

Needle Localization In CT-Guided Tumor Ablation

Group 14:

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Project Statement:

This project aims to develop an algorithm to localize and identify the orientation of the ablation needle to predict the ablation zone during a minimally-invasive tumor ablation procedure.



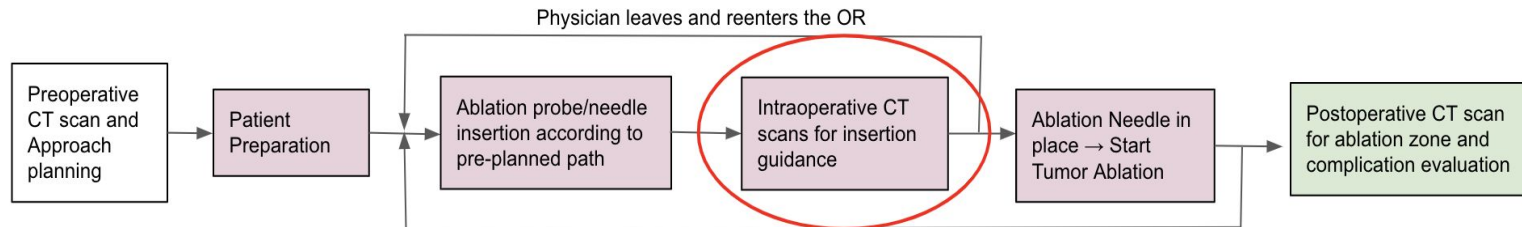
Clinical Motivation and Prior Work

Tumor Ablation with RFA, MWA or Cryoablation:

- High rates of undertreated regions → Recurrence [Egger et al]
- Overtreatment → Complications [Egger et al]

Highly Dependent on Image Guidance

- Location of the ablation needles is crucial [Wood et al]
- Several attempts to track location of the needle (Real Time Ultrasound [Zhou et al], Intraoperative CT [Wood et al], EM tracker [Amalou et al])
- Multiple needles in one image

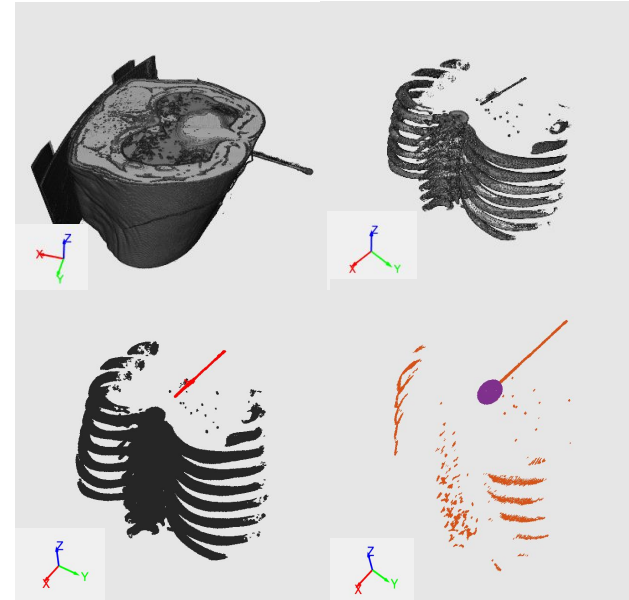


Multiple needle insertion depending on size of the tumor and the pre-planned approach

Project Goals

Localize and identify the orientation of the ablation needles in intraoperative CT images to support needle insertion accuracy

Generate and superimpose predicted ablation zone on CT images for visualization



Technical Approach

Preprocessing

- Normalization → Standardization
- Threshold → Remove soft tissue
- Morphological Opening and Closing → Remove artifacts and weak connections

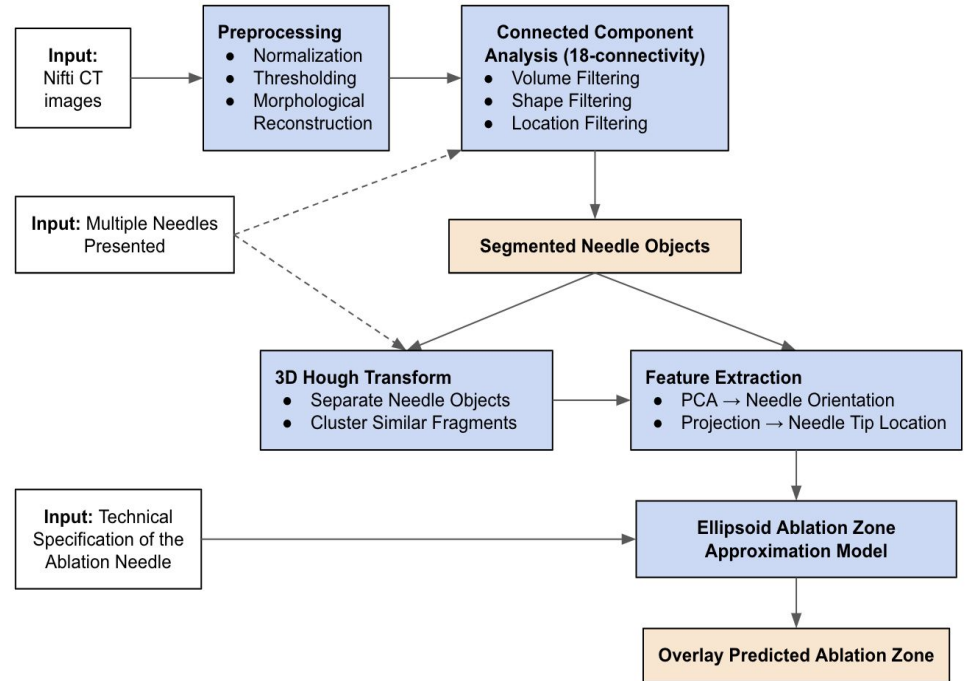
Connected Component Analysis

- Volume Filtering → Remove noise and large bone fragments
- Shape Filtering → Obtain only elongated image
- Location Filtering → Remove object far from ROI.

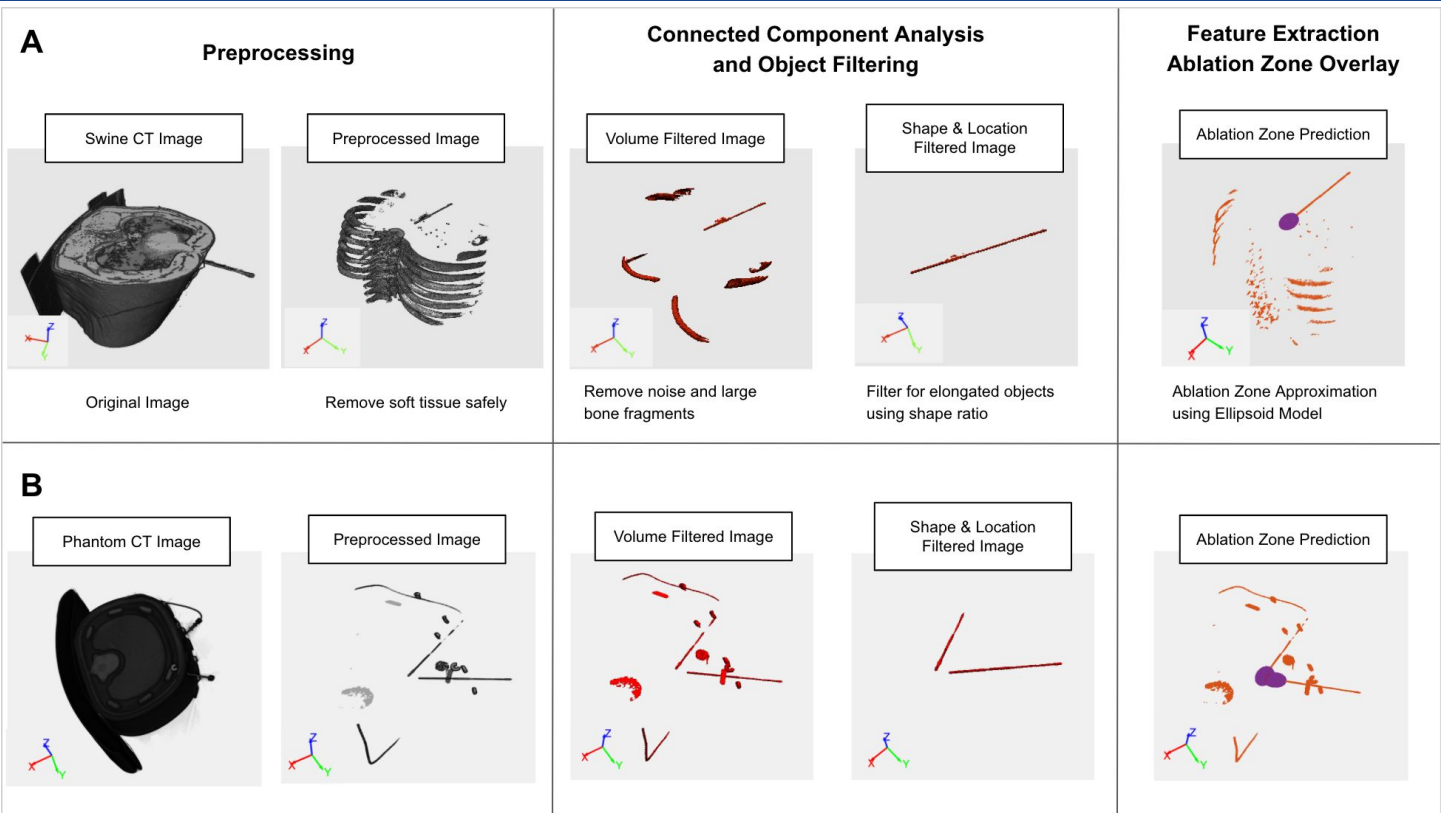
Feature Extraction

- 3D Hough Transform → Separate multiple needles
- PCA → Needle Orientation
- Project → Needle Tip Location

Ellipsoid Ablation Zone Overlay



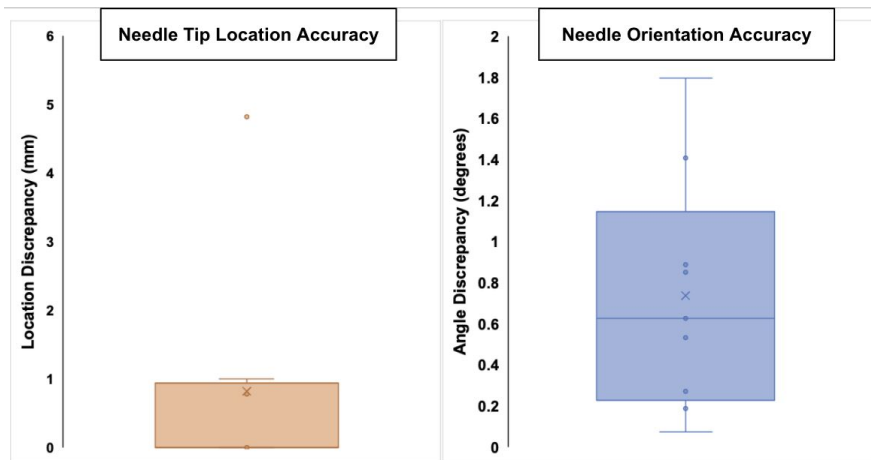
Results



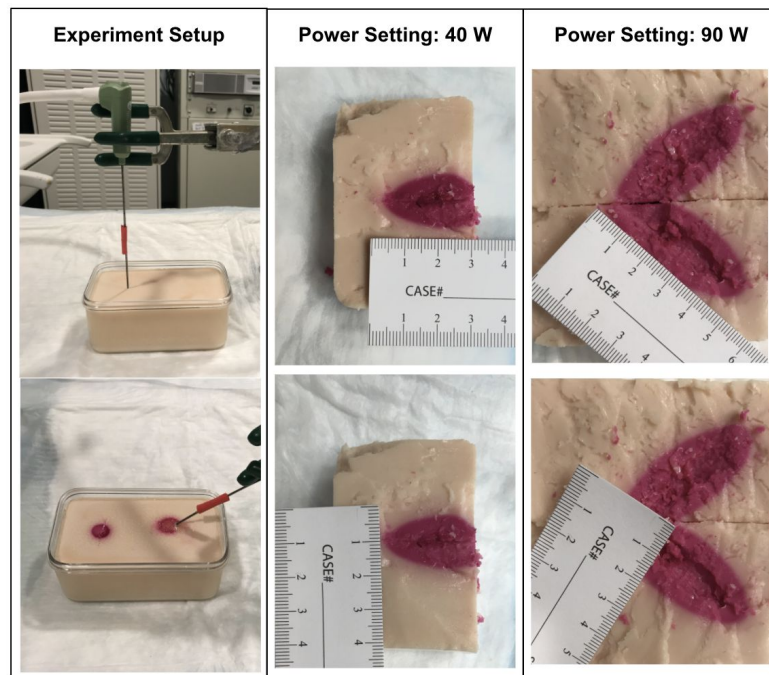
Evaluation

Performance (n = 8)

- Needle Tip Localization: 0.82 ± 0.59 mm
- Needle Orientation: $0.74^\circ \pm 0.19^\circ$
- Runtime: Less than 30 seconds per image

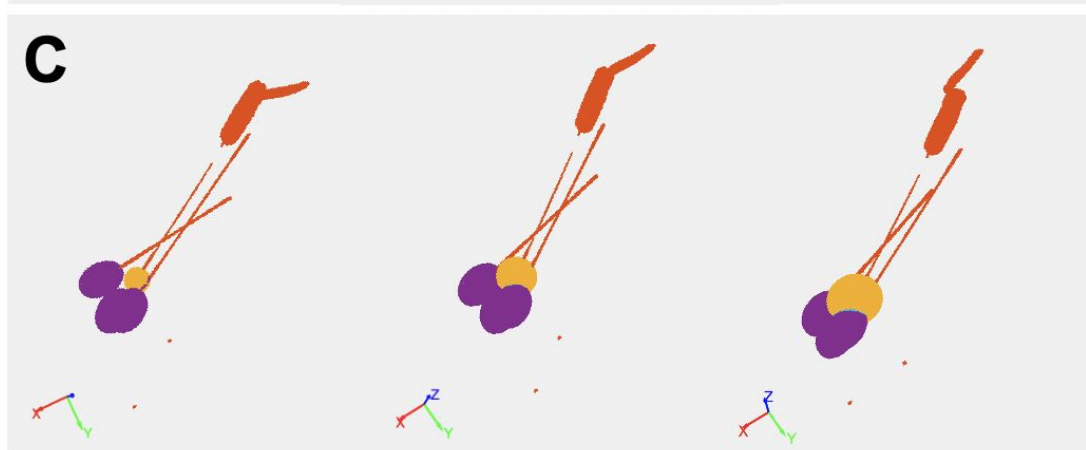
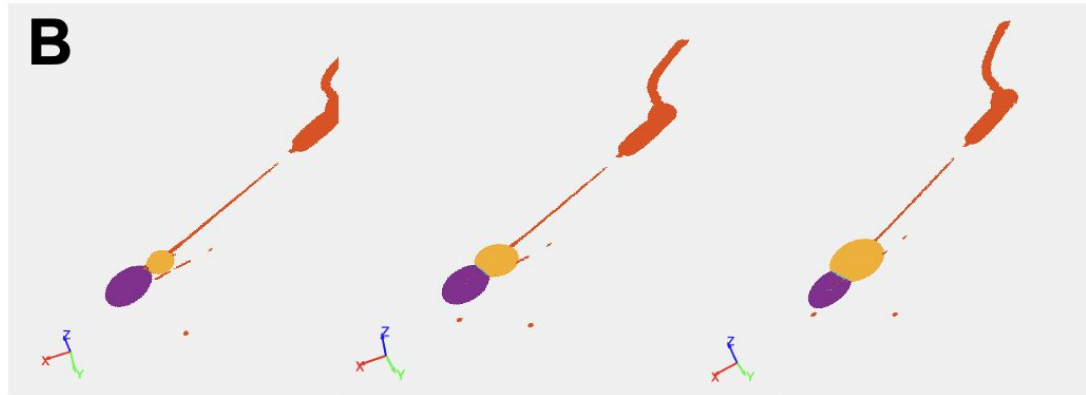
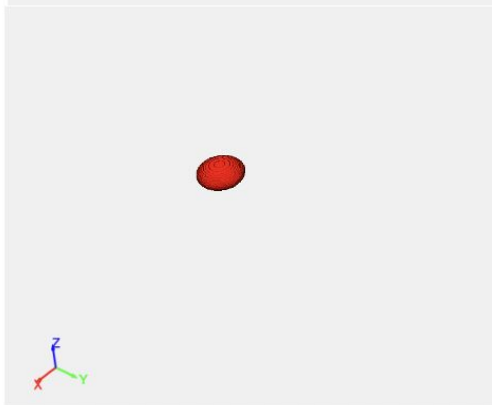
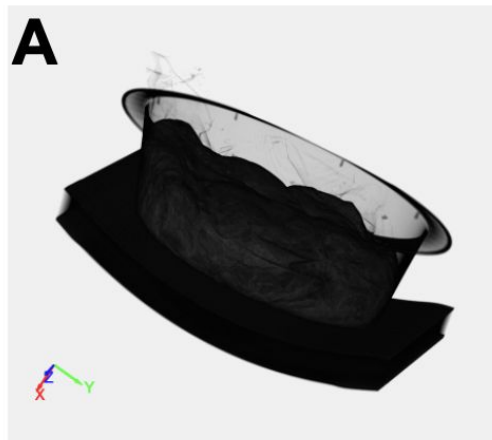


Feature Extraction Accuracy



MWA Ablation Zone Evaluation With Tissue-mimicking Thermochromic Phantom

Preliminary Integration Into Ablation Workflow



Discussion and Future Directions

Performance

- High accuracy
- Relatively good runtime

Limitations

- Occasional failures with multiple intertwining needles
- Dependent on hyperparameters
- Ellipsoid model inherently not perfect

Future Work

- Model optimization with a large dataset of patient images → generalizability
- Evaluate ablation zone approximation accuracy with CT-imagable thermochromic phantoms
- Incorporate tumor segmentation algorithms
- Extract more clinically meaningful information
- Improve visualization and incorporate user interface

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Thank you