Robot-Assisted Transcranial Magnetic Stimulation for Subjective Visual Vertical Assessment

Computer Integrated Surgery II

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Introduction

- We implemented the systematic application of transcranial magnetic stimulation (TMS) over a grid area on the brain cortex
- We also created software to move along linear unobstructed paths in a grid-like fashion with simple force feedback
- A custom tool was designed and built to hold the TMS coil parallel to end effector

The Problem

- The subjective visual vertical (SVV) has been linked to the activity of the supramarginal gyrus
- TMS is used to inhibit brain activity during the assessment of the SVV
- Manual application of TMS can be imprecise and forces researchers to take their focus away from experiments.
- There is also a need to visualize results of TMS application easily to identify key regions of the brain associated with certain activities

The Solution

- Our solution was to control location of TMS application by allowing a UR5 robot to hold the coil adjacent to the subject's head
- The robot was given a force sensor and strict safety limits to prevent excessive force against the head
- We created a custom tool that would hold the coil parallel to the end effector of the UR5, integrated with the force sensor
- We made an algorithm to find the optimal path to traverse a grid of points without exceeding force limits at any point

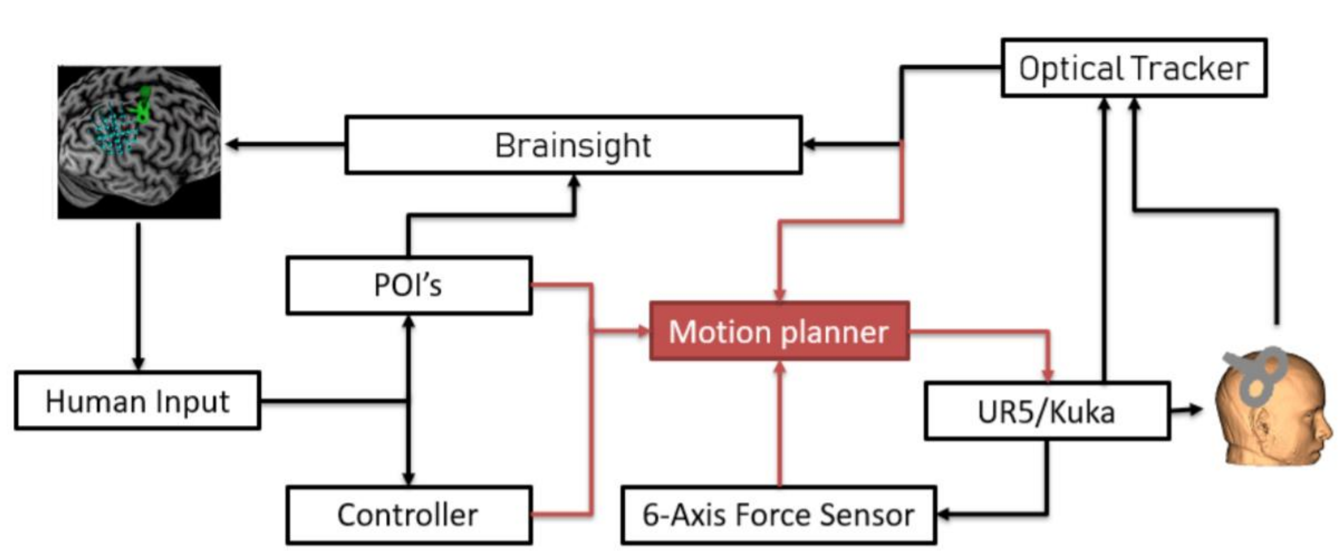

Figure 2. A flowchart diagram of the planned component along with necessary interfaces

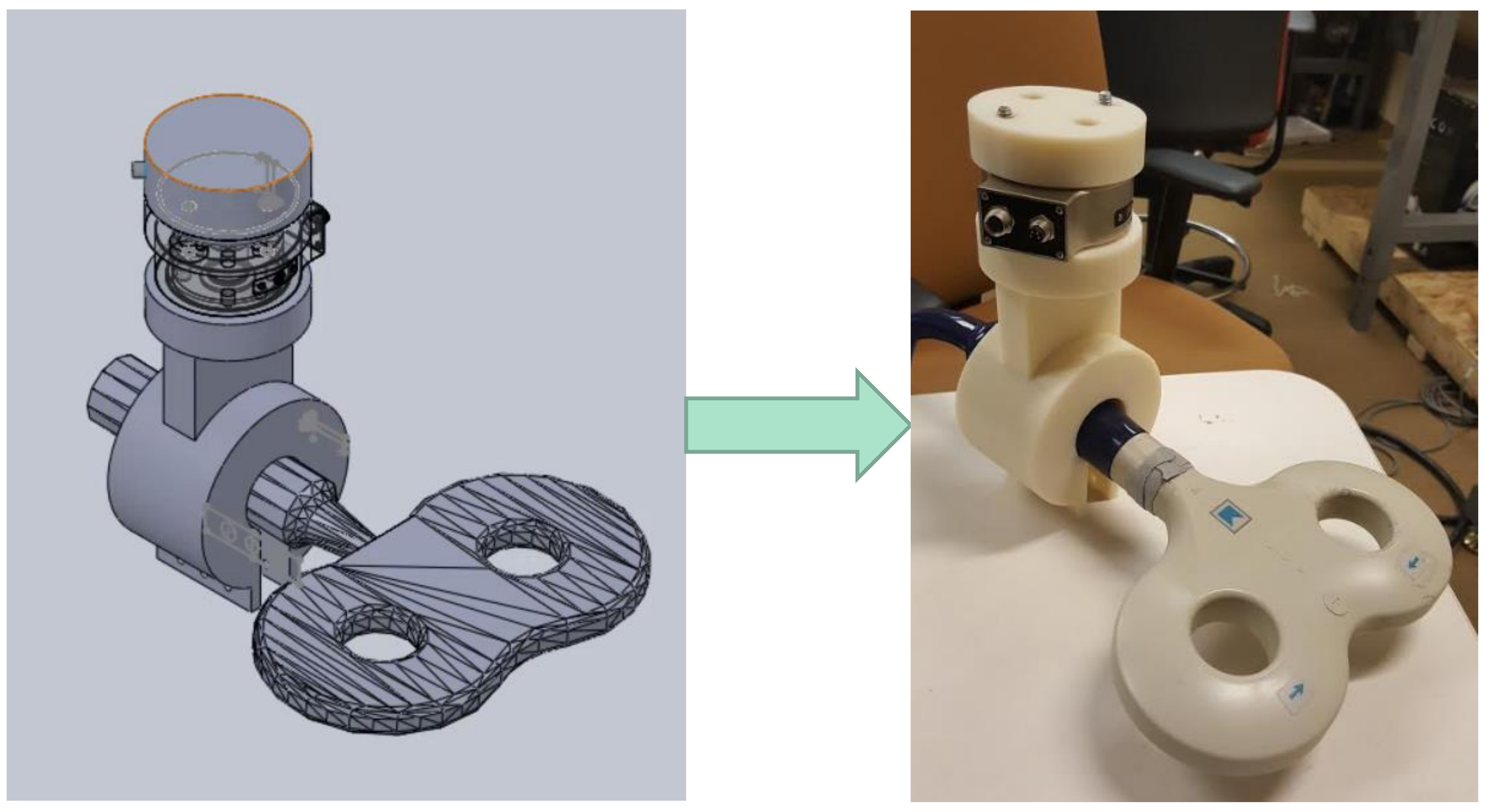

Figure 2. The CAD model of the custom tool (End effector is on top, coil is on bottom) along with the assembled parts (no UR5).

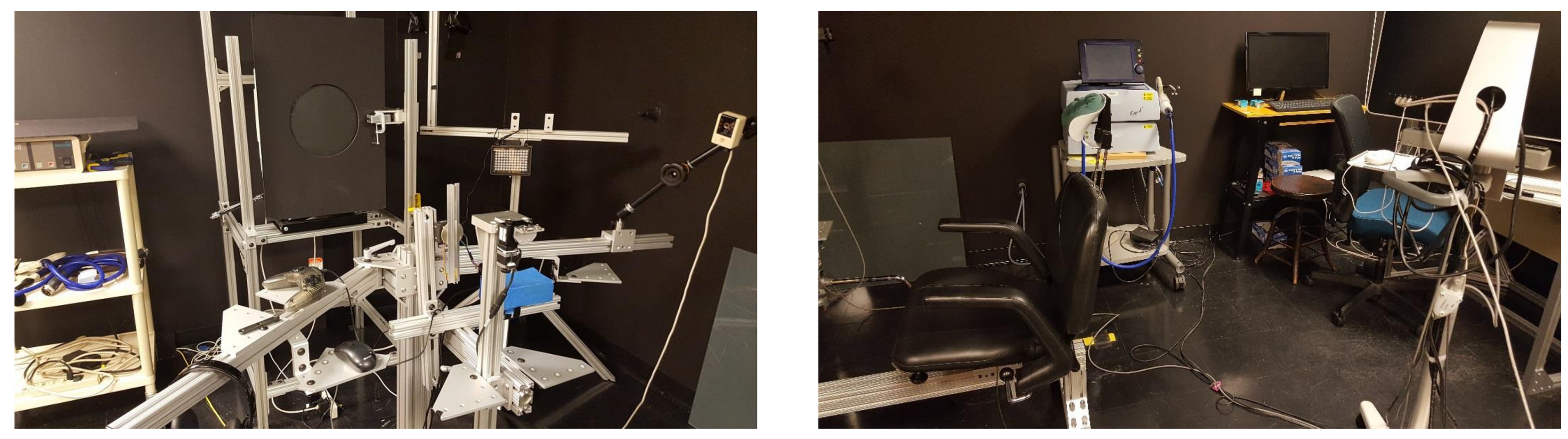

Figure 3. Set up in VORLAB for SVV assessment. Left: Bite bar with laser projection. Right: Researcher's table with TMS coil apparatus

Outcomes and Results

- The robot environment was set up in Slicer simulation with sample models of subject heads and approximate model of TMS coil
- Our robot was successfully able to position the end effector at specified locations and travel between them in a linear fashion
- Force feedback was implemented at a basic level (spring), but required more experimental data to be complete
- The tool was designed in SolidWorks and 3D-printed before being assembled and attached to the UR5

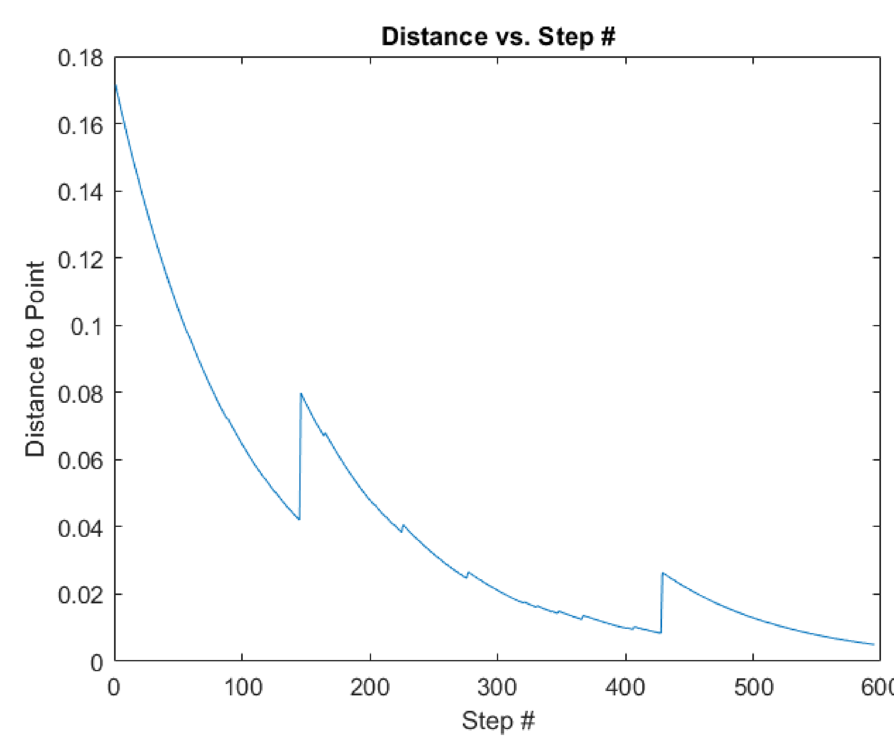

Figure 4. Distance from end effector to desired location over course of algorithm. Program ran until distance threshold was reached.

Future Work

- Work will be continued over the course of the next year and measurements from the force sensor could potentially be taken as soon as next week.
- We plan on interfacing with Brainsight for visualization of brain activity
- At the end, every step of the TMS application and SVV assessment should be possible from the same workstation without having to get up

Lessons Learned

- Experience with SolidWorks and Slicer
- Keeping tool orientation constant is somewhat tricky when the tool tip is angled in an odd way relative to the end effector.
- Construction of the tool holder should be started early to prevent inability to measure force constants
- Practical application of knowledge from class regarding constraints and frame transformations

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