Laparoscopic Image Guidance via Conoscopic Holography
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Spatially registered 3D preoperative medical images can improve surgical accuracy and reduce reliance on memory and hand-eye coordination by the surgeon. They enable visualization of internal structures within the anatomy of a patient on the operating table. In the case of biopsy, for example, this would allow the surgeon to guide the needle tip to a tumor though opaque tissue. It has been well established that for soft tissues, image registration can be performed aligning the preoperative image with a cloud of points (Fig. 2) that describe the surface of an organ [1].

Collecting this point cloud can be challenging, generally requiring open surgery to permit line-of-sight access for laser triangulation (e.g. the system of Pathfinder Therapeutics, Inc.). We present a conoscopic holography-based system (Figure 1) for collecting a point cloud less invasively - through a laparoscopic port. The system consists of a commercial conoscopes (Optimet, Inc., Probe Head Mk3), designed for precision machine-shop linear measurements, that is tracked (the surgical tool is also tracked) with an optical tracking system (Claron MicronTracker H3-60).

A potential source of error in collecting distance measurements with the conoscopes is the diffusion and/or absorption of the red laser light by tissue. Thus, we conducted an experiment to establish the accuracy of the conoscopes when measuring distances to biological tissues (see Figure 3). The accuracy observed in this experiment supports the hypothesis that conoscopic holography can facilitate image registration. Further experiments are currently underway assessing the accuracy of the complete system shown in Figure 1 in guiding a tracked needle to a desired subsurface target identified on preoperative images.


http://research.vuse.vanderbilt.edu/MEDLab/
Conclusions

Validation that distance measurements are accurate

Std. dev. 0.61mm

Experiments have demonstrated the feasibility of a spatially registered 3D preoperative medical image

Applications include:
- Novel application of industrial quality control
- Automated medical measurement of the hip of the knee
- Microtomography demonstration of the feasibility of an X-ray machine registration system for medical applications
- Experiments have demonstrated the feasibility of a 3D optical fluoroscopy system

Conclusions

Surf Prep

CT scan data using CT

Overlays of conoscope data registered to segmented

The current commercial contour-based registration

Holography and dual capture open surgery

Laparoscopic Conoscopic Holography

1D Test Apparatus

Laparoscopic fluoroscopy is a commercially available technology to medicine

Conoscopic Holography for Image Registration

1D Test Apparatus

Laparoscopic fluoroscopy and dual capture open surgery

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