Needle localization for needle steering under 3D ultrasound feedback
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**Motivation and objectives**

- In needle steering, estimating the needle pose is a critical problem.
- In 3D ultrasound volumes, fine needle localization is difficult and requires a combination of estimation and image processing to be successful. Indeed, 3D ultrasound imaging suffers from noise, artifacts and works at a low frequency.
- We propose a needle tip pose estimation method in the context of 3D robotic needle steering under 3D ultrasound feedback, based on multi-rate, multi-sensor fusion [1].
- This estimation feeds a segmentation algorithm for robust needle detection.

**Tools**

**Robotic device**
- PROSPER robot for brachytherapy procedure [2]
- 6 degrees of freedom, needle insertion and rotation module

**Ultrasound (US) imaging**
- 3D US imaging in B-mode
  - 3D B-mode US volume @ 1Hz
  - 3D end-fire probe 4DEC-9/10 with Ultrasonix Sonix RP US system

**Pre-operative shear wave imaging (SWE)**
- SWE estimates tissues Young’s modulus from their response to a shear wave US stimulation
- The needle curvature is proportional to the tissue stiffness

**Results**
- 51 insertions of 8 cm at 1.5 mm.s⁻¹
- Validation on phantoms and ex vivo tissue sample

**Conclusion**
- The tip pose estimation is accurate, robust to needle disappearance and 3D ultrasound imaging artefacts
- An adapted segmentation method, inherited from [4], uses the resulting ROI for needle tip segmentation in the 3D US volumes
- The good estimation of the tip behavior and its uncertainties could benefit to adapted control laws and path planning methods

**References**


