Semi–Automated Reconstruction of Biological Surfaces from Few Contours in the Visible Female Dataset

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We describe a simple strategy for reconstructing a tube–like surface from a set of few well–chosen, arbirarily–oriented contours. Our approach is straightforward to implement, and only relies upon the geometric and topological information present in the contours.

Surface reconstruction from data like points or curves (contours) sampled from the surface has been extensively studied in the literature. In the case of segmentation of biological structures from large volumetric datasets, like those developed for the National Library of Medicine Visible Human Project, the traditional approach has been to automatically or semi–automatically generate parallel (e.g. transverse) contours, apply an optimal tiling algorithm [3] to the resulting stack of contours, then adjust the input contours if the resulting surface is anatomically (or even geometrically and/or topologically) inaccurate. The implied iteration is both time–consuming and costly; a method for generating reasonable surfaces from sparse data would be of immense utility.

Briefly, the steps in our approach are: (i) in a volumetric data set, trace a small number of curves which capture the shape of a tube–like surface, (ii) refine the contours and generate a surface by optimal quadrilateral tiling of pairs of contours, then (iii) refine this initial surface by interpolating subdivision [1] to create a smoother surface. We have chosen to implement a quadrilateral tiling algorithm, rather than a triangular tiling algorithm, to greatly simplify the implementation. In particular, both generating the initial coarse surface and refining to generate a smoother surface are straightforward to program in only a few hundred lines of C++.

Figure 1 depicts results of two experiments using our approach. The first experiment demonstrates the small visual difference between an optimal triangular tiling or an optimal quadrilateral tiling of parallel contours. The second experiment shows an example of using our approach to tile and fit a smooth surface to a set of aritrarily–oriented contours. All contours were hand–traced in the Visible Female color dataset. In the paper, we describe a simple color segmentation–based mechanism to help speed up contour tracing. We also discuss extensions to our approach in the paper; in particular, we will describe a similar technique for generating a surface from more complex (e.g. branching) structures. We will also discuss hierarchical (multiresolution) techniques [2] to speed up the quadrilateral tiling algorithm.

Our surface reconstruction approach represents a step towards simplifying the process of semi–

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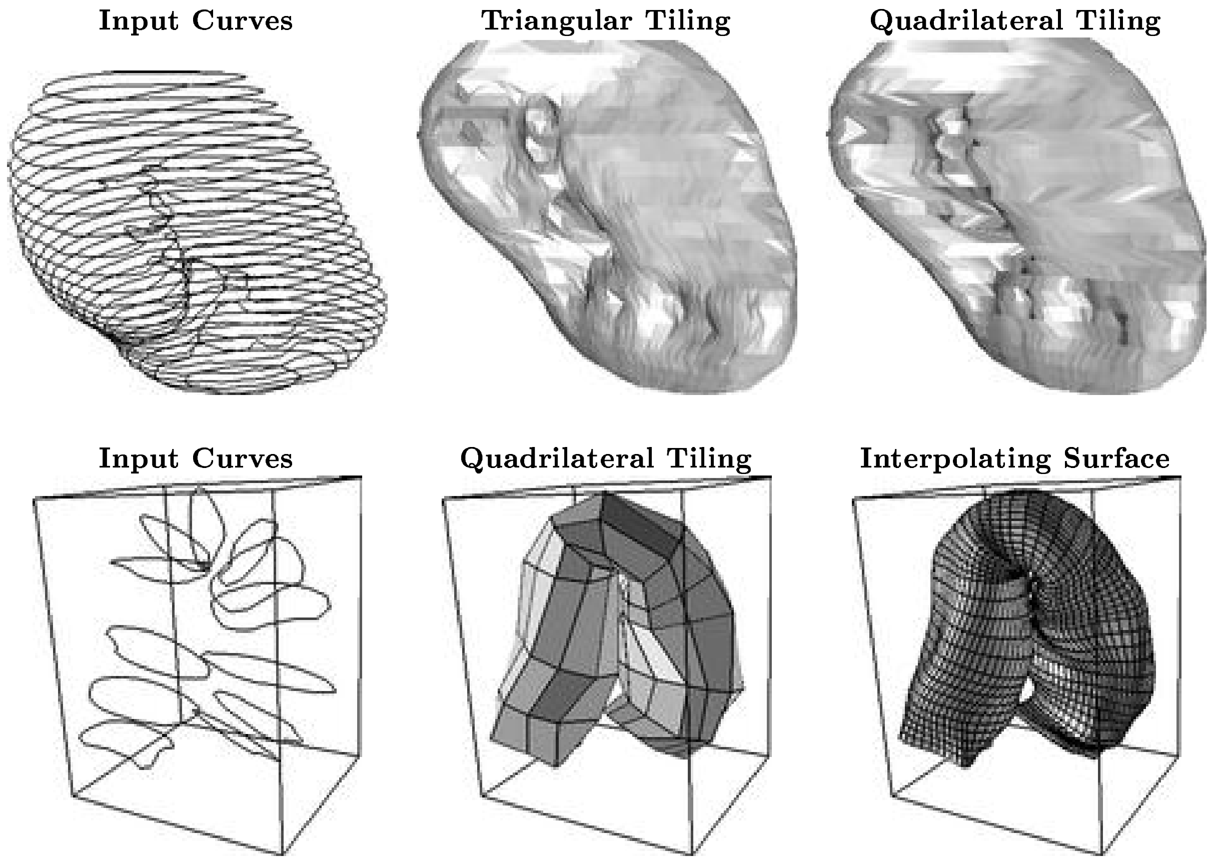

Figure 1: From top to bottom: optimally tiling transverse contours on a spleen; optimal tiling and surface fitting oblique contours drawn on a colon.

automatic segmentation of complex biological structures from large volumetric datasets.

References

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