UnlimitedHand: Input and Output Hand Gestures with Less Calibration Time

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ABSTRACT

Numerous devices that either track hand gestures or provide haptic feedback have been developed with the aim of manipulating objects within Virtual Reality(VR) and Augmented Reality(AR) environments. However, these devices implement lengthy calibration processes to ease out individual differences.

In this research, a wearable device that simultaneously recognizes hand gestures and outputs haptic feedback: UnlimitedHand is suggested. Photo-reflectors are placed over specific muscle groups on the forearm to read in hand gestures. For output, electrodes are placed over the same muscles to control the user's hand movements. Both sensors and electrodes target main muscle groups responsible for moving the hand. Since the positions of these muscle groups are common between humans, UnlimitedHand is able to reduce the time spent on performing calibration.

Author Keywords

Haptic sensation; Photo-reflector array; EMS(Electric Muscle Stimulation); FES(Functional Electric Stimulation); Electric Stimulation; Hand Gesture; AR(Augmented Reality); VR(Virtual Reality)

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI):

INTRODUCTION

Sensations produced by the human body are formed through various closed loop systems that require both an input and an output. The agenda for VR and AR research have been to simultaneously provide the two, in order to simulate sensations recognizable by the human sensory system.

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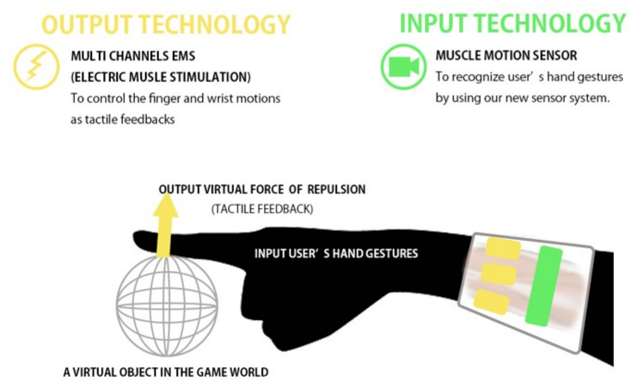

Figure 1. UnlimitedHand: Input and Output System

Pursuits have largely focused on the visual and auditory faculties. However, we hope to build upon a strand of research focused on the hand, an aspect of the human body that allows for rich haptic experiences[1]. Wearable systems tracking hand movements require intricate sensing mechanisms that resolve physical individual differences. Lengthy calibration processes are often implemented to ensure consistency amongst users.

RELATED WORK

Various calibration processes have been applied by systems that input and output hand gestures.

Lopes *et. al* suggested a way to perceive impact in VR with EMS[2]. The EMS calibration procedure took about 4 minutes, during which contraction to the biceps was repeated ten times. Because this system has no sensors, users have to check the relation between the EMS and hand motions by themselves.

PossessedHand is a EMS stimulation kit that uses multiple electrodes for calibration[3]. PossessedHand uses 14 channel electrodes to decrease calibration time. By applying EMS to each electrode, PossessedHand eventually identifies the points that delivers haptic feedback. Because it can be worn at any angle, the system does not take into account of the user's muscle size. The device had to match electrodes to corresponding muscle groups. The EMS calibration procedure took more than 5 minutes.

Myo, a gesture recognition armband, has 8ch electrodes that detect muscle motions via EMG to obtain finger movements[4]. Because it can be worn at any angle, this system too does not take a user's muscle size into account. The device had to match electrodes to corresponding muscle groups. The calibration procedure took more than 4 minutes.

The three systems mentioned have in common that they are worn around the user's forearm to either sense or actuate on targeted muscles responsible for creating hand gestures. Because of this they share the same obstacle of having to reconfigure hardware or software settings when put to use with forearms of differing sizes.

With UnlimitedHand, we contribute by providing a solution that will encourage further research done on haptic feedback by rendering FES based experiments less cumbersome to execute and replicate, while retaining versatile sensing and actuation functionalities.

SYSTEM CONFIGURATION

In this report, a wearable device named "UnlimitedHand" that allows users to interact with virtual dimensions through their hands is described. The device simultaneously tracks hand movements while passing electrical current onto the user's forearm muscles to generate haptic feedback. When worn, both sensors and actuators rest naturally on targeted main muscles groups of the forearm. They are responsible for triggering hand movements. Since the positions of main muscle groups are common amongst humans, the time needed for calibration is reduced.

Input Interface

To facilitate the making of various hand gestures, muscles and tendons located at the forearm undergoes a series of minute flexes. By tracking these displacements with an 8 channel photo-reflector array, the device is able to deduce wrist and finger movements of the wearer.

Output Interface

The 8 channel electrodes built into the device functions to produce haptic feedback(kinesthetic) through Electric Muscle Stimulation(EMS). This is done by passing current between electrodes positioned on the wearer's forearm. As a result, targeted sets of muscles contract to trigger involuntary movement of the hand.

Tackling Individual Differences

Human forearms naturally come in different sizes and builds. UnlimitedHand's arrangement of sensors and electrodes makes it easier to target stimulation points.

Both electrodes and photo-reflectors are arranged on a V-shaped resin sheet. Electrodes are distributed into three portions on the device, left side, right side and the center. Rectangular electrodes are inclined at 32 degrees to the circumferential direction of the forearm. With this design, whenever the device is worn (by wrapping the left and right wings around the circumference of the forearm), electrodes naturally settle on targeted muscle groups.

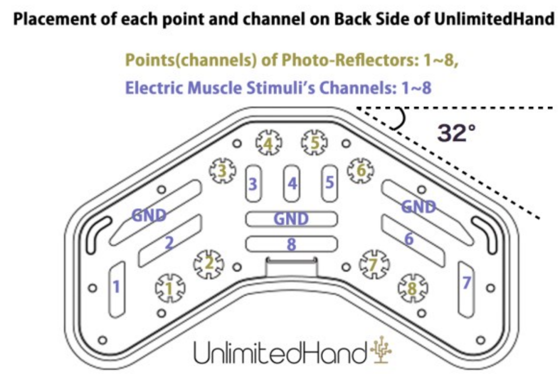

Figure 2. Placement of photo-reflectors and electrodes

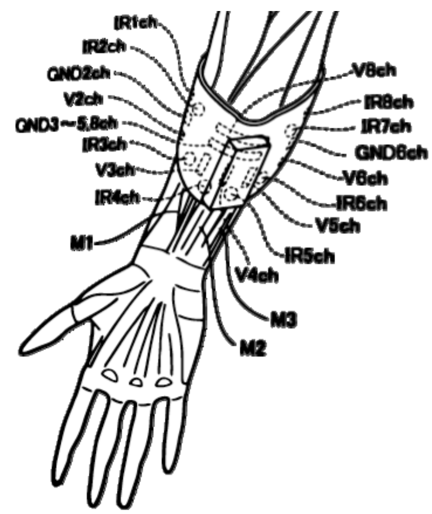

Figure 3. Sensors(IR) and Electrodes(V and GND) situated over main muscle groups(M)

CALIBRATION PROCESS

We prepared tests that measured the time taken for UnlimitedHand to calibrate itself to a user's forearm. In our test we specified 4 types of hand gestures to be tracked. It took 10 seconds to complete the calibration, during which sensor and stimulation levels are read. The input system parses the data to identify gestures created by the user. During calibration, the output system applies stimulation to the user in 6 ascending levels to find optimum stimulation levels. The output system then controls the 4 type gestures. We worked out averages and standard deviations from sensor values to deduce the movement of individual muscles.

FUTURE WORK

The goal of this research project is to allow for dexterous interactions hand gestures to be made remotely with less calibration. With the combination of muscle motion sensors and EMS, UnlimitedHand will control the joint angles. Accuracy levels will be measured for this research.

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REFERENCES
1. Ramsamy, P., Haffegee, A., Jamieson, R., and Alexandrov, V. Using haptics to improve immersion in virtual environments. Proc. ICCS'06, 603–609.
2. Lopes, P., Ion, A., & Baudisch, P. (2015, November). Impacto: Simulating Physical Impact by Combining Tactile Stimulation with Electrical Muscle Stimulation. In *Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology* (pp. 11-19). ACM.
3. Tamaki, E., Miyaki, T., and Rekimoto, J. PossessedHand. In Proceedings of the 2011 annual conference on Human factors in computing systems - CHI ’11, ACM Press (New York, New York, USA, May 2011), 543.
4. Tamaki, E., Miyaki, T., and Rekimoto, J. PossessedHand. In Proceedings of the 2011 annual conference on Human factors in computing systems - CHI ’11, ACM Press (New York, New York, USA, May 2011), 543.
5. Myo - Gesture control armband by Thalmic Labs. Retrieved January 13, 2016 from https://www.myo.com