Gesture-controlled VR for applications in neurodevelopmental therapy

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Introduction

According to a UN report [1], 1 in 6 people in the world suffer from a neurological disorder. Neurological disorders affect the brain, spine, and nerves. Many disorders, such as Multiple Sclerosis, Parkinson's, stroke, and cerebral palsy include neurological impairments that affect muscle action and motor skills. One disorder in particular, cerebral palsy, affects children specifically.

A very common impairment of children with cerebral palsy is upper limb dysfunction. Some manifestations of this include issues with grasp and release, thumb articulation, general weakness of the affected limb, and poor wrist flexion [2]. This can greatly impact quality of life by limiting the ability to do basic tasks at home and school such as buttoning clothing, tying shoes, and writing.

Because a child's brain is still developing, early treatment through integrated therapy methods are often successful so that abnormal physical patterns are not established. *Neurodevelopmental therapy* (NDT) is one such therapy approach that focuses on inhibiting abnormal movement [3].

Although successful treatment options exist, many cases of cerebral palsy go untreated, leaving a child with limited abilities for life. Treatment is both long-term and costly. Many families of children with cerebral palsy may not live near adequate health delivery services. And with the rising healthcare costs, the financial burden for such services may be impossible to incur.

However, home-based and cost effective therapy options are being made possible by advancements in *virtual reality* (VR). Because children have a heightened emotional state and can reach fatigue faster, it can be difficult for them to stay motivated with conventional therapies. But VR systems can create a fun and encouraging environment. Research is showing that such systems have "better intervention effects than clinic-based interventions" [4]. They also do not limit care-giving families on location and financial burden.

Application of VR

Interacting with the VR world is an important aspect of these systems. *Hand gesture control,* is one type of interaction method that is proving to have practical application in these home-based therapy prototypes. With this type of interaction, a system can read hand gestures with no physical contact. Gestures are interpreted by the system to provide feedback in the VR world.

One such gesture control device, the Myo armband (*Figure 1*) is having much success in aiding VR systems. The Myo armband is worn on an individual's forearm. Eight *electromyography* (EMG) sensors read data from forearm muscles in order to recognize a hand gesture such as fist, wave left, wave right, and spread fingers. It also has an accelerometer, which measures acceleration, and a gyroscope, which measures position and rotation. When used with a VR system as the user's way of interaction, it can be both fun and challenging.

Figure 1. Thalmic Lab's Myo armband.

Researchers are using this armband to develop VR programs for children with cerebral palsy because it encourages proper articulation of the hand and forearm muscles in order to produce a gesture. Munroe, et al. designed an augmented reality game using the Myo for this very application. In the game, the participant is fitted with the Myo armband and *augmented reality* (AR) glasses. The participant must perform a specific hand gesture to interact with the game seen through the AR glasses (*Figure 2*). There are other researchers developing similar systems, but no data is available as of yet.

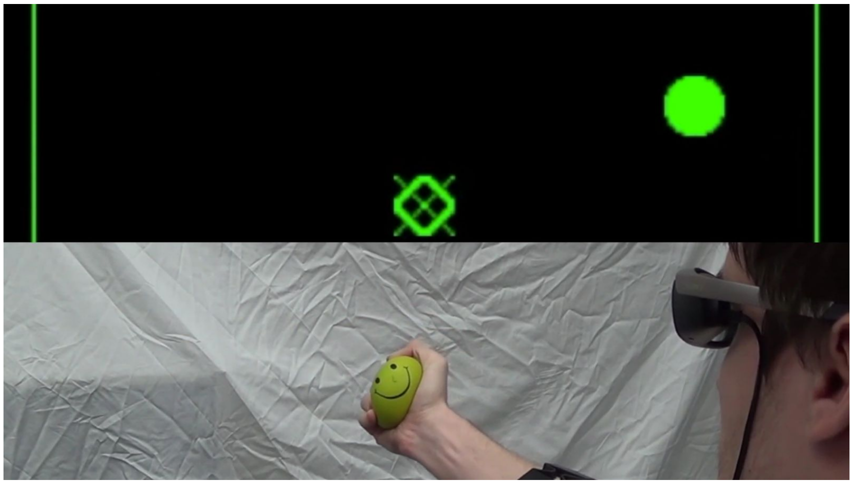

Figure 2. User wearing Myo to interact with AR game.

Prototype design

I am developing a similar gesture control prototype, also using the Myo armband. In my prototype, a user wearing the Myo, must perform three exact gestures in order to interact with a virtual world. The virtual world will be presented in a Unity-built game on iPhone as seen through Google Cardboard glasses. This is both cost efficient and consumer-ready.

Hardware used is as follows:

- iPhone 5
- MacBook Pro (Retina, 15-inch)
- Myo Gesture Control Armband
- Myo Bluetooth Adapter   Google Minkanak Cardboard V2

Software used is as follows:

- Mac OSX 10.11.6
- Myo SDK OSX 0.9.0
- Myo iOS SDK 0.5.2
- Myo Data Capture OSX and/or Myo Diagnostics
- iOS 10.1.1
- Xcode 8.1
- Unity 5.4.0f3 Personal Edition

In the game, users are immersed in a desert scene of cactuses and rocks (*Figure 3*). Walking movement is static, but the view around the user position can be changed by a left and right arm extension on the Myo-wearing arm. To encourage this, there are two enemy spawn points, one in front of the default user view and one directly behind. Enemies can be destroyed with the user's choice of two weapons. Changing from the default weapon to the alternated weapon requires the "wave in" gesture. Changing back, requires the "wave out" gesture. To fire a weapon, the "fist" gesture is performed and held for the duration of the required weapon activation.

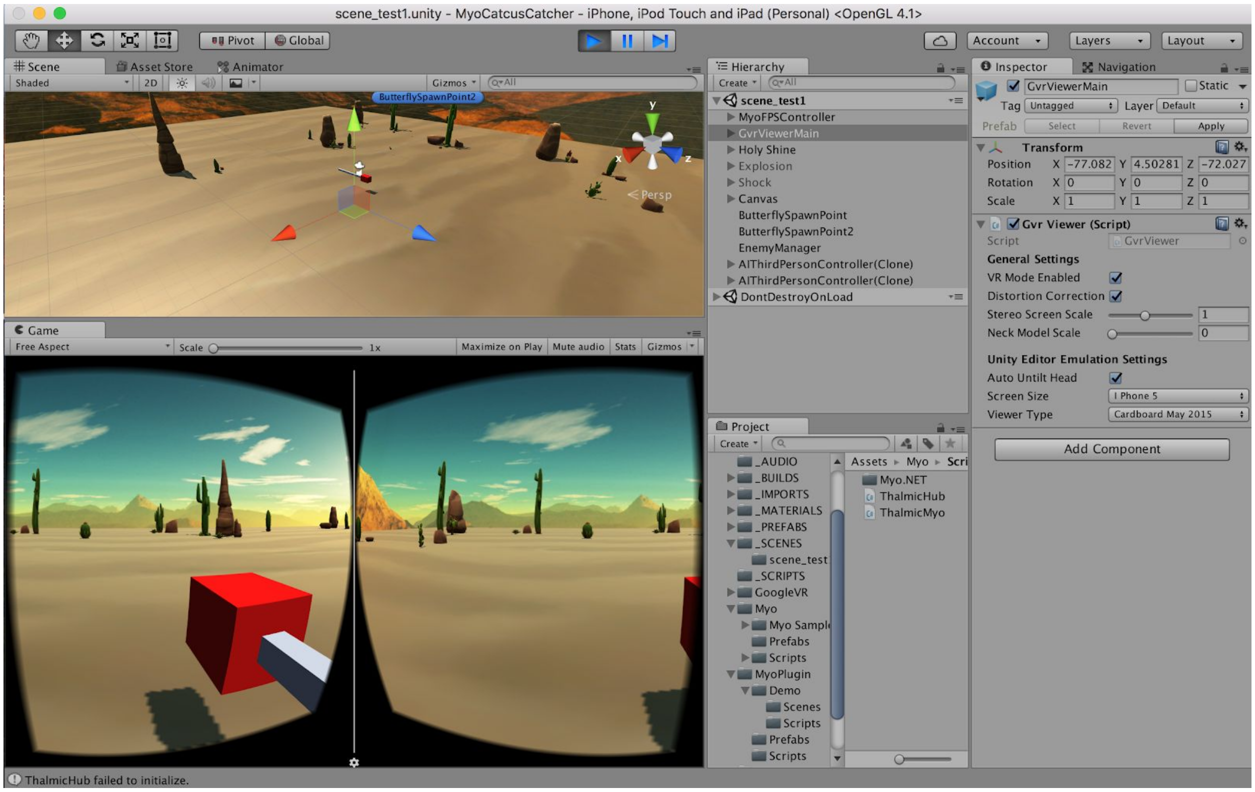

Figure 3: Unity-built game, "Cactus Catcher." Default weapon and user view state.

Gestures must be deliberate in order to match a Myo classifier in the Unity code. The classifier is mapped to an action on the appropriate game object: fire weapon, change weapon, change view. If the muscle contractions are not strong enough, the gesture action will not be initiated. There is currently no scoring and no enemy or player health. The game has no plot objective and is simply intended as a test of the gesture control abilities of the user.

Final outcome

Unfortunately, I was unable to build my game from Unity to iPhone using XCode. When the Myo armband was released two years ago, they provided code kits (SDK) for OSX and iOS. These can be imported and changed through code for specific use in Unity. However, I suspect that code depreciations are causing issues with the Xcode simulation for iPhone. I tried various versions of different SDK's, frameworks, and libraries, both in Unity and in Xcode. But was not able to troubleshoot the errors to produce a successful iPhone build.

However, testing of the game on Mac Book Pro proved to be just as advantageous as having a VR experience. I tested on a variety of different users: different muscle tones, different hand dominance, and different ages. Game play was performed in a home environment (*Figure 4*). In order to monitor performance of gestures, I ran and monitored Myo Diagnostic during game play, which reads IMU and EMG signals from the user (*Figure 5*). Users were given a break after EMG signals started to decrease as this was seen as user fatigue.

EMG data can be helpful to doctors monitoring patient progress in an home-based therapy system. It allows doctors to be remote, but understand through data if their patient is retaining benefits from the therapy sessions.

Figure 4: User performing "fist" gesture

In order to compensate for not having participants with cerebral palsy, I instead used participants that were left-hand dominant, and placed the Myo on the right arm. Because hand dominance is learned in early motor development, I thought that using the non-dominant hand may present some slight but similar struggles to common upper limb impairment such as general weakness. These users experienced initial difficulty in understanding and articulating gestures strong enough to produce an interaction. But as time in the game progressed, so did the strength of their gestures as seen in their EMG data.

Figure 5: Myo Diagnostic readings during game play.

Relationship to course content

The course content introduced me to gesture control. Having not grown up with video games, I consider myself more removed from gaming technology than my peers who have a progressing and avid love for it. Although game-based VR experiences serve an entertainment purpose, the course content exposed me to think about different applications of game-based gesture control. I do believe that we have a social responsibility to apply these types of technology to current issues, especially in the medical community.

In doing my research, I was happy to see that other students had similar applications to mine. The guest lecturers helped me realize that even though my development has numerous flaws, by better understanding the application, I may be able to asses what is absolute necessary in another attempt. Human-computer interaction targets the user’s learning and understanding of the system. Only by understanding the user and the system’s application to the user can we begin to understand our build.

Summary

Having never worked in Unity or Xcode before, I should have started small with my game. Less time spent on game design and more time spent on getting a solid simulation for iPhone may have accomplished the VR experience I was looking for. Reading existing documentation about Myo SDK limitations prior to build would have helped me understand the iOS challenges that other developers have faced. I was only able to find a few successful builds using Myo and iOS, but they provided no documentation.

Additionally, Myo has a size restriction on the diameter of the sensor band. It only provides a tight fight on children ages 12 and up. Ideally, my application would be used for children younger than this. After contacting the developers at Myo, they informed me there is no stable way to retrofit the armband to a user with a smaller forearm. At 12 years old, most children with cerebral palsy have already formed strong patterns in abnormal hand gestures. A home-based prototype such as mine may be more frustrating than it would be fun and encouraging.

Furthermore, some level of frustration was reached by users when their gestures were producing no game interaction. Although EMG signals were strong, gestures were not matching classifiers in the game for unknown reasons. It seems proper gesturing worked about 80% of the time. This is something I would like to further investigate.

Through this project, I was able to form a relationship with a local VR company, VR for Kids. Their developers have reached out to me to provide assistance in my continuing efforts to produce a successful build for iPhone. Their current product uses an Oculus Rift development kit, and they must tirelessly fundraise to extend their product reach. They like the idea of having a smaller and more cost-effective VR experience to reach children with disabilities.

References

[1] Nearly 1 in 6 of world's population suffer from neurological disorders – UN report. United Nations. Published February 27, 2007. Accessed November 28, 2016.
http://www.un.org/apps/news/story.asp?newsid=21689&cr=neurological#.WENY3ZKDxPs

[2] Bhardwaj P, Sabapathy SR. (September 2011). Assessment of the hand in cerebral palsy. *Indian Journal of Plastic Surgery*. 2011;44(2):348-356. doi:http://doi.org/10.4103/0970-0358.85356.

[3] Tatjana D. Veličković, Milivoj V. Perat. (2004). Basic Principles of Neurodevelopmental Treatment. *Medcina*. Vol. 41, No. 1.

[4] Chen Y.-P., Lee S.-Y., Howard A. M. (2014) Effect of virtual reality on upper extremity function in children with cerebral palsy: a meta-analysis. *Pediatric Physical Therapy*. 2014;26(3):289–300. doi: http://doi.org/10.1097/pep.0000000000000046.

[4] Chen, Y., Garcia-Vergara, S., & Howard, A. M. (2015). Effect of a Home-Based Virtual Reality Intervention for Children with Cerebral Palsy Using Super Pop VR Evaluation Metrics: A Feasibility Study. *Rehabilitation Research and Practice*, *2015*, 812348. http://doi.org/10.1155/2015/812348

[5] Christopher Munroe, Yuanliang Meng, Holly Yanco, and Momotaz Begum. 2016. Augmented Reality Eyeglasses for Promoting Home-Based Rehabilitation for Children with Cerebral Palsy. In *The Eleventh ACM/IEEE International Conference on Human Robot Interaction* (HRI '16). IEEE Press, Piscataway, NJ, USA, 565-565.