Augmented-Reality Guidance for Pain Medicine Spine Injections

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Challenge

Image-guided epidural steroid injections (ESI) are mainstays of pain medicine practice, but fluoroscopy and CT guidance expose providers and patients to harmful radiation.

Augmented reality image guidance is revolutionizing parallel interventional procedures by increasing accuracy and speed and reducing radiation exposure.

No adaptations of this technology exist specifically for use in ESIs for pain management.

Our solution

Microsoft HoloLens augmented reality headsets will project true-to-life holograms of patients' own anatomy generated from diagnostic imaging on the real patient to guide needle trajectory.

This will:

1.Save time before and during the operation

2.Increase accuracy of the injections

3.Reduce radiation exposure, more sustainable

- **Upwards of 10 X-ray images saved per patient = about 1 mSv per procedure**
- **Single diagnostic scan can be used in multiple procedures**

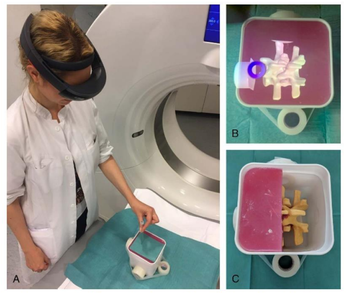

FIGURE 1. Radiologist performing an augmented reality–guided facet joint injection (A). Photo from the radiologist's point of view through the HoloLens shows the hologram inside the phantom container (B). Only the holographic ring marker to the left is visible in this photo, due to a limited field of view. The blue ring is the HoloLens live cursor. Last image shows partially released sawbone vertebral bodies in agar (C).

3D Reconstruction

The first component of this project is a software solution to handle reconstruction of medical images and data, including

- Reconstructing annotated 3D meshes of the lumbar spine using U-Net based on patients' MRI scans
- Overlaying key features between the point cloud generated through ultrasound scans and the 3D reconstruction from MRI to accurately update the location and orientation of spine before and during the operation

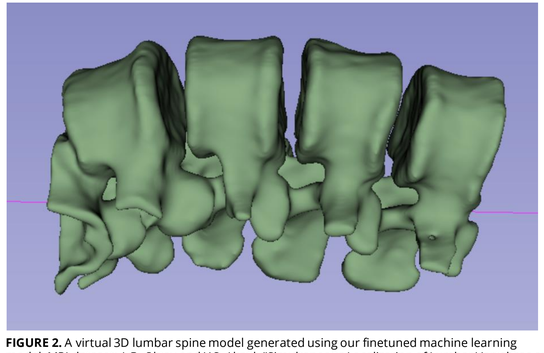

FIGURE 2. A virtual 3D lumbar spine model generated using our finetuned machine learning model. MRI dataset: A.B. Oktay and Y.S. Akgul, "Simultaneous Localization of Lumbar Vertebrae and Intervertebral Discs with SVM based MRF", IEEE Transactions on Biomedical Engineering, 2013

Multi-objects tracking

The second component of this project is a software and hardware system that handles tracking and coordinate transformation according to the movement of patient's body, including

- Utilizing a laser based external tracking system to track the real-time positions of HoloLens headset, ultrasound probe, and the needle
- Performing coordinates transformation between ultrasound probe, external tracking system, and HoloLens to compensate the limitations in accuracy and range of the HoloLens internal tracking system

AR Interface

The third component of this project is a software solution to handle model visualization and user interface, including

- Visualizing the 3D lumbar spine model and projecting it onto its physical location using the ultrasound guidance
- Developing a software solution to calibrate the model projection based on external tracking device, thereby steadily improve the accuracy of the projected model over time

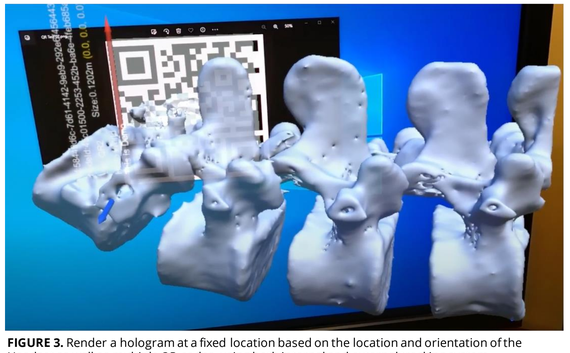

FIGURE 3. Render a hologram at a fixed location based on the location and orientation of the Headset as well as multiple QR codes, using both internal and external tracking system.

Competitive Analysis

Combination of ultrasound-guidance with traditional fluoroscopic guidance

Limitations

- Limited to 2-dimensional views
- Extensive physician training required to use US-guidance
- Limited structural visualization by ultrasound, ex. deep to bony structures
- Only portends a small decrease in radiation exposure

Our Solution

- Provides 3-dimensional visualization of the planned needle trajectory
- Intuitive, true-to-life visualization projected on the patient in real space, requiring minimal additional training

References

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