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Resection Process Modeling Based on 3D Images

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Abstract

Virtual planning software using CT/MR images allows preoperative planning of a patient-specific resection path by considering three-dimensional (3D) vascular structures as guiding anatomical reference points. A time-series simulation of the resection process is also desirable to provide a preview of the locally visible anatomical structures in the intraoperative deformed state. In the conventional modeling of incisions, tetrahedral elements of the organ model are divided or replaced, and their surfaces are rendered to visualize deformation [1]. However, the computation time is prohibitively expensive due to the large number of vertices needed to adequately represent the physical behavior.

In this study, we introduce resection process modeling methods to create cutting simulations with deformations based on 3D CT/MR images (Figure 1). A sparse tetrahedral mesh is first constructed to enclose the organ region. For a given cutting point, the vertices are relocated to satisfy the geometrical constraints of the resection path. The mesh deformation is computed using the finite element method and rendered volumetrically by slicing the tetrahedral mesh [2, 3]. This approach models smooth resection paths and produces a high-quality visual simulation of the resection process. Real-time animation at greater than 10 frames/s is possible because vertex addition is not required. Moreover, the only manual step in the setup process is the segmentation of the target organ. In this presentation we demonstrate some simulation results in liver resection.

Keywords: Surgical process modeling, cutting simulation, volume deformation and liver resection

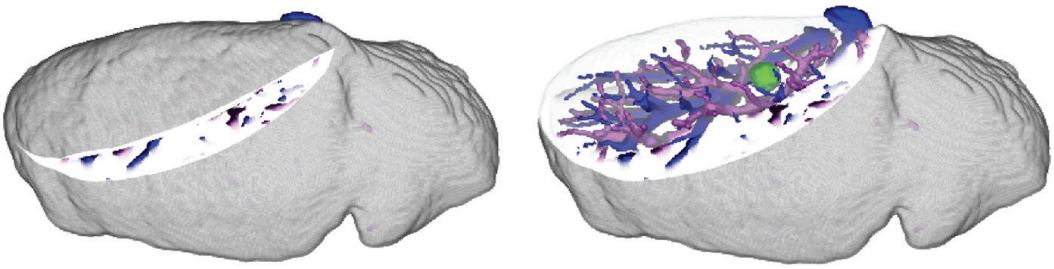

Figure 1. Visualizing liver resection process with volume deformation

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