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Using Augmented Reality to Interact with 3D Holographic Images of Intracardiac Geometry and Catheter Positions During Cardiac Ablation Procedures

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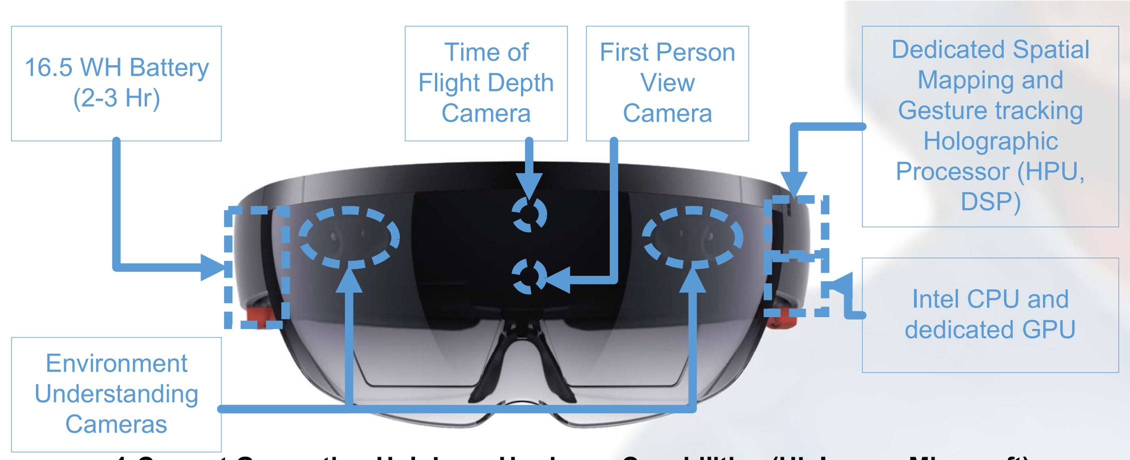
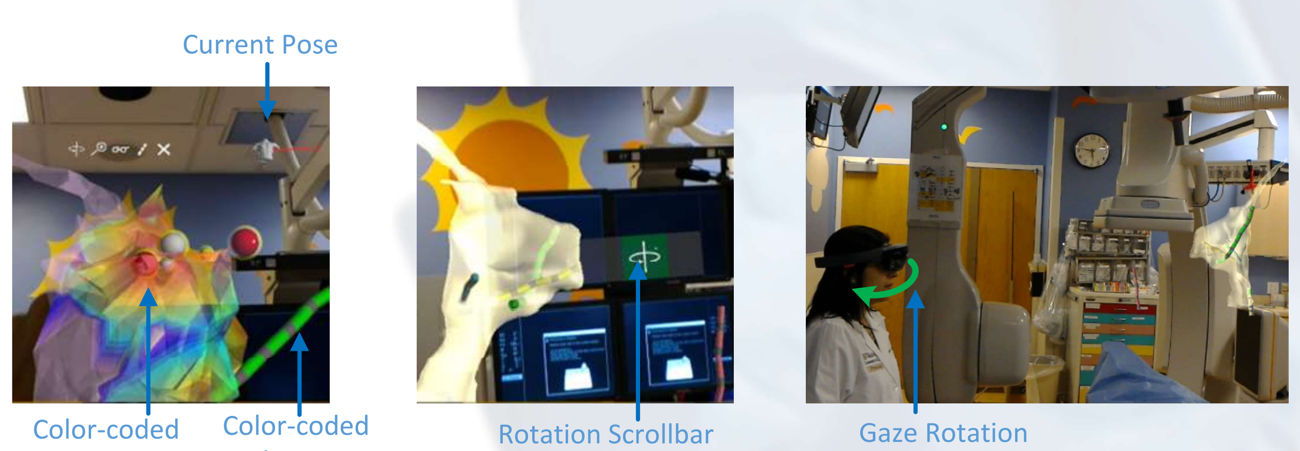
Abstract:
Arrhythmias affect >5% of the US population and can cause dizziness, fainting, and sudden death[1]. Minimally invasive catheter-based ablation procedures are the current standard of care for many patients, but reduce the interventionalist's ability to directly visualize catheter placement[2] increasing their reliance on multiple coordinated systems and other personnel to manage multiple data streams, including projections of the cardiac model. We hypothesize that empowering interventionalists to directly interact with a true 3D representation of electroanatomic mapping system (EAMS) data will improve their understanding of patient-specific anatomy[2] and shorten overall procedure time[3]. We have developed an augmented reality (AR), head mounted display (HMD) system corresponding feasibility metrics for evaluation based on the Windows Mixed Reality (WMR) (Microsoft) platform to provide a shared, interactive, 3D holographic display of real-time cardiac geometry and catheter positions with sterile hand gesture and head directed control interfaces for intra-procedural use.

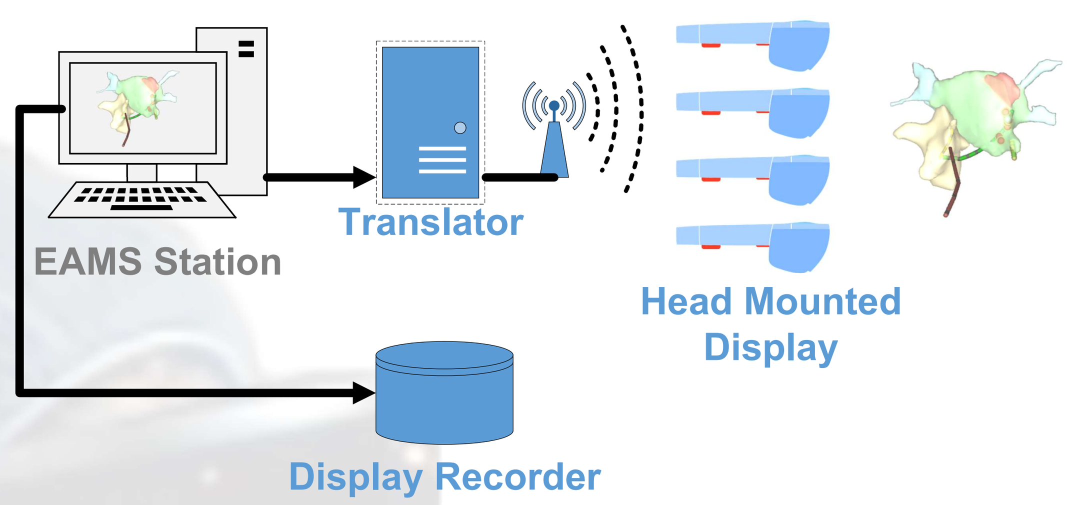


1-Current Generation HoloLens Hardware Capabilities (HL Image: Microsoft)

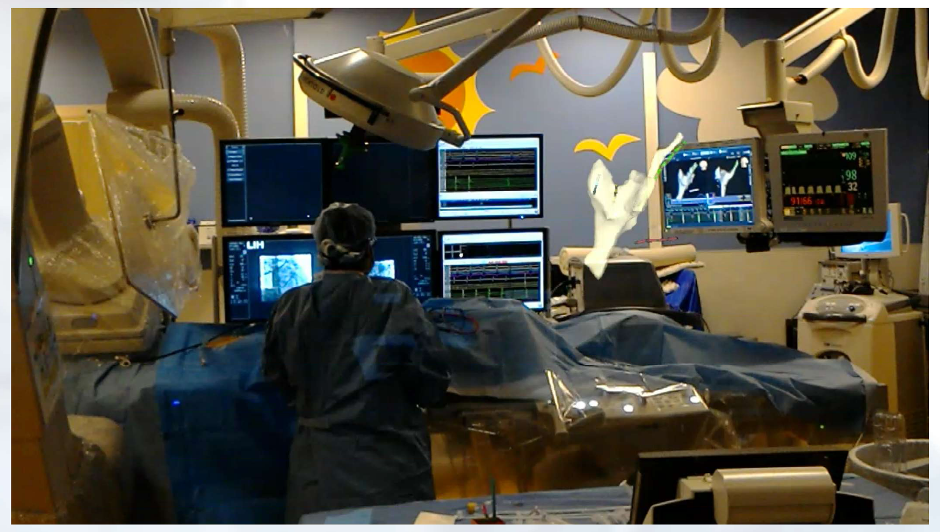
Platform[4]:
Although the Microsoft HoloLens does not have the general processing capabilities of a high-end laptop computer, it has a careful balance of dedicated processing to maintain a high level of capability for rendering current EAMS data on an HMD, with a clinically useful battery runtime.
- Dedicated 24 core DSP for offloading sensor data processing of 3D spatial localization and gestures
- Dedicated GPU core for maintaining high framerate required
- Quad Core CPU for handling application logic
- Charge through battery allows for an external battery pack to extend 2-3 hour runtime if necessary
- Self contained, un-tethered, 579g HMD



3-Hands-free interface



3-System Architecture overview

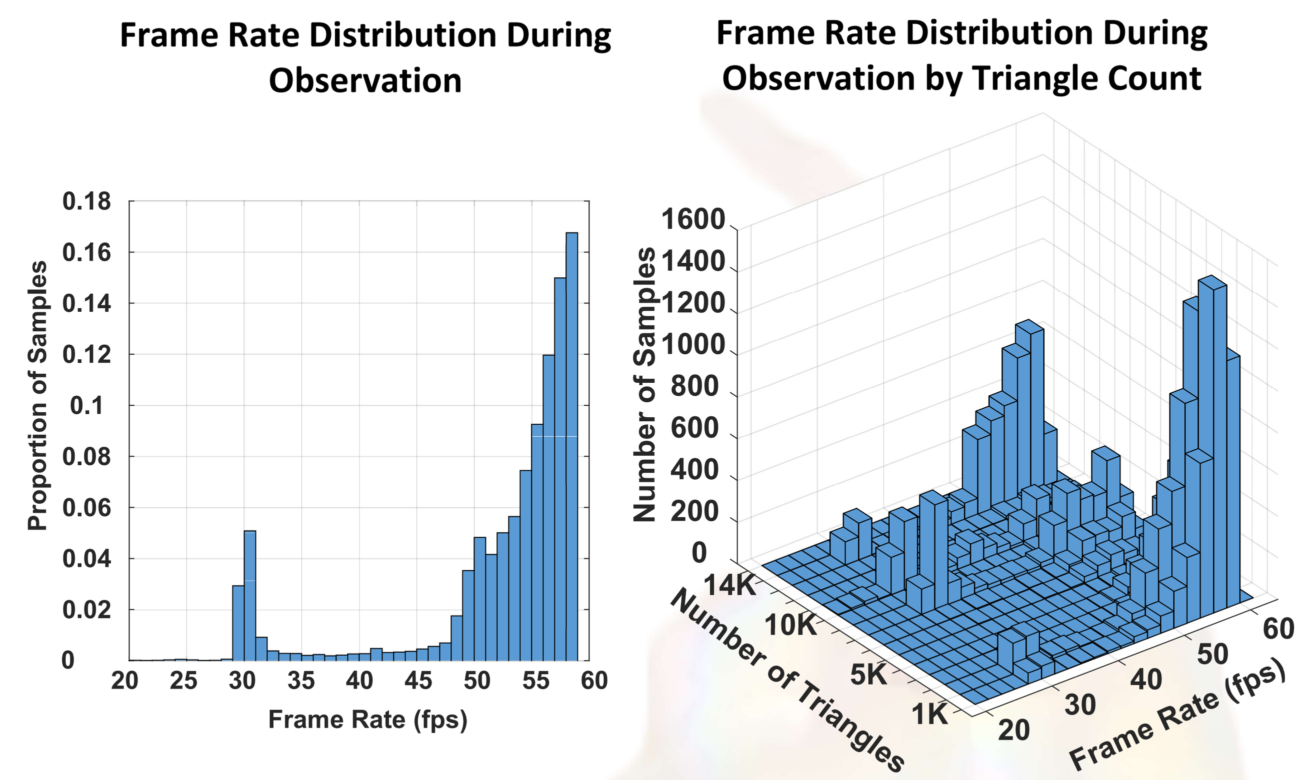


4-View through HoloLens from control room during procedure

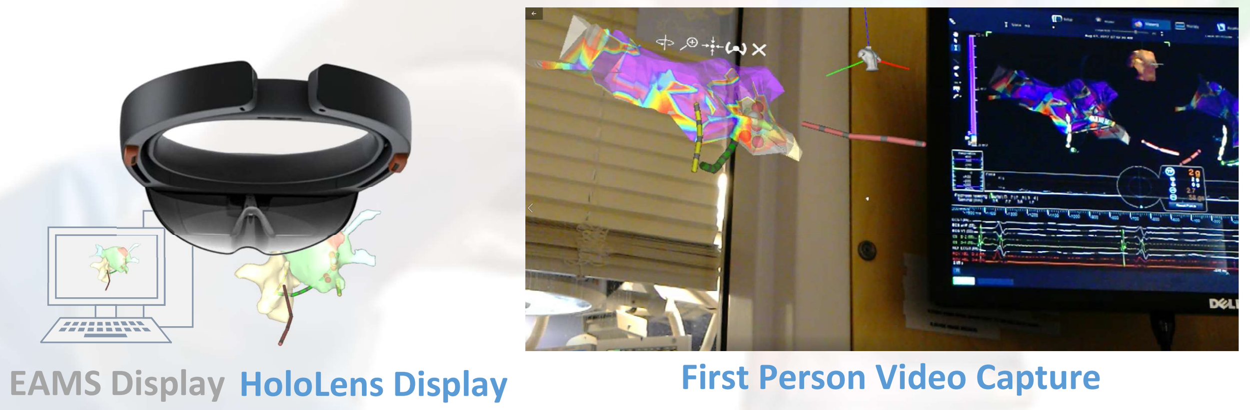
System:
Inputs:
- Real-time EAMS data (geometry, catheters, lesions)
- Pre-recorded EAMS data
- Diagnostic MRI/CT
- Gaze, Gesture control

Processing:
- High throughput geometry translation (Translator)
- Low latency WiFi (802.11AC) message queueing
- WMR input processing and rendering

Outputs:
- Stereo 3D display of cardiac geometry, catheters, lesions positioned in environment
- Shared positioning and display data
- Shared hands-free and touch-free manipulation of data
- Recorded EAMS station monitor display output (Display Recorder)



6-Framerate sampling
Framerate remains consistently skewed toward 50 fps across model triangle counts. 30 fps samples may be attributable to framerate drops during video recording



5-View through latency measurement configuration (HL Image: Microsoft, EAMS: Abbott Velocity)

Methods and Results:
- 1 Hz sampling
- 20.4 hours total observation

Latency:
- Screen to Screen latency

Usability:
- Hands Free
- Gesture Control
- Battery discharge rate
- EP, Technician, Engineer experience

Study Characteristics	
# of Patients Enrolled	10
Age (years)	13±4.5
EP Diagnoses	
AVNRT	3
Right Sided AP AVRT	1
Left Sided AP AVRT	6
Geometries Created	
Right Atrium	10
Left Atrium	6
Maps Created	
Activation Map	7
Voltage Map	5
Preliminary Metrics (n=3)	
Polygons	6k-12k
Frame Rate	31-60fps
Battery Performance	191 min
Latency	<131 ms

Conclusions:
- Real-time AR display of EAMS data feasible
- Current hardware meets minimum performance requirements

Future Work:
- More accurate latency characterization
- Quantifying benefits of AR HMD in EP
  - Workload distribution
  - Time to dense map
  - Overall procedure time

We believe the system will reduce the time to understand complex anatomy, simplify human machine interaction of complex systems and shorten overall procedure times to improve access to higher quality care for arrhythmia patients.

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Disclosures:
Jennifer N Avari Silva, MD and Jonathan Silva, PhD are founders of SentiAR, Inc. and Michael Southworth holds shares in SentiAR, Inc.
SentiAR, Incorporated is a medical device company pursuing the application of augmented reality in electrophysiology.

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