3D Ultrasound-Guided Focal Liver Tumor Ablation

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Disclosure

Licenses to Companies: Eigen, Perfint Healthcare, Focal Healthcare, Hitachi, Nucletron, B&K, Enable Technologies, Varian, Resonant Medical, OTI, VisualSonics

Research Agreements: Radialis Medical, COSM Medical, Endra Life Sciences, Canon

CT-guided focal liver tumor thermal ablation

Advantages

- Can provide a large field-of-view
- Vessel visualization with contrast agents

Disadvantages

- Costly
- Not applicable for real-time monitoring
- Ionizing radiation
- metal artifacts

3D US-guided focal liver tumour ablation

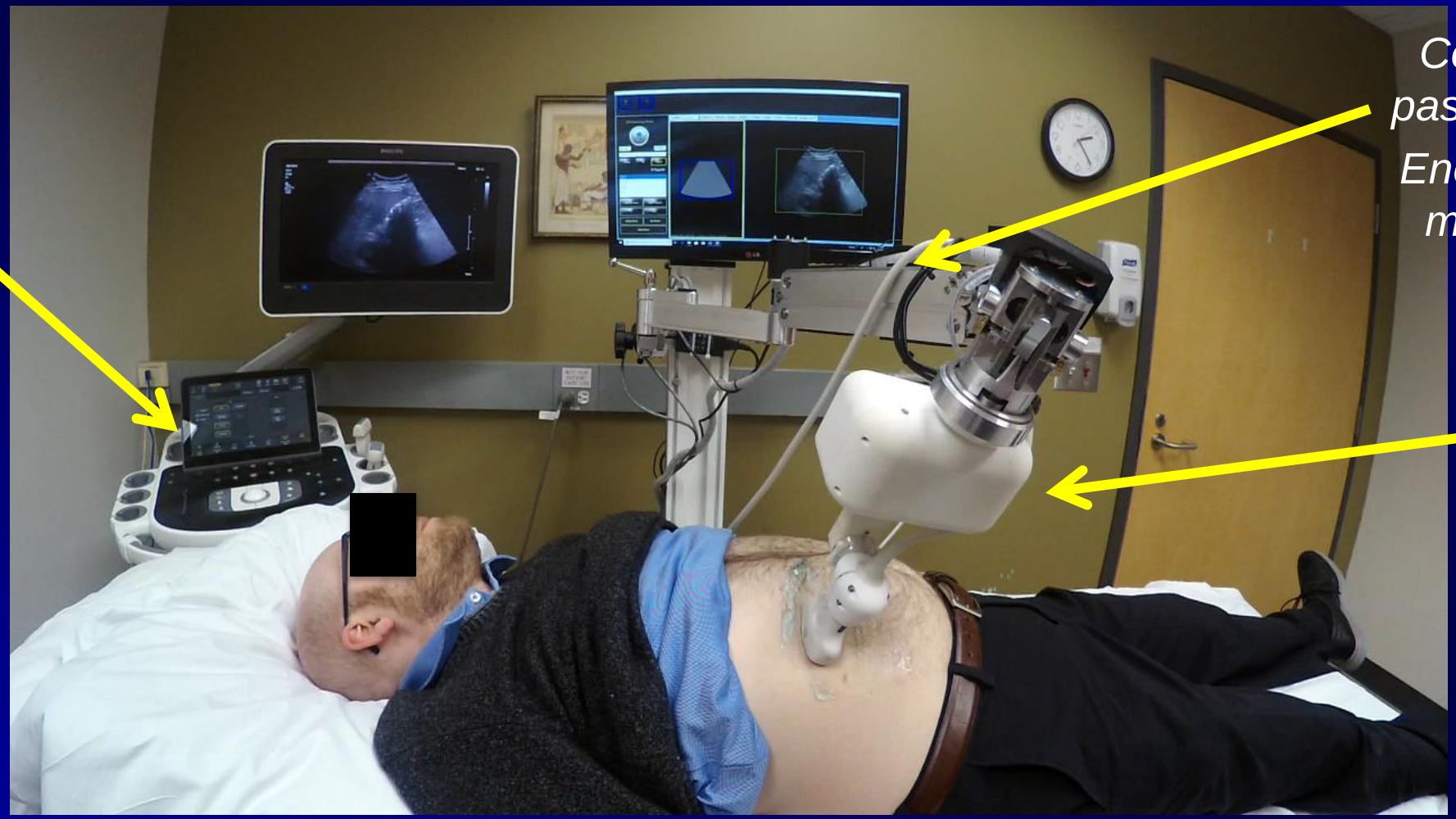
UNMET CLINICAL NEED:

Provide greater access to focal ablation procedures using accurate, precise, and efficient US guidance and verification of therapy applicators location.

OUR SOLUTION:

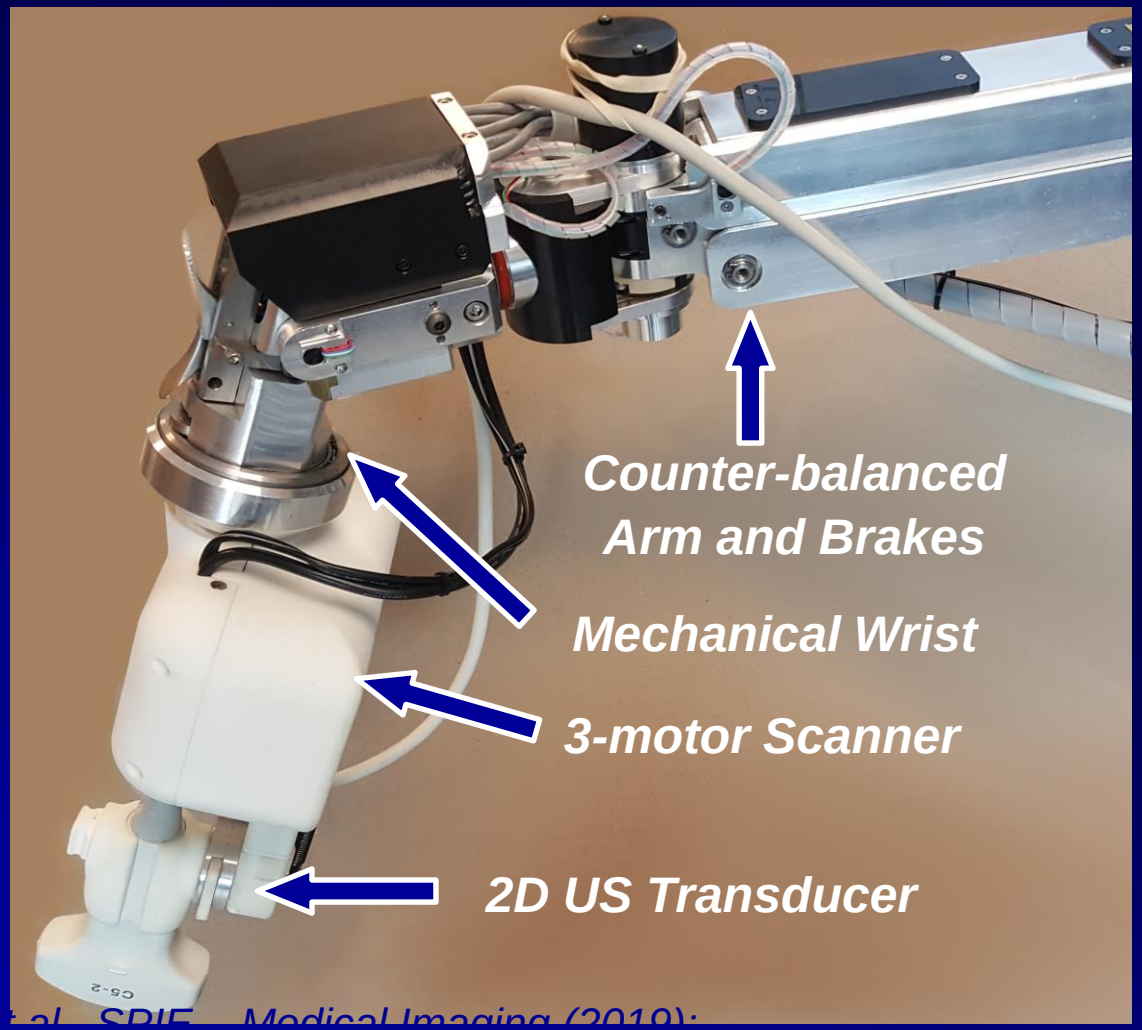
*Develop an **affordable 3D US-based** system with a large field-of-view and software tools for intra-operative guidance of tumor ablation procedures with minimal interference of the clinical routine.*

3D US Liver Imaging System

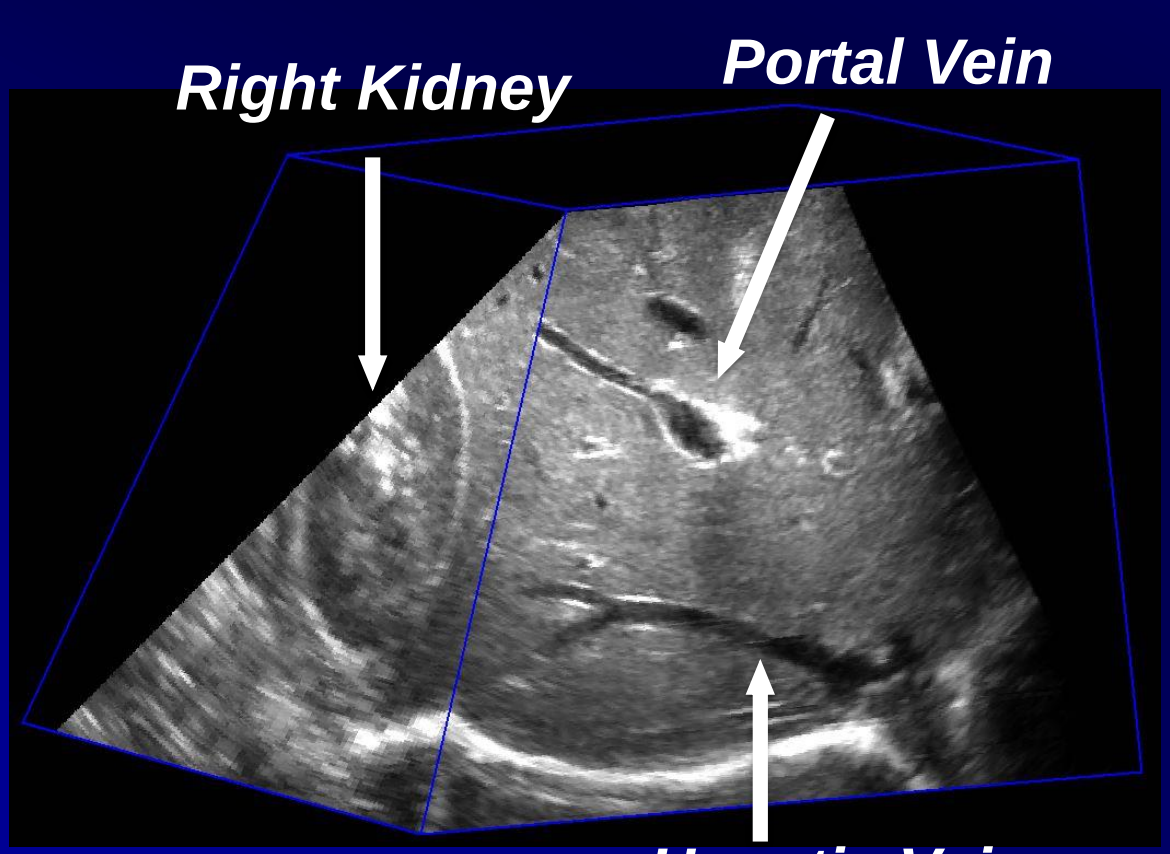


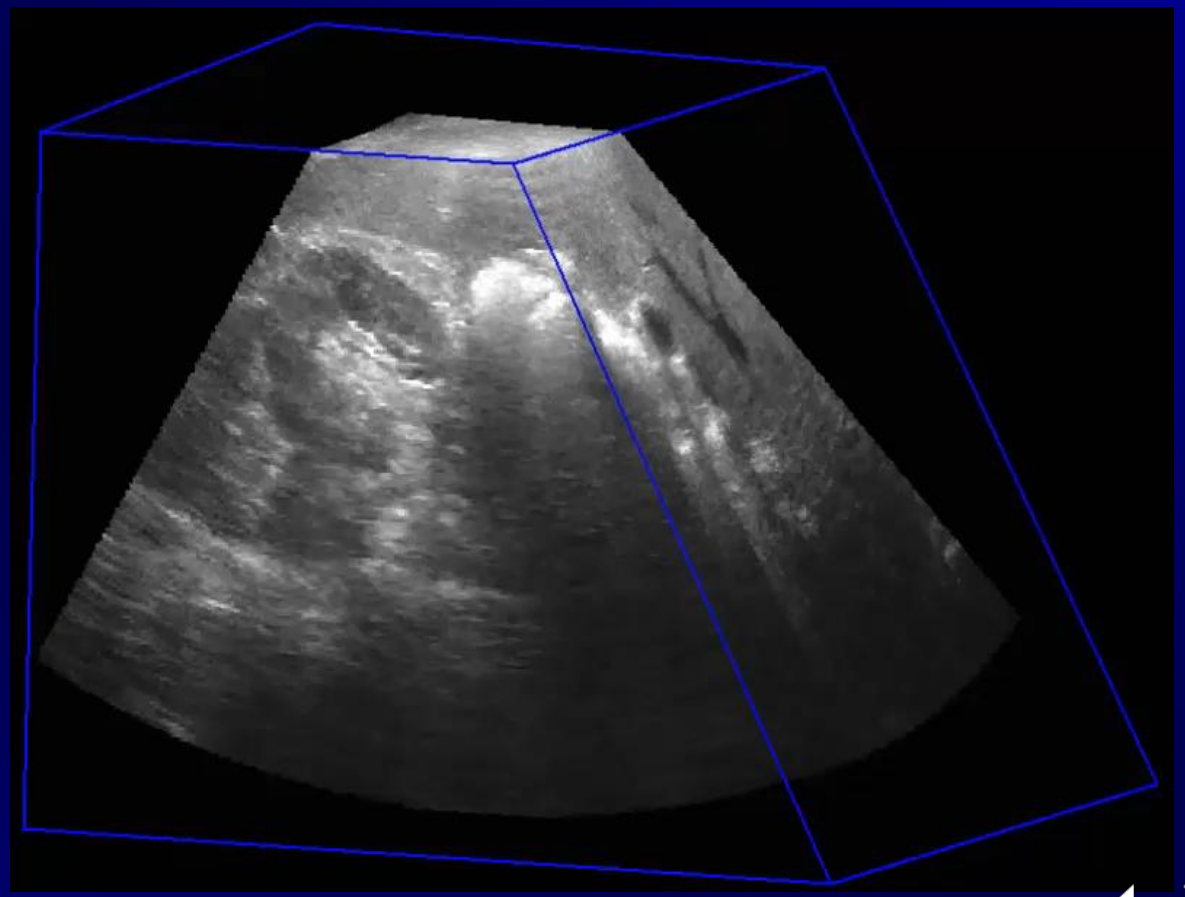
Details: paper by D. Gillies TH-D-TRACK 4-6

3D US Image Guidance System

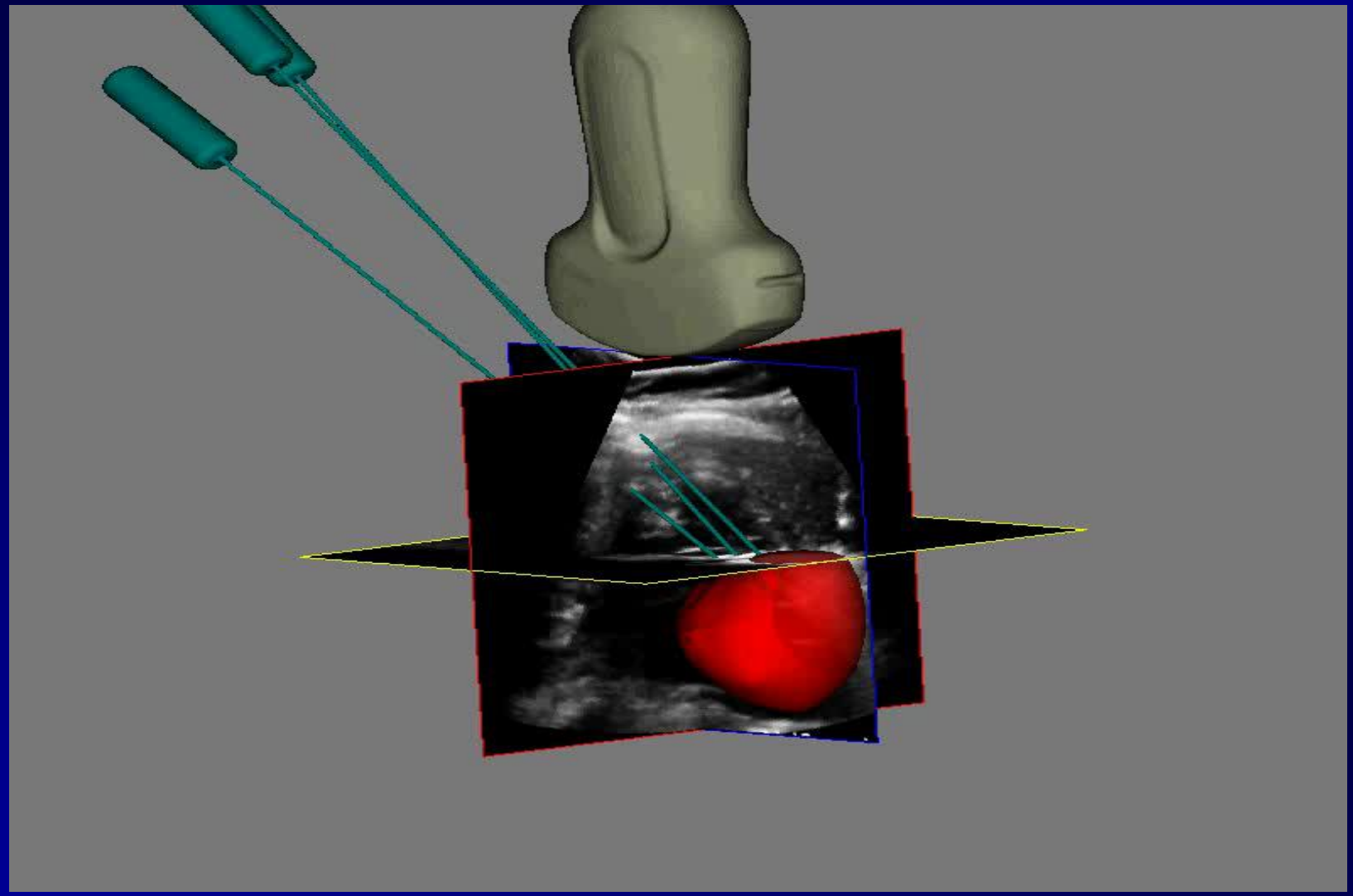


3D US Liver of Volunteer

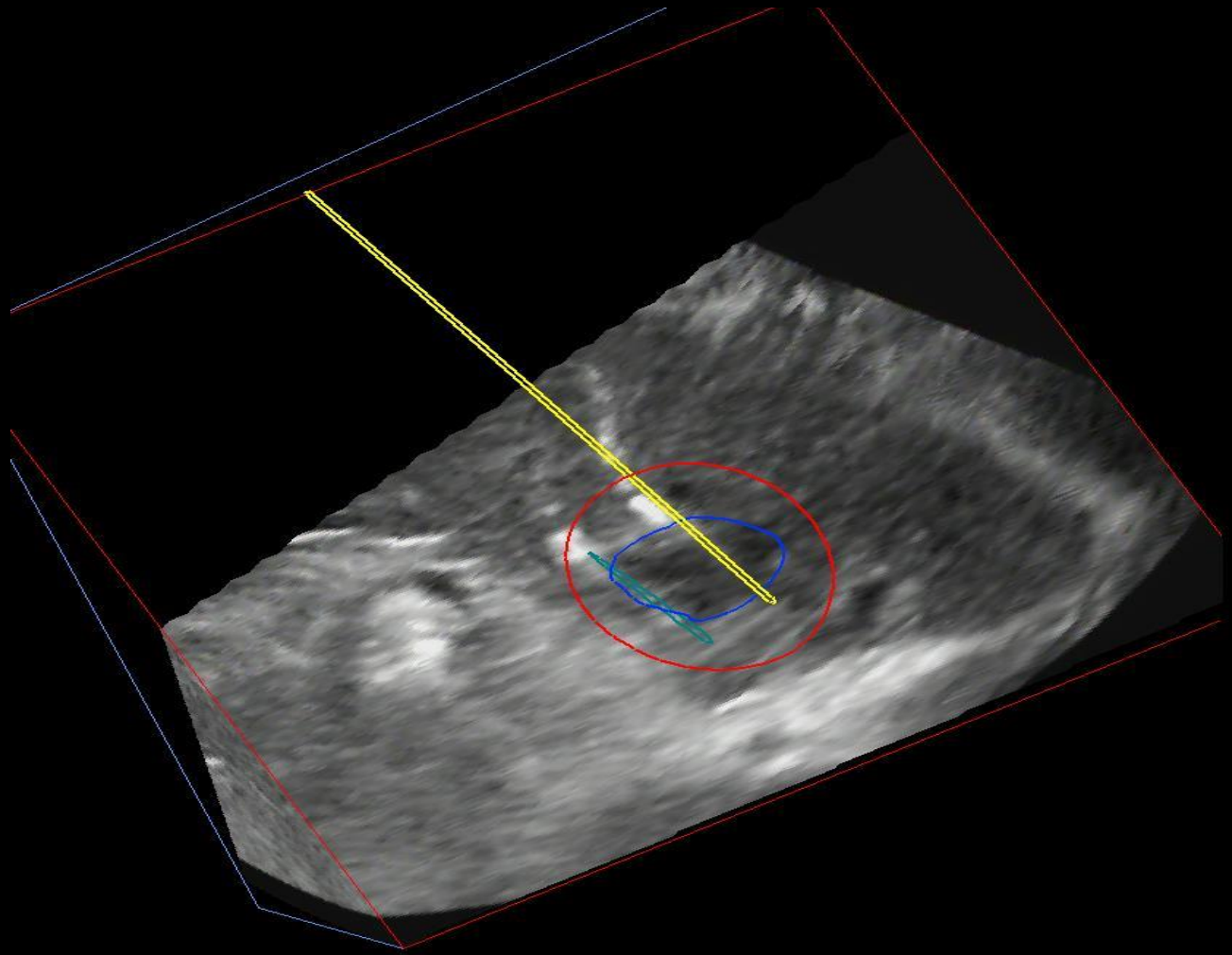


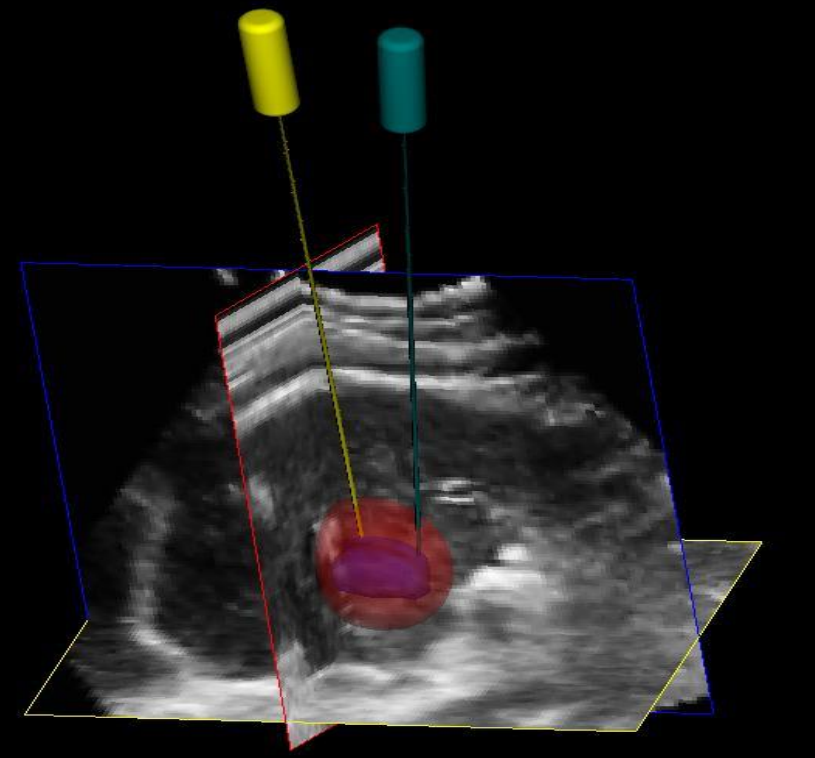


3D US Intra-operative Focal Liver Ablation

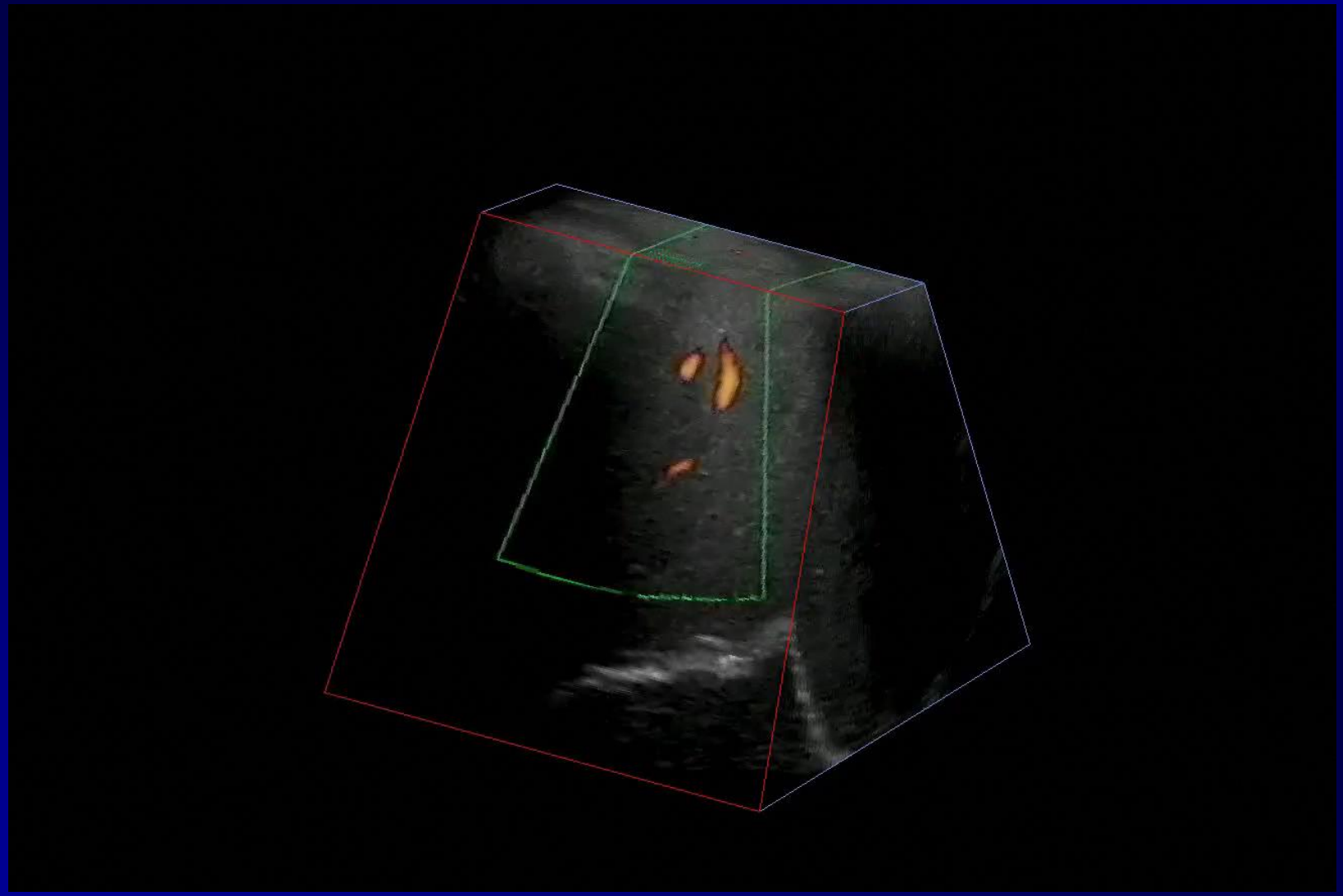


3D US Intra-operative Focal Liver Ablation





3D Doppler US of the liver



Needle segmentation

Unmet clinical need:

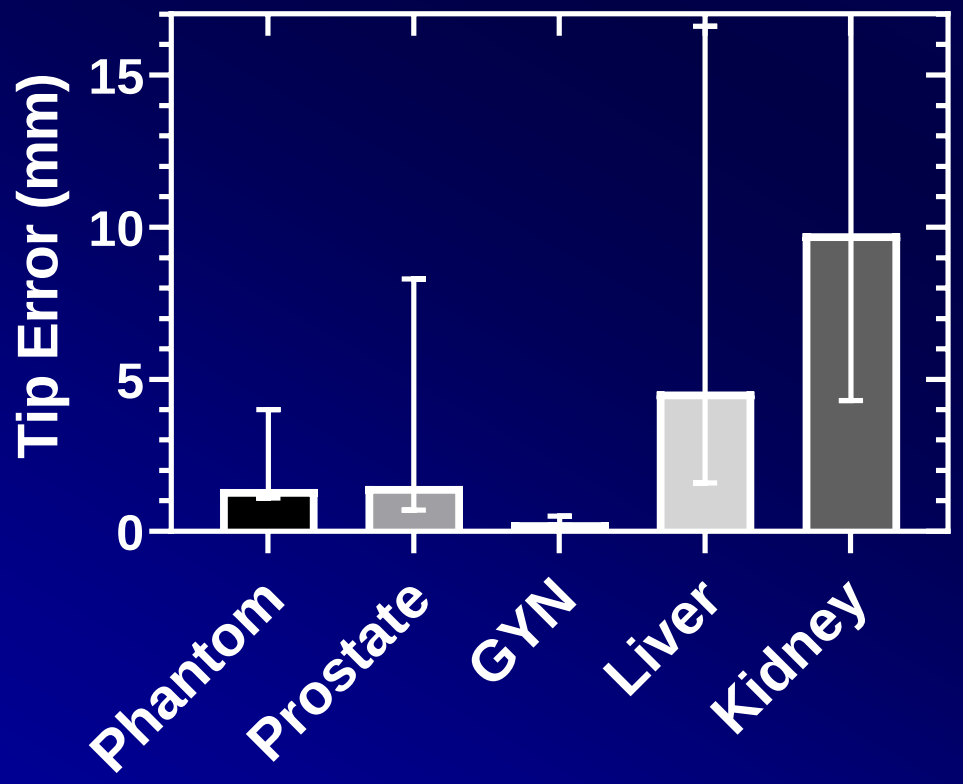
Automated and real-time needle segmentation in interventional procedures to increase accuracy, reduce variability, and reduce procedure time

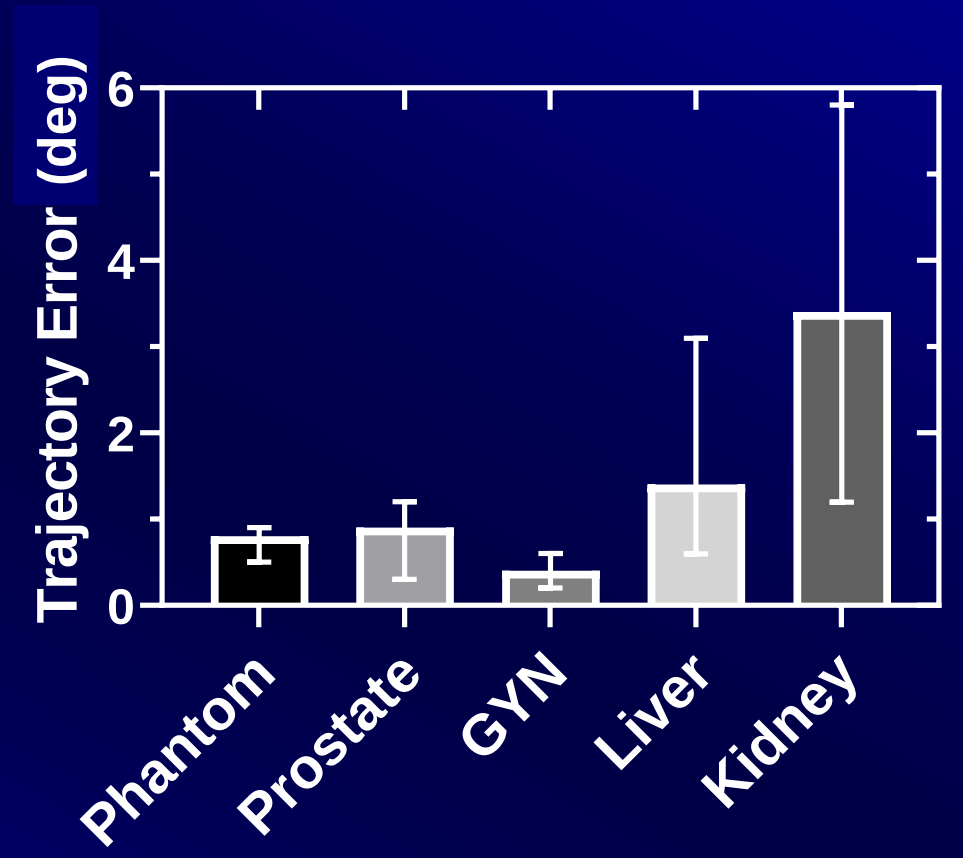
Modified U-Net: 2D US Clinical Dataset

Image Background	2D Images in Training Set	2D Images in Test Set
Phantom	23	9
Prostate	18	8
Gynecologic	34	18
Liver	540	256
Kidney	302	34
	917	**327**

Gillies DJ, Rodgers J, Gyackov I, Roy P, Kakani N, Cool DW, Fenster A. Med Phys. 2020. Revisions.

Results: Tip and Trajectory

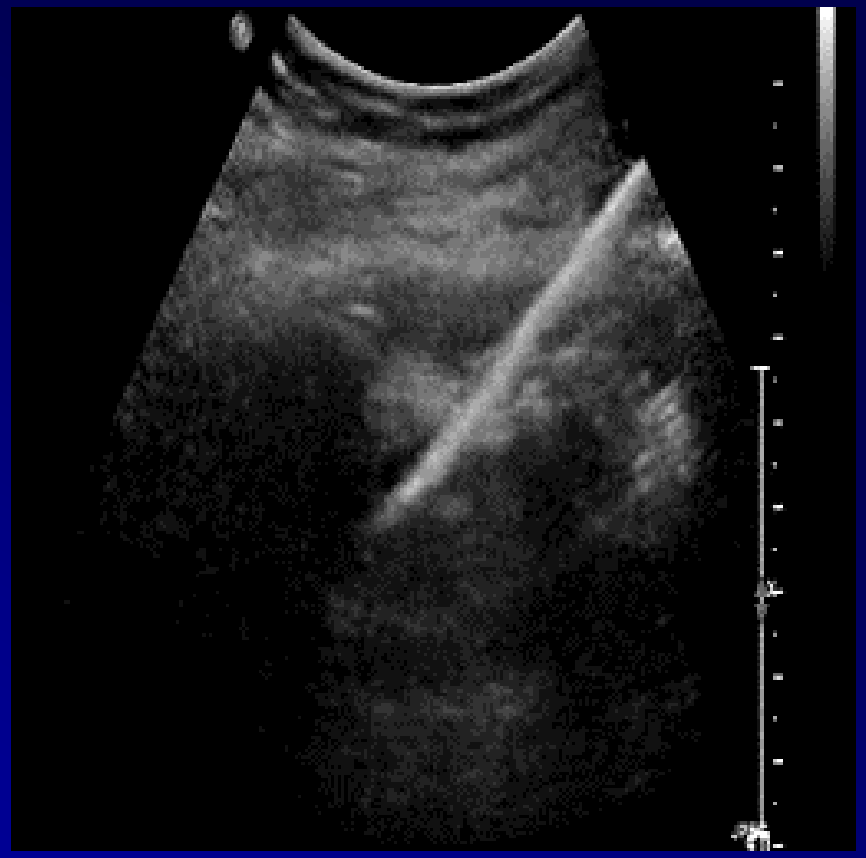




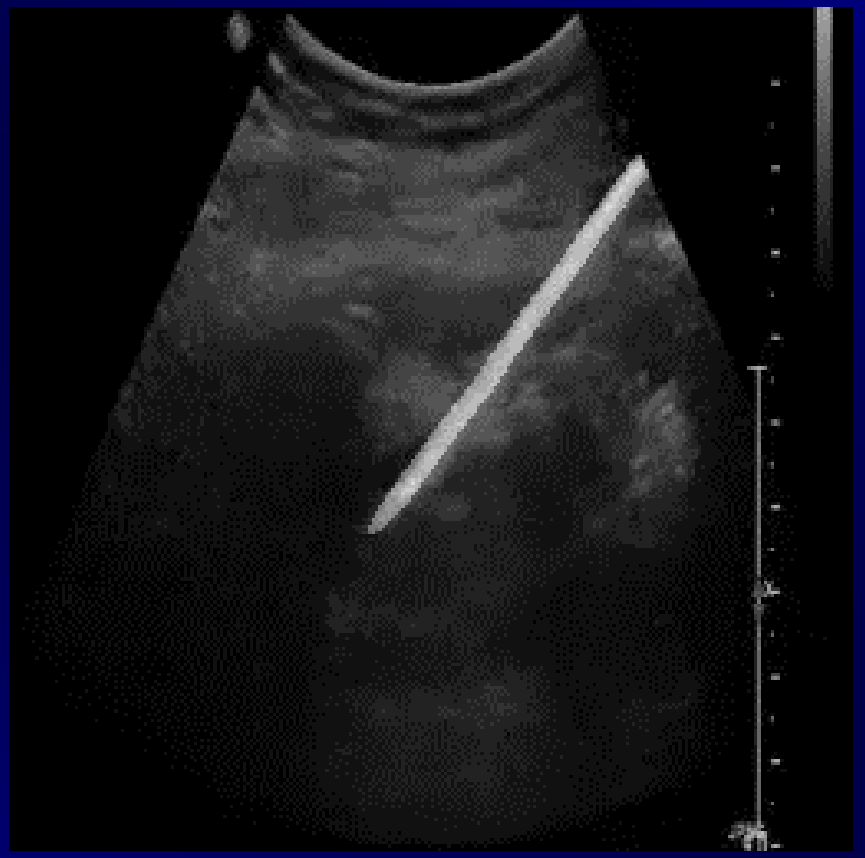
Segmentation time = ~50ms

Implementation in video stream

Original video



Original with segmented needle

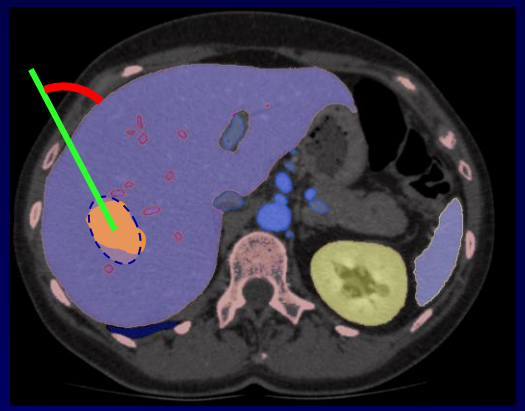


Automated Planning

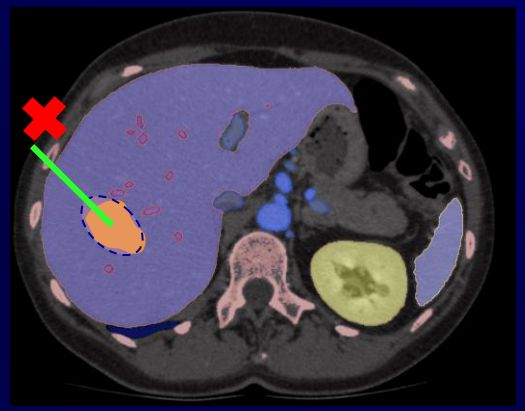
Unmet clinical need:

Automated planning of number of electrodes and their placements for complete tumor ablation and reduction of procedure time

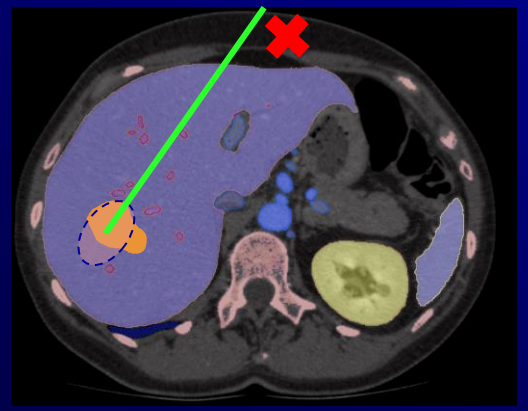
Ablation Planning: multiple clinical constraints



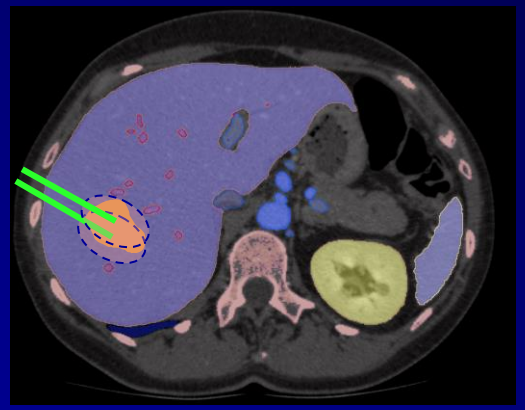
Proper angle



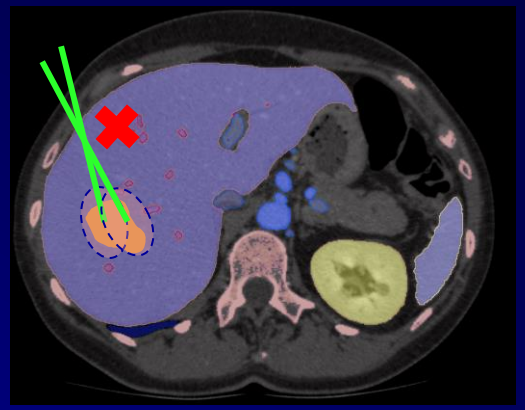
No crossing of the vital organs



Proper trajectory length



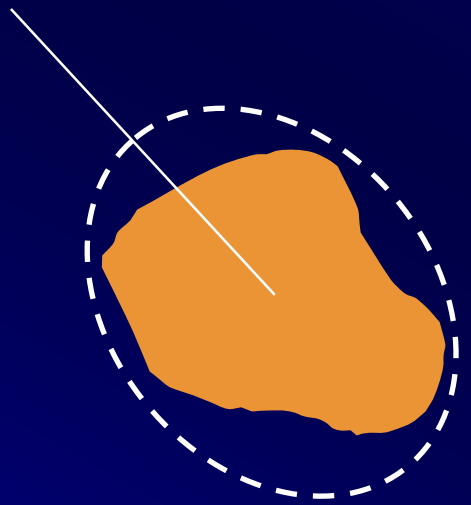
Full coverage of tumor



No collision between electrodes

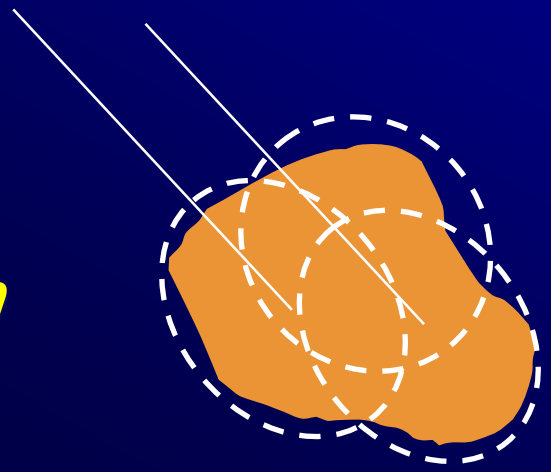
Multiple clinical constraints make the planning complex

Liver Ablation: multiple objective planning



Minimize number of electrodes

contradiction



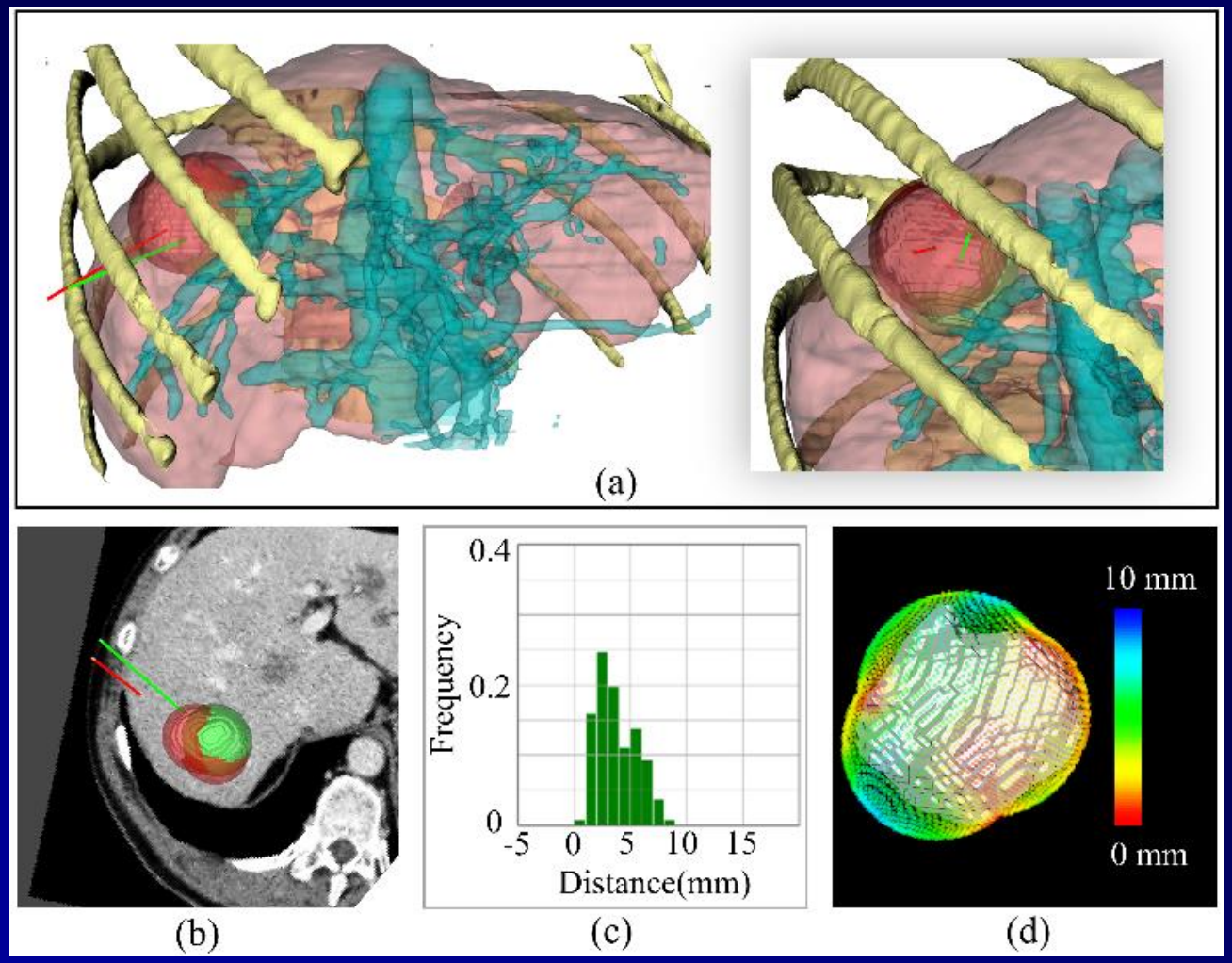
Minimize damage to the surrounding tissues

Solution

- ***Set cover-based model*** *to generate multiple plans*
- ***Pareto optimization*** *to find the tradeoff between the 2 planning goals.*

Liang L, Cool D, Kakani N, Wang G, Ding H, Fenster A. IEEE-TMI, 39(5) 1459-1471, 2020

RFA planning results



a) Display of the RFA plan.

b) The RFA plan is displayed on a CT slice.

c) Normalized histogram of distance from ablation to treatment zone boundary.

d) 3D view of ablation zones with a distance color map.

Conclusions

- *We developed a 3D US-guided focal liver ablation system*
  - *Based on mechanical tracking*
  - *Any US probe can be used to generate 3D US images*
  - *Automated applicator segmentation*
  - *Automated therapy planning*
- *Components to be developed*
  - *CT - 3D US registration*
  - *Improvements in applicator segmentation*

Thank You

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