Ultrasound-guided spinal needle placement on open source platform

Abstract to the CCO/CINO Consortium

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BACKGROUND: Freehand ultrasound guidance in spinal injection has been reported previously, but this technique has not been adopted in the clinic due to challenges in ultrasound image interpretation, and difficulties in simultaneous manipulation of the ultrasound and needle.

HYPOTHESIS: Software engineering carried out on open source platform results in a system that is effortlessly and rapidly configurable to support various image guidance display modes.

METHODS: The system includes a Sonix Touch (Ultrasonix) ultrasound scanner with GPS extension (Ascension DriveBay electromagnetic tracker). Tracked 3D position sensors are affixed to the US probe, needle, and subject (or cadaveric specimen). Two modes of navigation are implemented. The operator can manipulate the US probe to optimal position and insert the needle under live ultrasound guidance (Fig. 1). Alternatively, the operator can freeze the image, remove the probe from the patient and insert the tracked needle navigated by the frozen snapshot. The needle placement is validated in two orthogonal X-ray images (Fig. 2). The software system implementation is entirely open-source (Fig. 3). OpenIGTLink broadcaster application of the PLUS open-source software library is used for sending synchronized tracked image data to the navigation computer through a network connection. 3D Slicer (www.slicer.org) image analysis & visualization application is used for needle navigation. Optimal guidance display arrangement is achieved by configuration of the 3D Slicer interface.

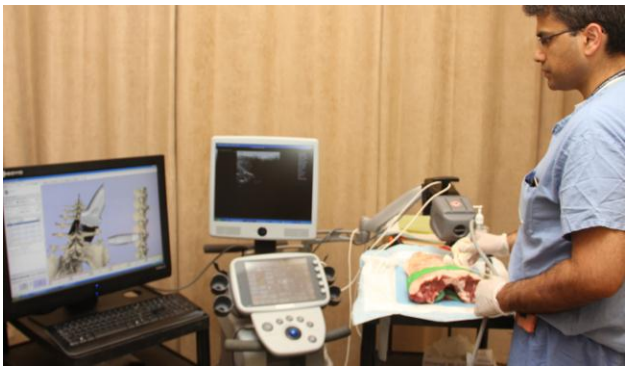

Fig. 1: *Photo of the system in spinal facet joint injection training on lamb model.*

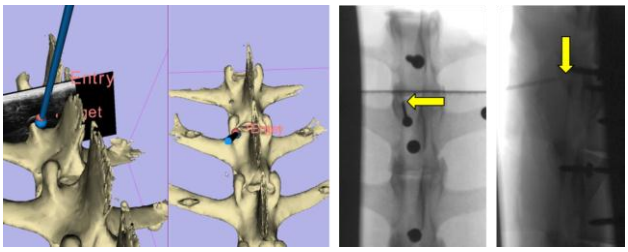

Fig. 2: *Clouse-up of the needle guidance and X-ray verification display.*

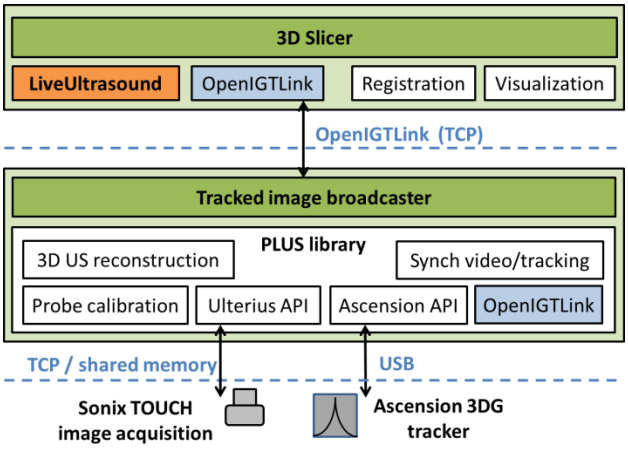

Fig. 3: *Software design: Communication components highlighted in blue. The module developed for this application is marked by orange colour.*

RESULTS: The intrinsic accuracy of the system in geometric gel phantom was 1.03 ±0.48 mm; more than sufficient for the procedure. The system was used experimentally with a cadaveric lamb model (Fig. 1) to measure surgical operator performance in terms of success rate, accuracy, and procedure time. The display and visual representations were optimized for most intuitive needle navigation. The open source development platform allows for rapid prototyping of image-guided needle placement applications, and readily translates to a variety of imaging modalities, organ systems and diseases.