mesh for a set of contours drawn from 3D medical data. (a) The drawn contours that represent target mesh points. (b) Resulting meshes using two state of the art methods; top: [Macedo et al. 2009], bottom: [Liu et al. 2008]. Our method aims to utilize prior knowledge of mesh shape. (c) An expert derived mesh for the same type of structure and the contours for those intersecting planes. (d) The naive result of deforming the mesh in (c) to the target contours in (a) using [Sorkine and Alexa 2007]. (e) The ground truth mesh.*

1 Introduction

In clinical practice, when a subject is imaged (i.e. CT scan or MRI) the result is a 3D image of volumetric data. In order to study the organ, bone, or other object of interest, this data needs to be segmented to obtain a 3D model that can be used in any number of down stream applications. When used for treatment planning these segmentations need to not only be accurate but also produced quickly to avoid health risks. Automatic segmentation methods are becoming more reliable but many experts in the scientific community still rely on time consuming manual segmentation.

One method of manual segmentation is to draw planar contours around the boundary of the object in the 3D image data as seen in Figure 1(a). The segmentation can then be found by constructing a mesh using methods such as [Macedo et al. 2009; Liu et al. 2008]. However, the structure's shape and topology are often not accurately reconstructed if insufficient contours are provided as seen in Figure 1(b). It can therefore be very time consuming to draw the necessary amount of contours to ensure segmentation quality. In clinical practice it is often the case that the scientist or researcher always segments the same type of structure across a multitude of patients. In this case there is a great deal of prior knowledge of the structure's shape and topology from previously segmented subjects. In this work we aim to utilize this prior knowledge in order to find a segmentation from a set of contours that ensures the correct topology and general structure shape.

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2 Our Approach

In order to minimize the amount of work required by a user to produce an accurate segmentation, we will utilize prior knowledge of structure shape and topology. Instead of constructing a surface from contours from scratch, we want to deform an existing good segmentation surface of the same type of structure (Figure 1(c)) to a set of drawn contours for a new image/patient (Figure 1(d)).

To deform the surface we need to map the points on the target contours to vertices in the source mesh. Therefore, our main contribution in this work is to find an optimal correspondence between the source mesh and the target contours such that the deformation retains the original surface topology and general shape, is smooth and free of artifacts, and fits the target contours. We utilize the As-Rigid-As-Possible [Sorkine and Alexa 2007] deformation energy in this approach. The results of a naive attempt of this method and the ground truth can be seen in Figure 1(d,e), where we found a correspondence by forcing each target contour to map to a correlating source contour on the source mesh. However there are various resulting surface artifacts from imposing this limitation. The goal of our algorithm is to find an optimal correspondence that minimizes the deformation energy while fitting the target contours.

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