Augmented Reality-based Surgical Navigation System

Songyuan Lu, Ananya Rajan, Steven Hui, Eric Lee, Capalina Melentyev, Kirsten Ramos, Darin Tsui, Dr. Frank E. Talke

University of California, San Diego, Center for Memory and Recording Research

UC San Diego
JACOBS SCHOOL OF ENGINEERING

Background

Augmented Reality (AR) is used as a tool in medical technology to guide complex surgical procedures through real-time, 3D anatomical views, prioritizing:

- Real-time tracking
- High precision
- Improved clinical outcomes and efficiency
- Low-cost

Objective

Design an optical tracking system that is:

- Cost-effective
- Radiation exposure limiting
- Accurate

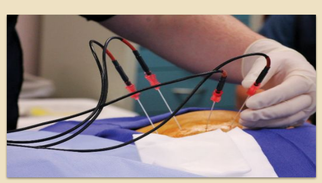
We plan to achieve this through:

- Videometric tracking using stereoscopy
- Overlaying patient-specific medical scans via AR
- Validating design with pre-clinical testing

Method

The proposed system is specifically designed to support interventional pain management therapies, focusing on the treatment of back pain

Epidural steroid injection procedure



Radiofrequency ablation procedure

The project is divided into 3 parts:

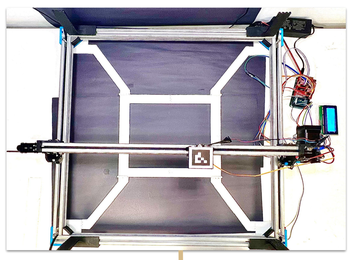
- ArUco marker tracking
- Development of AR application
- Human body and spine model design and manufacture, and design validation.

Marker Tracking

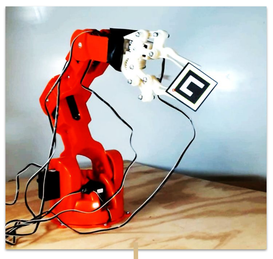
Fiducial Markers
Utilizing open source ArUco markers provides positional information

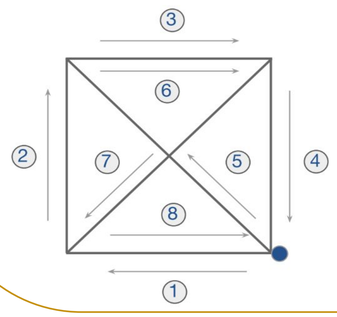
Stereoscopic Vision
Using two inexpensive cameras, depth of marker can be perceived

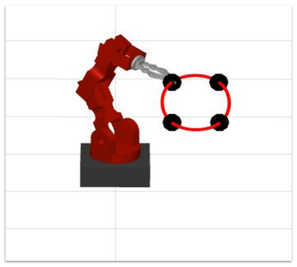
XY Positioning Platform
Tracking in 2D space for MRI image overlay over patient



5DOF Robotic Arm
Tracking in 3D space for surgical instrument trajectory planning



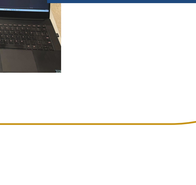




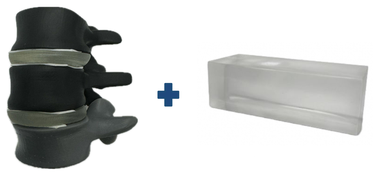
AR(Augmented Reality) Application

3D Engine
Building AR environment and managing AR models with Unity

CAD Model
Utilizing an open source spine model as an AR model and to manufacture test model

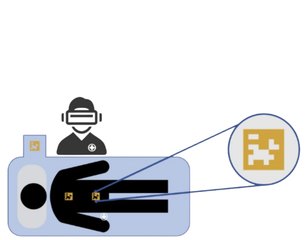


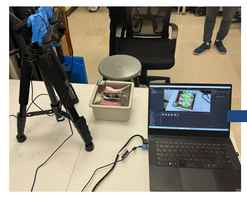
Soft-Transparent Test Model
Wrapping 1:1 human spine model (3D printed from CAD model) with ballistic gel



AR Headset
Using Meta Quest3(An MR headset) to show navigation to the user

Set up and Test the system
Left is the concept figure for our system, right is our current system





Conclusion

Combining advancements in marker tracking, AR application development, and 3D model creation, this project pioneers a low cost AR surgical navigation system.

Future Scope

- Integrate tracking methods with AR application
- Perform validation through pre-clinical testing
- Measure efficiency of system by conducting usability studies with clinicians