Learning-empowered Real-time Needle Identification for Ultrasound-guided Percutaneous Liver Tumour Ablations

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MOTIVATION

In liver tumour ablations, both needle tips and shafts need to be accurately tracked in real time during freehand ultrasound-guided insertion. However, the visibility of the needle may be only partial or imperceptible.

Challenges:

- In-plane imaging limitations
  - Needle veering away from the plane
  - Micro-motions from maintaining in-plane insertion
  - Abrupt changes from breathing, pulsation
- Additional constraints
  - Poor US image quality
  - Steep insertion angle and high insertion depth
  - Trade-off between US penetration depth and image resolution
  - Similar acoustic impedances as needle

Contributions:

Developed a robust real-time identification method for the needle tip and shaft in freehand percutaneous liver tumour ablations. Specially:

- Reference window control module for “memory” data filtering
- Proposal feature aggregation module for needle enhancement
- Needle tip detection module for suppressing outside “noise”

METHODS

Data description:

- 64 US video clips
- 13 patients with focal liver tumours
- 651 US frames per clip on average

Training: Testing = 50:12

RESULTS

Case A: linear structure confusion
Case B: Poor image quality
Case C: Multiple needles
Case D: Sequential images with abrupt changes

SUMMARY

Developed a deep learning-based algorithm with “memory” function, which
- Achieved clinically acceptable accuracy (1.85° ± 0.62°, 4.19 mm ± 1.13 mm)
- Robust performance in micro- and macro-motions
- Trained and evaluated on patient data

ACKNOWLEDGEMENTS

References:

1W. Yan, et al. (2023) Medical Image Analysis 88, 102847.