Direct Volume Manipulation for Navigating Liver Resection

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ABSTRACT

We propose a set of algorithms and interface on direct volume manipulation to navigate liver resection surgery. Our navigation system creates the incision surface on a three-dimensional liver model created from patient's CT images, and visualizes a change of the incision surface by deformation of the liver model. Visualization of the incision surface assuming intraoperative deformation can help a surgeon resect precisely in the surgery.

KEYWORDS: Direct volume manipulation, Liver resection surgery, Surgery planning

1 INTRODUCTION

In liver resection surgery, surgeons guess the direction to resect from the image of preoperative planning, operative field and intraoperative ultrasounography and gradually resect the organ.
Existing liver resection surgery simulation system can plan the incision surface against a three-dimensional model created from CT images. However, surgeons deform the liver due to physical constraints in the actual surgery. This makes resection procedure difficult because the incision surface and positional relationship of the blood vessels totally change from the initial state. In this study, we aim to visualize the incision surface deformed by surgical procedure and to support preoperative planning of liver resection surgery.

2 GENERATING AND VISUALIZATION THE INCISION SURFACE

Our navigation system has three steps: (1) Input of the incision surface, (2) Visualization of the incision surface, (3) Deformation of the organ. (Fig.1)

(1) Input of the incision surface: The user inputs a free curve with the mouse, and two parameters: width and depth. Cylindrical objects defined by the free curve, width and depth create open space between incision surfaces.
(2) Visualization of the incision surface: By using different LUT for each of the hepatic parenchyma part and the incision surface part, the incision surface is visualized. LUT (Look Up Table) is a user-defined color map information that transfers CT values to RGBA values.
(3) Deformation of the organ: The tetrahedral mesh created from CT images is deformed, and deformation of the incision surface is visualized using volume rendering based on deformation of the mesh.

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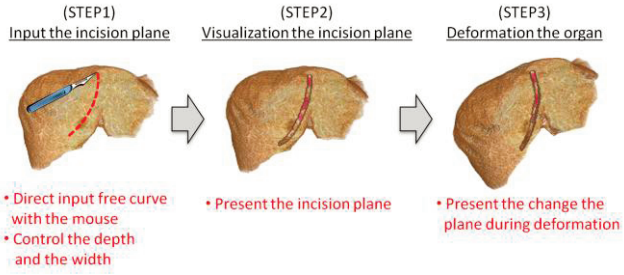

Figure 1. Our navigation system flow

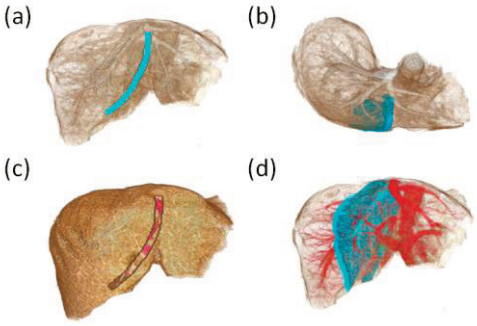

Figure 2. Input results of the incision surface

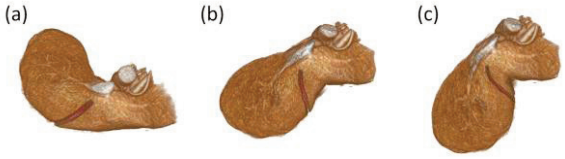

Figure 3. Results of deformation

3 RESULTS AND CONCLUSION

Fig.2 shows results of the incision surface, which is given by the user on a liver object modeled from patient's CT images. (a) and (b) show a planned incision surface visualized by different viewpoints. (c) and (d) are other visualization results of incision surface using different LUT sets. This result makes it easy to understand the relationship between the incision surface and others. Fig.3 shows results of deformation of an organ. This performs with high-quality rendering and user can operate interactively (13-15FPS). The surgeons used the developed system commented that direct deformation of liver with incision surface could contribute to more precise resection in the surgery.

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