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:

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

In-plane imaging limitations

- Needle veering away from the plane
- Micro-motions from maintaining in-plane insertion
- Abrupt changes from breathing, pulsation[1]

Additional constraints

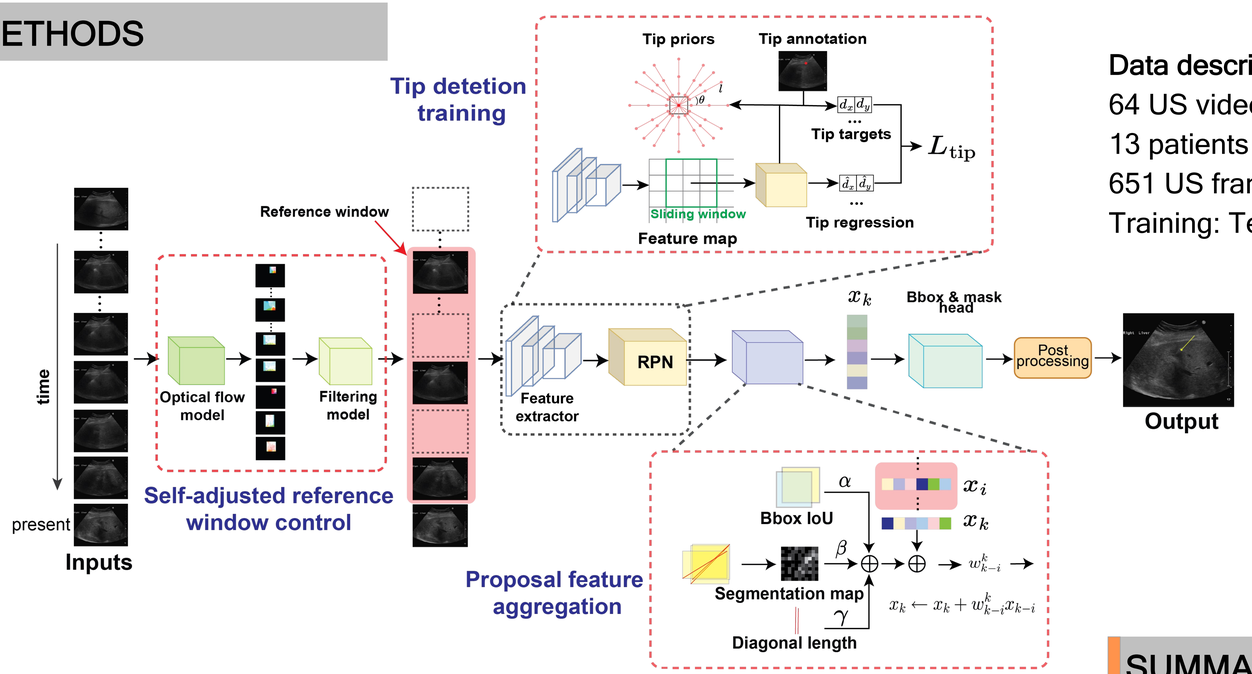
- Common US artifacts (reverberation)
- Straight-line shaped structures resemble the needle[2]

Contributions:

Developed a robust real-time identification method for the needle tip and shaft in freehand percutaneous liver tumor 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:

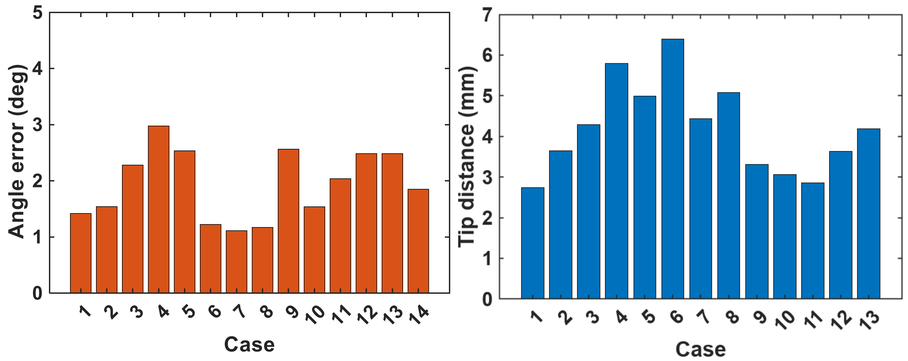
64 US video clips

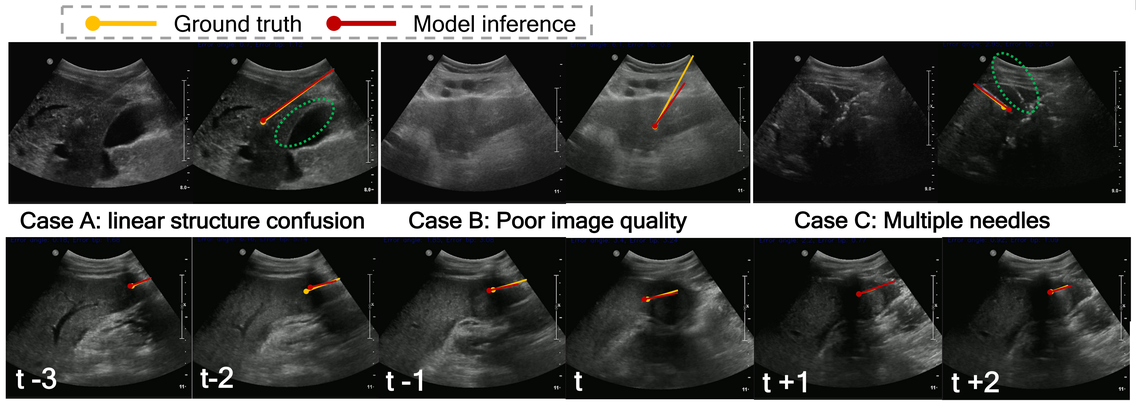
13 patients with focal liver tumours

651 US frames per clip on average

Training: Testing = 50:12

RESULTS





SUMMARY

Developed a deep learning-based algorithm with "memory" function, which

- Achieved clinically acceptable accuracy $(1.85° \pm 0.62°, 4.19\ mm \pm 1.13\ mm)$
- Robust performance in micro- and macro-motions
- Trained and evaluated on patient data

References: [1]W. Yan, et al. (2023) Medical Image Analysis 88, 102847.
[2]D. Gillies, et al. (2020) Medical Physics 47(10):4956-4970.

ACKNOWLEDGEMENTS