

Developing Technology for DBS Parkinson's Patients

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Abstract

Assessing symptoms in Parkinson's disease patients can be very difficult as clinicians must make subjective evaluations based on tests that patients complete, such as opening/closing the hand, pinching fingers together, and toe tapping. However, often what the clinician sees is not consistent with what the patient experiences. We have worked to develop technology using commercial sensors to aid both patients and clinicians in the clinical setting in order to improve patient engagement in their own treatment and increase communication between patient and clinician.

1. Introduction

Parkinson's disease (PD) is a neurological disease characterized by symptoms such as tremors, rigidity, bradykinesia (slowness of movement), dyskinesia, and gait problems. There is currently no cure for PD; however, there are a number of treatment options. One such option is a surgical procedure known as Deep Brain Stimulation (DBS). DBS uses electrodes to target specific areas of the brain, most commonly the subthalamic nucleus (STN), to help regulate patients' PD symptoms [2]. DBS has been shown to be effective in improving quality of life for many patients as indicated by the Unified Parkinson's Disease Rating Scale (UPDRS) and reducing the amount of medication that patients need on a daily basis [2]. Within the DBS system, there are different settings that can be customized to each patient, including frequency, voltage, pulse width, and the number of leads [2]. Bilateral stimulation (the use of two leads) is most frequently used in PD patients. Each lead contains four electrodes that can be turned on or off and [2]. The electrodes are placed in the desired location in the brain and a wire connects the lead(s) to the pulse generator implanted in the patient's chest [2]. Every four to six months, patients who have undergone the DBS surgery will come in for programming appointments to have the settings on their DBS system evaluated, and if needed, adjusted. In addition to the adjustments made at the clinic, patients are also given control over certain parameters outside of the clinic, so they have the ability to change a specific setting as symptoms fluctuate throughout the day.

2. Background

Among the patients that we observed in the Neurology Clinic at the University of Maryland School of Medicine, the majority had very low health literacy levels and an extremely limited knowledge of their DBS system. Despite having patient control to adjust certain DBS parameters on a daily basis, very few patients utilized their patient control, even in cases where it could have significantly improved their symptoms. Contributing to the disuse of the patient control and the lack of patient engagement is the limited communication between patient and clinician during programming appointments. When making a programming change, the clinicians ran through a series of tests to determine if the change improved or worsened a particular symptom. The problem, however, was that patients were often unaware of what changes the clinician were making and their desired effect. So while a clinician might see a symptom improvement after a programming change, the patient might not immediately feel the intended effect of that change. This then places patients in a passive role as they are forced to accept the advice of the clinician, which causes the patient to become disengaged. Eijk et al describe the importance of having a patient-centered approach for PD care, which includes ensuring that patients guide all clinical decisions

[3]. In the case of DBS programming this is not occurring, which is the reason we are developing technology with the goal that it will validate the patient's felt experience and increase communication between patient and clinician.

2. Methods

My research focused on developing technology that could be used to more effectively evaluate PD patient's symptoms during DBS programming appointments. The goal is to facilitate communication between the clinician and patient about the DBS changes made and the effect that these changes have on patients' symptoms. To accomplish this, we are working to replicate the tests used in the clinic to evaluate PD symptoms. The most frequently used test is having patients open and close their hands, so this was the starting point for the research. Opening and closing the hand helps the clinician evaluate speed and determine if the hand becomes fatigued quickly.

2.1 Creating the Technology

The Leap Motion sensor was the basis for replicating the open and close hand test. The Leap Motion SDK has several methods used for skeletal tracking, including a method called `grabStrength()`, which returns a value in the range of 0 to 1, with zero signifying that the hand is fully open and one indicating that the hand is fully closed. Figure 1 shows the Leap Motion Visualizer and the skeletal tracking. I developed a Graphical User Interface (GUI) using Eclipse, so the user can start collecting data when the patient begins the test and stop data collection when the test is finished. The GUI includes a place to enter a Patient ID and a button to indicate whether the test is pre or post any programming changes. In addition to these functions, the GUI includes a button to manually count the number of times a patient closes his or her hand. This functionality was added so that we can validate the data that the Leap Motion sensor collects. For the duration of the test the program outputs a value in the range of 0 to 1 approximately every ten milliseconds, so we are able to consistently track the hand. All of this data is written to a CSV file to be stored.

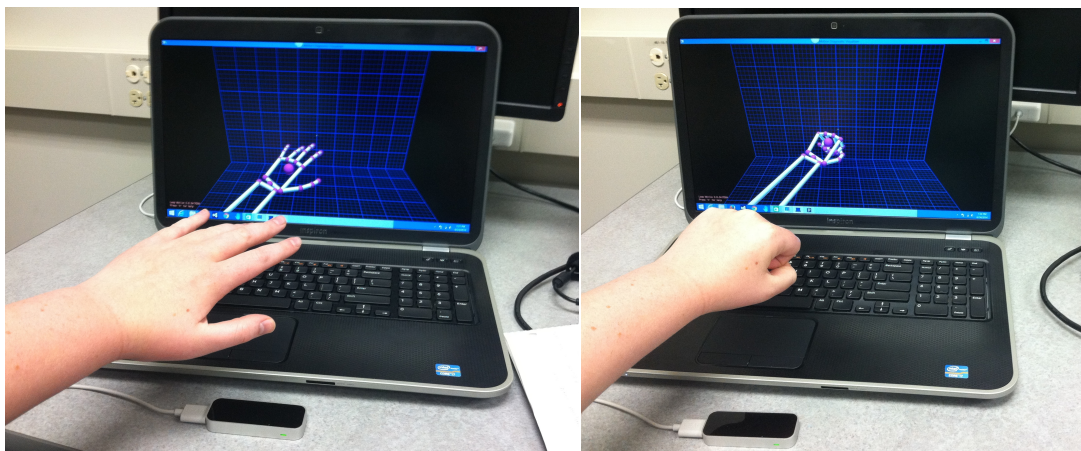


Figure 1: Hand Open/Hand Closed

2.2 Developing the Visualizations

Visualizing all of the data that Leap Motion sensor collects proved to be the most difficult aspect of this study. We currently have a few different visualizations that we will use as a starting point before we ascertain which visualizations will be most effective for the in-clinic study. The line graph (figure 2) and a graph that displays the time when the hand is closed (figure 3) are shown below. The purpose of Figure 3 is to help visualize the time between each hand close to determine if fatigue is occurring quickly, which can be a symptom of PD. The problem with our current visualizations is that the majority of people have difficulty understanding graphs and numerical information [1]. Therefore, these visualizations will need to be modified to make them easier to understand for PD patients.

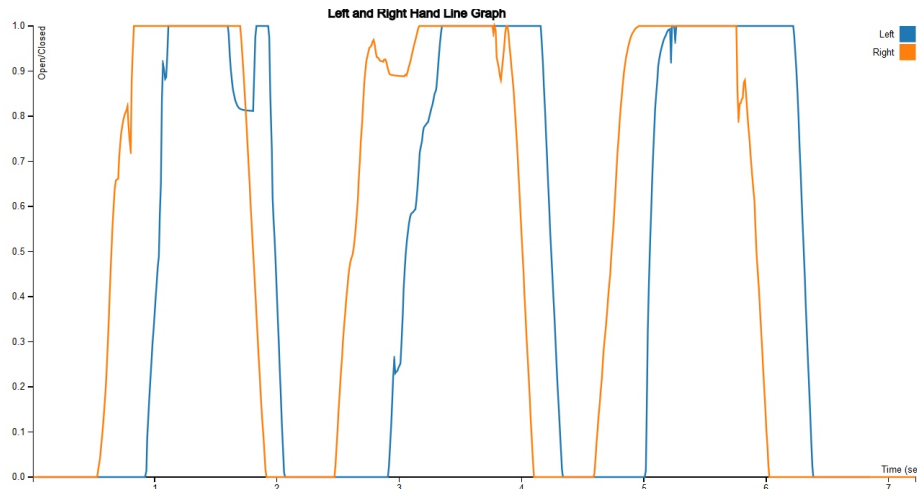


Figure 2: Line Graph Visualization

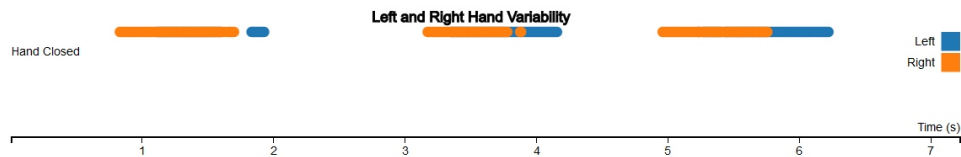


Figure 3: Variability Graph

3. Conclusion

We successfully developed a digitized hand assessment to assess rigidity and slow movement in Parkinson's patients. This technology is designed to aid clinicians in determining the efficacy of programming changes and to help validate the patient's felt experience during programming appointments. There are still improvements to be made in terms of visualizing this information in an understandable manner for PD patients.

4. Future Work

The next steps to continue this project are to run studies at the University of Maryland, Baltimore County (UMBC) and at the Neurology Clinic at the University of Maryland School of Medicine. The goal of the internal study at UMBC is to improve the visualizations we currently have for the hand visualizations before beginning the in-clinic study. We will be asking members of the UMBC community to open and close their hands and then give us feedback on the visualizations that we present to them. We will also be asking the volunteers to design their own simple visualization, which will hopefully lead to creative solutions that we can implement. For the in-clinic study at the University of Maryland School of Medicine, we are hoping to gather data about whether patients can understand our visualizations, determine whether the technology actually aids them in understanding their DBS system and the programming changes better, and ascertain if the technology increases communication between patient and clinician.

In addition, there are other tests frequently used in the clinic, such as toe tapping, pinching the thumb and forefinger together, and speech analysis, which we would like to replicate using technology.

Acknowledgments

I would like to thank my mentor, Dr. Helena Mentis, Ph.D. student Rita Shewbridge, and many other faculty members and students at UMBC for their support and guidance throughout the summer.

I would also like to thank Professor John Magee at Clark University for his encouragement to apply to the DREU summer program.

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