Real Time Pose Estimation of the Head for TMS Neuronavigation

Grant Yang

May 26, 2017

1 Introduction

Transcranial magnetic stimulation (TMS) is a promising treatment for depression in patients who do not respond to medication. TMS stimulates specific regions of the brain, which are known to be less active in depression patients, using magnetic fields. The efficacy of TMS treatment is highly dependent on consistent and accurate targeting of the affected brain regions. However, current neuronavigation systems are not user-friendly and require lengthy set up times. A holographic augmented reality display of brain MRI data via the Microsoft HoloLens would allow clinicians to see "into" the patient to locate the target brain regions and facilitate TMS coil placement.

One challenge of the proposed neuronavigation system is accurate real-time estimation of the pose and position of the patient's head. Currently, the proposed neuronavigation system relies on markers placed on the patient's face [Leu17]. These markers are difficult to setup consistently and have limited accuracy. Real-time pose and position tracking via RGBD camera information would eliminate the need for markers, resulting in a more user-friendly device.[GBD+16]

2 Purpose

Integrate real-time pose and position estimation of the patient's head by streaming depth data via external sensors such as the Microsoft Kinect or Intel RealSense to the Microsoft Hololens in order to visualize MRI data for neuronavigation.

3 Methods

The Microsoft HoloLens is a promising augmented reality platform for visualizing MRI data for TMS neuronavigation. Unfortunately, the HoloLens does not provide real-time, high quality depth data, limiting its ability to perform real-time tracking of patient's pose and position. We augment the HoloLens capabilities by attaching an Intel RealSense camera, which provides high resolution

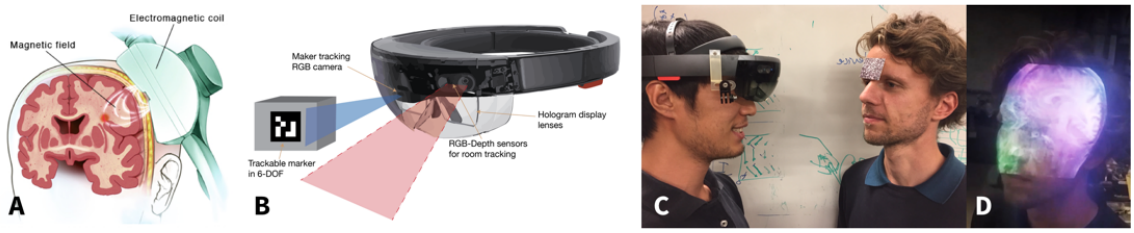

Figure 1: (A) Stimulation of a brain region using a TMS coil (Photo: Mayo foundation). (B) Microsoft HoloLens (HL) combines sensors, processing and display to track and place holograms in the on in the real world. (C) The observer (left) wears a holographic augmented reality device. The position of the subject's (right) head in the real world is measured using markers and anatomical features. (D) Preliminary data of a view through the HoloLens showing a hologram overlaid on the subject's head.

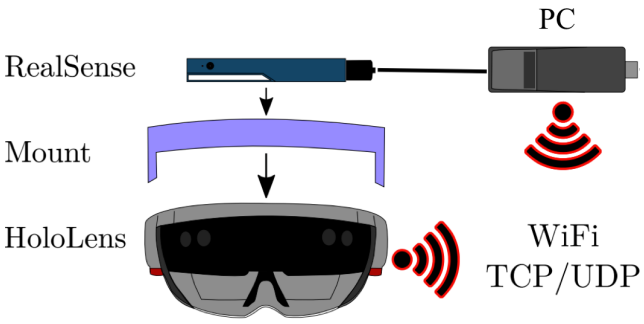

Figure 2: Hardware setup of the Intel RealSense RGBD camera mounted to the Microsoft HoloLens. (Photo: Garon, ISMAR 2016)

depth information. The RealSense camera will be calibrated to the Microsoft Hololens. RBGD information from the RealSense camera will be used to perform face and head tracking[H.15] on an external PC and the resulting information will be transformed into HoloLens coordinates and transmitted via wifi to the HoloLens. This information will be used to accurately project the patient's MRI data in real time. Future implementations may be completely untethered by using an Intel Compute Stick PC.

4 Timeline

- 5/25-5/30 Install SDK for HoloLens and Intel RealSense and get acquainted with their respective APIs.
- 5/30-6/1 Calibrate the Intel RealSense and HoloLens cameras. Compute the camera calibration matrix as well as the transformation between the RealSense RGB camera, depth camera, and HoloLens camera.
- 6/2-6/4 Establish face and head tracking with the Intel RealSense and relate the pose estimates to anatomical features on MRI.
- 6/5-6/6 Establish communication between PC and HoloLens via wifi and stream information from the RealSense camera
- 6/6-6/8 Use information from RealSense camera to accurately project MRI data onto the patient's head in real time.

References

[GBD+16] Mathieu Garon, Pierre-Olivier Boulet, Jean-Philippe Doiron, Luc Beaulieu, and JEan Francois Lalonde. Real-time high resolution 3d data on the hololens. In *ISMAR 2016*, Merida, Mexico, Sept. 19-23 2016.

[H.15] Gael H. Face and head tracking using the intel realsense sdk, 2015.

[Leu17] Subashini Lin Michael Hargreaves Brian Daniel Bruce McNab Jennifer Leuze, Christoph Srinivasan. Holographic visualization of brain mri with real-time alignment to a human subject. In *ISMRM 2017*, Honolulu, Hawaii, April 22-27 2017.