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An Instrumented Data Glove for Quantifying Movement Disorders

A common presenting symptom of Parkinson's disease is a tremor in one or both hands. Treatment for tremor currently requires appointments with a physician and tend to only offer a qualitative evaluation of symptoms. Quantitative systems have been developed, but they are restricted to controlled environments and are impractical for real world deployment. The flexi-sensor glove is an inexpensive alternative designed for patients to track their hand kinematics in the comfort of their homes.

The objectives for this research is to examine the performance of the flexi-sensor glove by comparing it to a currently marketed system, the CyberGlove, and to test its functioning in an uncontrolled environment. A comprehensive protocol has been developed in order to provide a thorough evaluation. It is composed of four phases – testing against the CyberGlove, supervised object grasps, supervised object manipulations, and monitoring in an unsupervised environment. In the first phase, test subjects wear both gloves and undergo a series of identical tasks. The gloves are calibrated by measuring both gloves at a set of known joint angles and compared by having participants grasp a set of objects with each glove. The second and third phases consist of training the system to identify grasped objects and performing manipulations with those same objects. In the last phase accuracy is tested in unsupervised tasks. Data is gathered from the flexi-sensor glove in an unsupervised, unpredictable environment that includes activities to be performed unmonitored in order to resemble a real-world environment. A LabVIEW program is used to record the metacarpophalangeal and interphalangeal joint angles for all five fingers throughout the testing session. Testing has begun and as of February 14, 2020, six subjects have completed the testing protocol, with the goal being a total of ten. The next step is to analyze the data in order to provide a complete evaluation of the flexi-glove's performance.

This project has the potential to be an asset for patients and doctors by creating a low-cost, quantitative means for measuring Parkinson's symptoms and eliminate the need for frequent appointments. By streamlining the process of symptom analysis and providing precise data, the flexi-sensor glove can help doctors improve condition management and create better patient outcomes.

An Instrumented Data Glove for Quantifying Movement Disorders

Zamin Akmal[1]; Marty Burns[2]; Ramana Vinjamuri, PhD[1,2]
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Abstract

Tremor in one or both hands is a common symptom of Parkinson's disease. Treatment for tremor currently requires appointments that tend to only offer a qualitative evaluation of symptoms. Quantitative systems exist, but are restricted to controlled environments. The Flexi-Sensor glove is an inexpensive alternative designed for patients to track their hand kinematics in the comfort of their homes.

Introduction

Parkinson's disease is the second most common neurodegenerative disorder [1]. A combination of slowed movement with poor motor control leads to a progressive loss of ability to complete simple hand movement tasks [2]. Traditionally, these symptoms have been evaluated qualitatively. While alternative systems have been developed to quantify symptoms, but they remain largely confined to a laboratory due to bulky equipment [3].

Recent research has been driven towards the development of portable measurement systems. In our lab, QAPD (Quantitative Assessment tool for Parkinson's Disease) and the flexi-sensor glove have been developed to expand on this goal. QAPD includes the use of the CyberGlove data gloves and a MATLAB user interface [4]. The Flexi-Sensor glove is an inexpensive, 3-D printed alternative that can measure the flexion and extension in the metacarpophalangeal (MCP) and proximal interphalangeal (PIP) joints of the first four fingers, and the MCP and interphalangeal (IP) joints of the thumb. This can provide quantitative data measurement that is as accurate or even more so than the current market standard.

Methods and Materials

The objectives for this research is to examine the performance of the flexi-sensor glove by comparing it to a currently marketed system, the CyberGlove, and to test its functioning in an uncontrolled environment. A comprehensive protocol has been developed in order to provide a thorough evaluation. It is composed of four phases:

CyberGlove and Flexi-Sensor Glove:
1. Testing Against the CyberGlove

Flexi-Sensor Glove only:
1. Supervised Object Grasps
2. Supervised Object Manipulations
3. Unsupervised Environment

Figure 1. Flexi-Sesnsor Glove (Left) and CyberGLove (RIght)

A LabVIEW program was used to record the metacarpophalangeal and interphalangeal joint flexion and extension for all five fingers throughout the testing session. During phases two, three, and four, test subjects also wore an RFID scanning glove on their hand in order to identify and label the grasped objects. Testing was conducted under an IRB approved protocol with a total of ten healthy subjects.

Contact Information

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References

[1] Jankovic J. Parkinson's disease: clinical features and diagnosis. Journal of Neurology, Neurosurgery & Psychiatry 2008;79:368-376.

[2] Lonneke ML de Lau, Monique MB Breteler, Epidemiology of Parkinson's disease, The Lancet Neurology, Volume 5, Issue 6, 2006, Pages 525-535

[3] O'Suilleabhain, P. E. and Dewey, R. B. (2001), Validation for tremor quantification of an electromagnetic tracking device. Movement Disorders., 16: 265-271.

[4] V. Patel, M. Burns, M. Pourfar, A. Mogilner, D. Kondziolka and R. Vinjamuri, "QAPD: An integrated system to quantify symptoms of Parkinson's disease," 2016 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Orlando, FL, 2016, pp. 1822-1825.

Slide 1

1 Hey Zamin, this copy is just to show the layout I was hinting at in my other comments.
Marty Burns, 3/17/2020

1 This does look much nicer, thanks for the feedback!
Zamin Akmal, 3/17/2020

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Results

For the first part of the experimen, data was recorded for both the CyberGlove and Flexi-Sensor Glove as test subjects performed controlled tasks. Test subjects would start flat on the table, pick up an object, place it down, and return to the start position, providing clear structured data. Figure 2 shows of one of these tasks, with a CD being the object.

The final part of the experiment gave test subjects free reign and a choice of objects to interact with such as a rubix cube, nuts and bolts, and microsoft paint, providing an unstructured stream of data as shown in Figure 3

Figure 2. CyberGlove and Flexi-Sensor Glove - Controlled CD Grasp

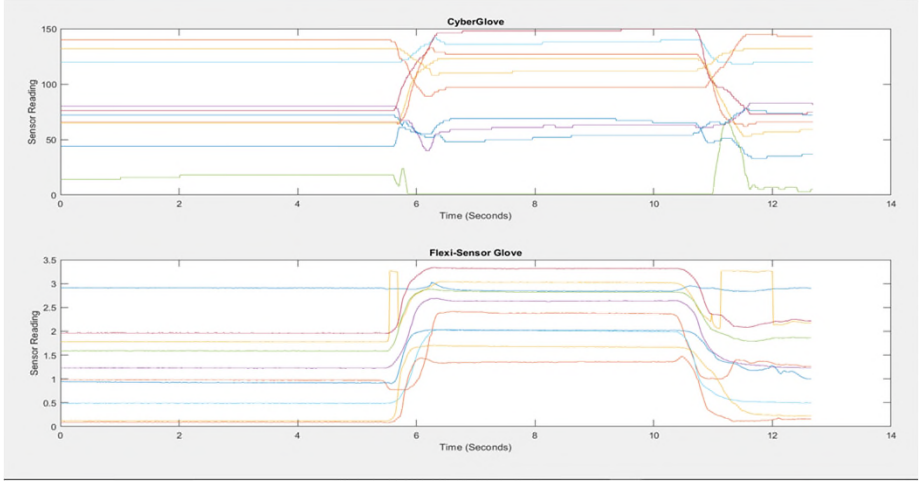
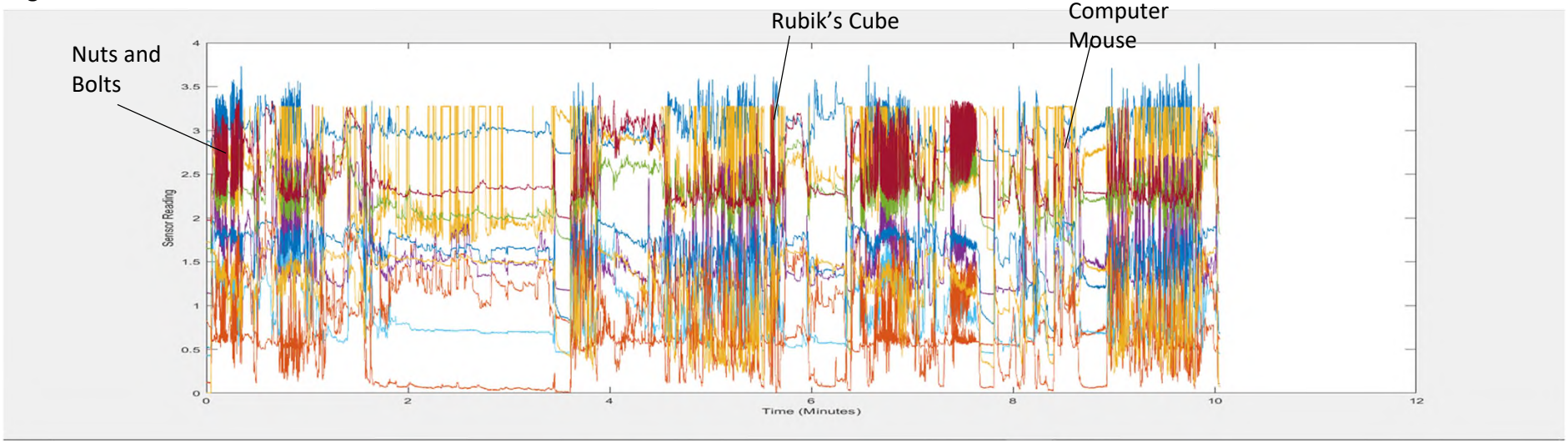


Figure 3. Flexi-Sensor Glove - Uncontrolled Environment



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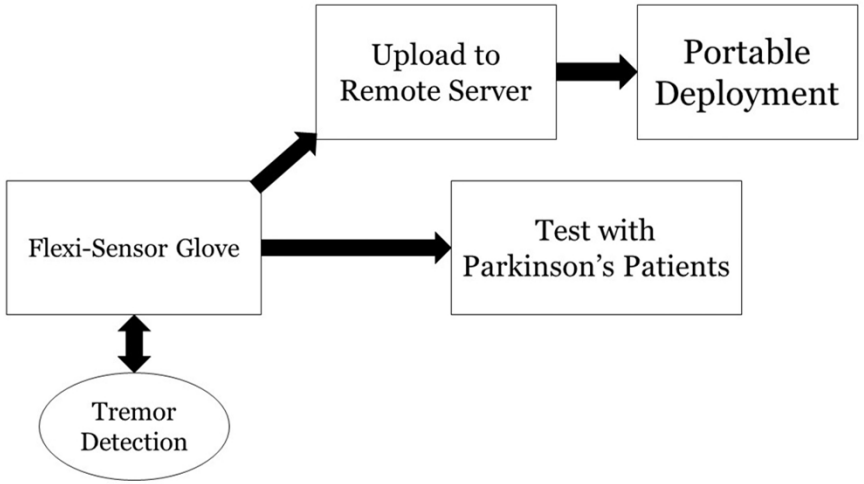
Discussion

Based on the gathered data, the Flexi-Sensor glove has shown to be capable of quantifying hand kinematics at a level comparable to the CyberGlove, while being far less expensive and much easier to produce. The flexi-sensor glove is able to measure precise angles, and capture a variety of grasp types. The design also proved to be robust and portable, so that patients would be able to take and use the device inside their homes. The next steps for this project is to include continued training with the device to to detect artificially inserted tremor, modifiying the glove to upload data to a remote server, and testing the flexi-sensor glove with Parkinson's patients.



Conclusion

The development and testing of the Flexi-Sensor glove has validated the design as a means to quantify hand kinematics with accuracy comprable to the market standard with a low-cost, flexible design. By streamlining the process of symptom analysis and providing precise data, the Flexi-Sensor glove can help doctors improve condition management and create better patient outcomes.

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