Intraoperative Image Generation Methods Reflecting Shape Changes in Bone Cutting Procedures

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Abstract—This study aims to develop intraoperative image generation methods reflecting shape changes in bone cutting procedures. The methods estimate the current shape of the cutting object based on the history of the tip position of the drill, and visualize the difference between the current shape and the goal shape in real time. The result of the experiments showed that the proposed method could reduce volumetric error. Furthermore, most subjects could realize the cutting that was close to the goal shape.

I. INTRODUCTION

In the field of orthopedic surgery, lumbar disc disease has recently been treated by minimally invasive procedures such as Microendoscopic Discectomy (MED) [1]. Since surgeons performing MED are required high technical skills, surgical navigation systems have attracted the attention. Intraoperative navigation products are currently used for only the purpose of presenting the 3D coordinates of the surgical tools. In addition to this, we thought that the information on the difference between the current shape and the goal shape enables us to cut more precisely. This presentation proposes intraoperative image generation methods reflecting shape changes in MED. The methods estimate the current shape of the cutting object based on the history of the tip position of the drill, and visualize the difference between the current shape and the goal shape in real time.

II. METHODS

In the real surgery, surgeons cut a part of spinal disk with a surgical drill. To confirm the effectiveness of our method, we developed an experimental system that supports precise cutting of a wood cube using the PHANToM haptic device (SensAble Inc.) and a handy router. Figure 1 shows the outline of image generation methods, and Figure 2 shows the experimental device. In the system, the tip of the router is obtained by PHANToM. Then, we estimate the area where the tip of the drill passes as the cutout region. During cutting operations, the 3D trajectory of the tip is stored in a volumetric label. The original CT volume and the volumetric label represent time-varying cutout region. When the tip of the router contacts with a real-world object, the corresponding voxels are removed on the rendered image. Consequently, we generate support image which reflects shape changes in cutting procedures in real time. We use the virtual cutting algorithm [2] for rendering the virtual image.

III. RESULTS AND CONCLUSION

We have conducted an experiment to verify the performance of the proposed image generation methods. 7 subjects joined in our experiments and tried to cut the wood cube based on our support image and the conventional image visualizing only a static goal shape. The cutout wood cubes were scanned using CT. Figure 3 shows the volumetric error between the goal shape and actual cutout result. 5 subjects could reduce volumetric error by using our method. Furthermore, although the shape after cutting differs from subject to subject, most of the subjects could cut the wood cube closed to the goal shape. As future work, we plan further improvement and experiments for more precise cutting.

REFERENCES
