EMG-Based Keyboard Controller for Video Games

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Abstract – **For people with limited fine motor control–such as those with Parkinson's Disease–tasks which require them to engage with a computer keyboard are often onerous, and potentially even impossible if the condition is severe enough. Beyond required daily tasks, those with limited fine motor control are also unable to enjoy fun tasks such as video games. This project entails a video game system which utilizes bicep and calf muscle contraction to play a video game, eliminating the need for the computer keyboard. The resulting system allowed the user to play their desired video game with minimal lag and a high degree of accuracy.**

Index Terms - **Parkinson's Disease, electromyography, video game**

I. INTRODUCTION

In this lab, we created a system where users control keys on the keyboard to play simple games using their limbs. For people struggling with fine motor skills, potentially due to diseases such as Parkinson's, it can be tough to use the keyboard in daily life. This means that simple pleasures like computer games can become extremely difficult for them to use[1].

We designed a system which allows users to flex either their bicep or calf muscles to control WASD keys to play video games. This system uses two electrodes on each limb to control the game. Although this system is intended to play games using the WASD keys, the controls can be easily altered to apply to control any other keys on the keyboard.

To accomplish our goal, we needed to obtain physiological signals. To obtain the signals, we used electrodes set up for an electromyography (EMG) on each of the four limbs on the user. One electrode was placed on the knee to serve as a grounding electrode. To condition the signal, we set up a conditioning circuit to filter and amplify the signal. The hardware consisted of filters and differential amplifiers for each of the limbs. The output of the filter is then fed into an Arduino which leads to the computer. In the software portion, the Arduino readings are acquired and quickly analyzed in MATLAB to press the key corresponding to the limb that was activated in the sample time.

II. EXPERIMENTAL SETUP

The whole system is divided into two major parts, namely hardware and software, to achieve our goal.

A. Hardware/Circuit

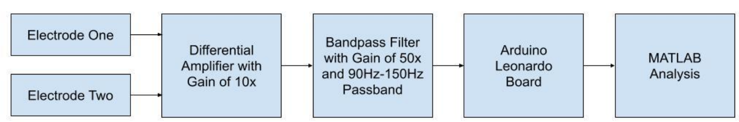

Fig. 1 Hardware Block Diagram

The hardware part consists of electrodes, which are used to acquire EMG signals, and signal conditioning circuits, which are used to process the original EMG signals. As shown in Fig. 1, the first step is using electrodes to acquire EMG signals from each limb. Two electrodes are attached to each bicep and calf muscle as one electrode pair, and one additional electrode is attached to the knee to serve as the physiological ground. After attaching electrodes, signals from each of the four electrode pairs are then fed into our signal conditioning circuits respectively.

Each of the signal conditioning circuits consists of one differential amplifier stage with gain of 10 and one bandpass filter stage with gain of 50 and cutoff frequencies of 90 Hz and 150 Hz. The differential amplifier stage is achieved by using AD620, and the bandpass filter stage is achieved by using LM741 together with resistors and capacitors whose values are precalculated. We found that the frequency range of EMG signals lies between 50 Hz to 150 Hz[2], but we set the high-pass cutoff frequency as 90 Hz, so that we can eliminate noise around 60 Hz, giving us a cleaner signal. The schematic of the two-stage signal conditioning circuit is shown below in Fig 2, and the circuit is repeated four times, one for each limb.

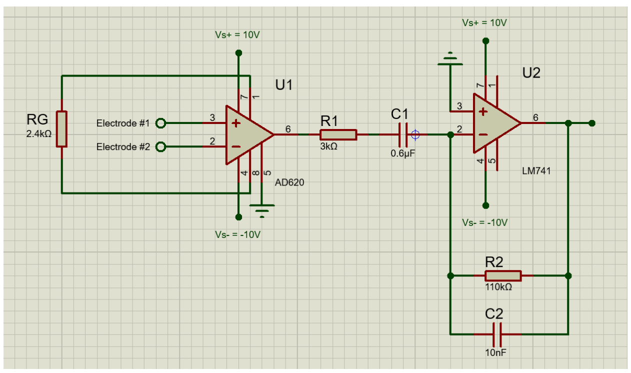

Fig. 2 Circuit Schematic

After passing the signal conditioning circuits, the processed EMG signals are then fed into the Arduino Leonardo board and prepared for MATLAB analysis.

B. Software

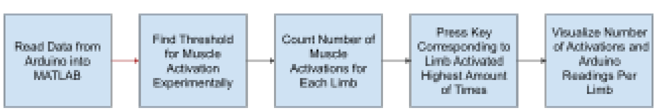

Fig. 3 Software Block Diagram

As seen in Figure 3, the first step was to read the data from the Arduino Leonardo into a MATLAB matrix. We took 10 samples per limb and used this as the dataset for each processing interval. We found the thresholds experimentally to be 0.05. This threshold is unitless as it is a reading from the Arduino. Choosing this threshold was a critical step in this project, as it should be high enough so that noise would not trigger key presses, but also low enough so that no data is missed. We found the most frequently activated limb in a particular sample timeframe and used that limb to press the corresponding keys on the keyboard. For the left arm, right arm, left leg, and right leg, the keys were W, S, A, and D respectively. At the end of this cycle, the number of activations per limb is reported in the Command Window of MATLAB and plots are made for the users to see the data in case they need to make adjustments to the thresholds in the future. The process is in an infinite loop so the users can use it for as long as they need.

For the command to trigger the key in MATLAB, we had to import the external *java.awt.Robot* library. From this library we were able to access commands such as *robot.keyPress(java.awt.event.KeyEvent.VK_A)* and *robot.keyRelease(java.awt.event.KeyEvent.VK_A)* which press and release the 'A' key respectively using subroutines.

III. RESULTS

The initial results for this project are presented in the form of MATLAB plot screenshots. Below, in Figure 4, an example of one of these screenshots is shown.

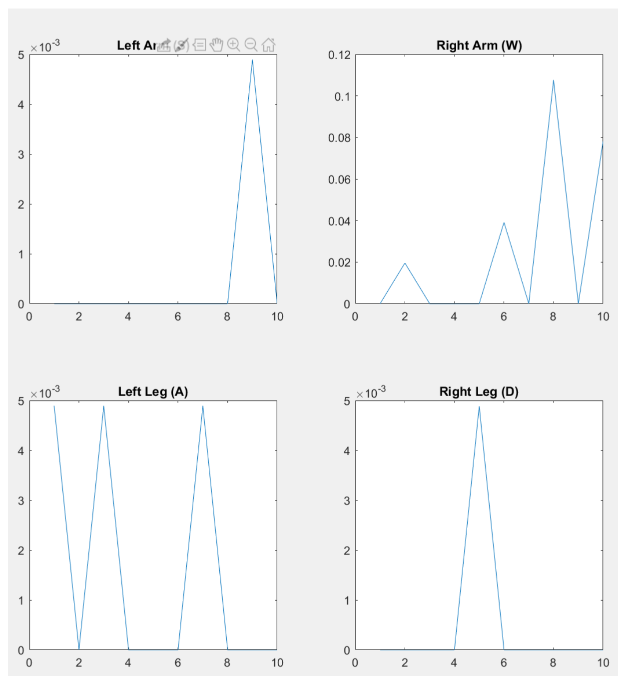

Fig. 4 MATLAB Plots of Muscle Activity (only right arm flexed)

As seen in Figure 4, the peak right arm voltage reading is about 0.11, while all of the other limbs readings are at or about zero. This validates our setup, as the limb being flexed had a much greater peak compared to the other limbs, which were at rest. Using these images, we were able to set a threshold that would ensure that only the limb being flexed was the one that was being recorded.

Once that threshold was found, we then did a test by ensuring that each limb flexed led to the correct key pressed. We did this by typing in our Matlab script, and we were able to ensure that only the certain letter that we wanted typed was being shown.

Once these tests were finished, we were able to use our system as intended and play a video game. We chose to play a snake game, in which the user controls a snake and tries to collect coins that make the snake grow. We were able to use the EMG signals to properly control the game in real time and with high accuracy.

IV. DISCUSSION AND CONCLUSION

The overall goal of this project was to develop an EMG-based gaming experience for users who have limited fine motor skills. The project utilized EMG signals from four limbs to activate keys on a computer keyboard. The user placed two electrodes on each of their bicep muscles and calf muscles, as well as another electrode on the knee to serve as a ground. The signals from each muscle were fed through a conditioning circuit to both amplify and filter them, then they were ultimately fed into MATLAB for further processing and analysis. In MATLAB, activation thresholds were determined experimentally for each muscle. Each limb corresponded to a particular key on the keyboard so that as the user contracted a particular limb, the avatar in the video game would move in the corresponding direction.

The overall system largely worked as intended. There were very few instances when the system would not detect a muscle contraction or would incorrectly detect a contraction in the wrong limb. This system also operates with minimal lag, so that the user can have a real-time gaming experience. The only goal that this system did not achieve was to create a new video game in LabVIEW. Rather than create a game, our team decided to generalize the system so that EMG signals can be used to play any keyboard-controlled video game. This allows for a wider variety of games to be played as the keys corresponding to each muscle can easily be changed.

V. APPLICATION

The main audience for this system is users with disorders such as Parkinson's Disease. Parkinson's can cause a loss of fine motor skills. With the way our program is set up, the user does not need to have fine motor skills to play a game and just needs to be able to activate the biceps and calves. The way that our program is set up allows the user to change the keys that they would like to use with the EMG, allowing them to play any game that uses four or less keys.

VI. ACKNOWLEDGEMENTS

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VII. REFERENCES

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