Integration of Real-Time Photoacoustic Image Guidance with da Vinci Surgical System

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Imagine Driving

In the OR

Endoscopic Real Time Video Feed

Intraoperative Location of Blood Vessels

Representative CT Image

Blood Vessel
Photoacoustic Imaging (PAI)
Previous Work

● Contrast-based vessel center determination$^{1,2}$
● Real blood visualized in the presence of bone$^3$
● Proposed integration of PAI with teleoperation$^2$


Research Objectives

- Find safe region to make incision through bone and other tissues
- Enable teleoperation for minimally invasive surgery
- Evaluate in the context of endonasal transsphenoidal surgery
Equipment

Single fiber with 0.5 NA coupled to:

- Quantel Ultra100 Nd:YAG Laser
- Laser Components LS Series Pulsed Laser Diode - 950 nm
- Custom Phantom Designed for Modular Blood Vessel Placement
- da Vinci Surgical System

http://www.litrax.com.tw/upload/image/products/Line%202%20For%20Medical/Laser%20Component/module%20jpg.jpg

http://cs.jhu.edu/CIRL/projects/SurgicalAssistance/daVinciSurgicalSystem2.jpg

http://sites.ieee.org/ius-2016/files/2016/06/ECUBE12_P.jpg
Experiment 1: Find Distance Between Vessels
Each Vessel Boundary Creates PA Signal
Computation on Compounded Image

Four Regions of Interest

Blood Vessel

Vessel Separation

Brightest Pixel
Experiment 2: Integrate with da Vinci Surgical System

- Repeated experiment with fiber teleoperated
Results

- RMS error <1 mm with image-based measurements
- Generally larger error with tracking-based measurements
Conclusions

- First integration of photoacoustic image guidance with the da Vinci surgical system
- Provides <1 mm RMS error when measuring vessel separation to find safe regions for incisions
- Improves accuracy compared to teleoperation alone
- Results are relevant to multiple minimally invasive surgeries
Future Work

Integrate with multi-fiber light delivery system that enables visualization of tool tip and vessels simultaneously.
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