

VESSEL PUNCTURE USING ULTRASOUND-FREE NEEDLE GUIDANCE BASED ON AUGMENTED REALITY

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Ultrasound-guided needle puncture procedures constitute one of the most widespread and rapidly growing categories of interventional acts in modern medicine. However, the operator faces a fundamental ergonomic constraint: one hand holds the probe on the patient surface while the other simultaneously advances the needle, requiring permanent mental coordination between the two independent instrument axes while monitoring a 2D screen that shows only a thin planar cross-section of a three-dimensional target. To mitigate these challenges, we proposed recently T-Play, a research platform, that allows real-time synchronisation, streaming and visualization of multi-sensor data. T-Play enables the visualization of anatomical structures in their true spatial context through the following pipeline:

- Acquisition: US images are acquired using a probe tracked in real-time by a magnetic sensor.
- 3D Reconstruction: A 3D volume is reconstructed in interactive time using an unsupervised Implicit Neural Representation network [Gaits et al., IEEE Access, 2024].
- Segmentation: Tissues of interest are segmented using on-the-shelf region growing algorithms.
- Visualization: The segmented volume is streamed to a Hololens 2 AR headset.
- Real-time needle Tracking: The syringe is integrated into a holder equipped with a magnetic sensor. The system provides real-time visualization of the trajectory and tip as a colored line. A green indicator confirms when the target is reached, facilitating a precise, hands-free medical act.

Two very recent randomized phantom studies provide direct experimental evidence of T-Play's clinical potential. In particular, one of these studies was conducted at the Faculty of Medicine of Toulouse, in the anesthesia department, where forty students were randomized between standard ultrasound-guided puncture and T-Play-assisted puncture on a standardized blue phantom. Vessel puncture accuracy was equivalent between the AR-guided and standard conditions, demonstrating that T-Play does not compromise technical precision. The decisive result, however, was on user experience: across both studies and across all experience levels, a large majority of participants reported that T-Play reduced frustration, increased their confidence that the procedure had been performed correctly, and increased their confidence in their ability to reproduce the procedure independently at one, three, and six months.

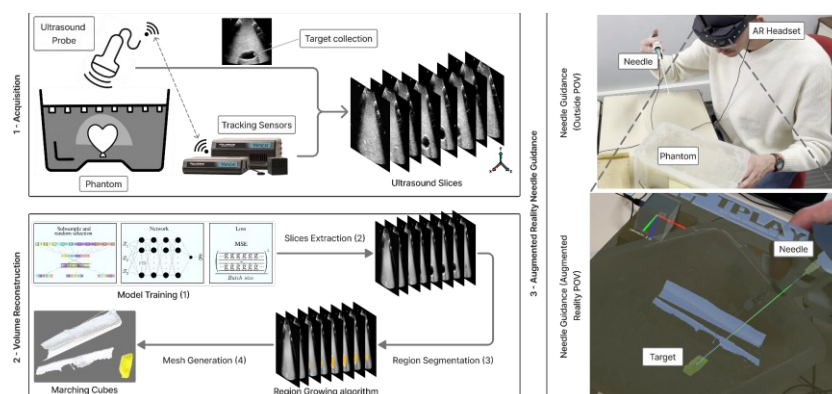


Figure 1. T-play workflow.