DICOM to 3D Holograms: Use Case for Augmented Reality in Diagnostic and Interventional Radiology

Alaa Beydoun, MD, University of Maryland Medical Center; Vikash Gupta, MD; Eliot Siegel, MD
University of Maryland School of Medicine, Baltimore, MD

Background

Virtual Reality (VR) and Augmented Reality (AR) are two related fields of image display technology which have seen major strides in the past five years as wearable computing has become more prevalent. Both fields are based on the concept that computer generated images can be displayed, rendered, and perceived from a first person perspective with the ability to entirely replace (VR) or supplement (AR) a user’s perception of the environment (Barfield 2015). While VR has seen practical application in video game and flight simulation industries, the technology allowing practical application of AR has only come to fruition in the past several years, most notably with the release of Microsoft’s HoloLens head-mounted computer display device in the first quarter of 2016. The potential applications of AR in medicine are vast, especially when used in conjunction with medical imaging.

Case Presentation

The development of a system to convert cross-sectional medical images into 3D models that can be perceived and manipulated as AR objects in the real world would be invaluable in advancing the fields of both diagnostic and interventional radiology. This could allow an interventionalist to more intuitively perceive the best and safest path of intervention on a patient during image guided procedures with the prospect of decreasing complication rates, needle re-directions, radiation dose, and procedure time (Figure 1). From a diagnostic perspective, benefits could mirror those seen with use of 3D printed models including pre-procedural planning and intuitive perception of medical imaging (Ventola 2014) with the added benefits of model size scaling, decreased cost, faster perception of 3D models, and teleconferencing collaboration.

Figure 1

[Images of initial and subsequent scan with needle trajectory off course and re-directed]
Outcome

The HoloLens is a head mounted wearable computer system that runs Windows 10 Universal as the operating system with the ability to generate a 3D mesh of a user’s environment, anchor objects within it, and stereoscopically display these objects from a 1st person perspective as if they are physically present in the environment. To take advantage of this device, we manually segmented anonymized DICOM data-sets into 3D models which were loaded onto the HoloLens device and perceived as AR objects in the real world (Figure 2). We were able to anchor these objects to points of space within the environment and rotate, resize, and walk around these objects as if they were physically present in the real world (Figure 3). Additionally we were able to overlay and accurately coregister these virtual holograms directly on the subject from which they were derived giving an impression of “seeing into” the subject.

Figure 2

Figure 3

54 year old male coronary CTA evaluation. Reconstruction of proximal pulmonary vasculature
Discussion

In preliminary use of our system, we discovered many benefits and some potential limitations of the application of this technology in its current form. From a diagnostic perspective, many of the benefits involve the intuitive perception of 3D rendered medical imaging with the ability of the user to walk around and view the hologram as if it was an object in the room while being able to manipulate its size and position freely. From a procedural perspective, coregistration of the 3D rendered model to the imaged subject gives the impression of seeing into the subject, potentially providing an in-vivo perception of medical imaging within a patient. This could drastically aid in planning and implementation of image guided interventions.

Limitations of the device predominantly relate to it being an early consumer product with a limited field of view and a fairly hefty size. Although the HoloLens proves to be a major technical accomplishment as it operates as a stand-alone computer with a built-in stereoscopic high-resolution display, full wireless connectivity, multiple positional sensors/cameras, and a fairly comfortable headband mount, many of our users that experienced this system noted that wearing 1.2 lbs of weight on one’s head for an extended period of time can lead to fatigue.

Additionally, while ground breaking, there are major limitations with the current display system if it was to be used by current interventionalists and diagnosticians. The HoloLens display is composed of a tinted visor overlying a pair of holographic display lenses which covers 30 x 17 degrees of one’s field of view (equivalent to a 15” monitor from 2 feet away). This limited field of view requires a user to turn their head to view rendered images outside this display area. For proceduralists, is cumbersome and limits its overall utility.

These holographic lenses also suffer from a distracting rainbow type artifact when viewing holographic objects projected on luminous white backgrounds. This artifact is particularly apparent when viewing flat screen monitors with bright backgrounds. The visor that overlies the display acts as a tinting screen, dampening ambient light and increasing the relative vibrancy of displayed holograms, especially in well-lit environments. From a diagnostician’s perspective, this may decrease the efficacy of diagnostic monitors as the perceived luminance is less than the monitor is rated for, potentially affecting a user’s ability to appreciate subtle findings. Ultimately, in its current form, this device cannot be worn while actively interpreting diagnostic exams due to these limitations.

Finally, a major limitation of our system is the time intensive process needed to manually segment DICOM data sets and convert these images into holograms. Fortunately, there continues to be increasing interest in automated advanced segmentation techniques which ultimately will translate to easier application of AR in medicine (Viergever et al. 2016).

Conclusion

The field of AR is still in its early infancy and the HoloLens provides the first consumer head-mounted display device which is widely available for purchase and distribution allowing practical application of this technology in various industries, including medicine. Our preliminary experiences of converting medical imaging into AR holograms suggests that this type of technology, as it matures, will ultimately revolutionize the practice of medicine.

References


**Keywords**

- augmented reality, wearables, image guided interventions