CHAPTER 8: CONCLUSION AND RECOMMENDATIONS

8.1. INTRODUCTION

This chapter concludes with a review of the design of a sEMG platform to create a human-machine interface (HMI) between an amputee and the Matlab®/Simulink® environment. As part of the validation process, the HMI is demonstrated by the implementation of a decoding algorithm in Simulink®. The chapter concludes with a discussion around the results and by giving recommendations for future research possibilities that can emerge from this project.

8.2. SUMMARY OF WORK DONE

An HMI was developed using surface electromyography (sEMG). It consists of a set of five electrodes in a wrist-band fitted on a patient's forearm and connects to the sEMG platform. The electrodes sense dual-channel muscle activity through the patient's skin, and is regarded as a non-invasive HMI.

The sEMG platform acts as a serial emulator (COM port) that connects the sEMG sensors to Matlab®/Simulink® environment via USB. The entire circuit is included in the sEMG platform to convert the dual-channel analog input sEMG signals into digital format. A calibration algorithm programmed into the firmware of the platform, calibrates the sensors with the push of a button, using the built-in automatic gain control (AGC).

The proportional control algorithm originates from an antagonist muscle model, followed by the proportional control model implemented in Simulink®. It has the capability of decoding dual-channel antagonist muscles' sEMG signals into position and force information intended for use for proportional controlled powered prosthesis. Although the force result has not been tested for accuracy, it serves as a measure of total muscle effort of both flexor and extensor muscle groups.

Finally, the position decoding algorithm result is sent to a PDM servo, to test the effect visual feedback has on the accuracy of performing a gesture mimic of an animation.

8.3. MOST SIGNIFICANT RESULTS

The accuracy of the decoding algorithm to decode position from sEMG, taken from a patient, is as high as 73% with visual feedback. Visual feedback plays a major role in the accuracy of human gestures. An average position offset of 140% is achieved without visual feedback, showing the effect visual feedback has on the patient's accuracy, following the animation's position. As there is an approximate linear relationship between muscle contractions, sEMG output and position, that the system proves to be controllable with visual feedback.

The developed sEMG sensing platform has a time constant of 200 ms. This is much faster than the Utah system having a time constant of 500 ms [15]. This allows the developed sEMG sensing platform to be more responsive.

A well-planned layout could improve system performance. A prototype platform was built on prototyping board to test the concept and verify the design, before a final PCB layout is done. Although both platforms have identical schematics, the SNR on the prototype platform has improved from 10:1 to the final PCB layout SNR of 50:1.

Inexpensive stainless steel electrodes show similar performance in comparison to popular Ag/AgCl electrodes, due to the high input impedance of the instrumentation amplifiers used. The use of inexpensive electrodes, and the double-sided single layer PCB layout (rather than a multi-layer PCB), limit the cost of sEMG technology.

8.4. EVALUATION OF METHOD

The functional capability of the sEMG platform and electrodes was compared with other studies, with positive results. Reliability of the system was measured through SNR. The automatic calibration of sensors eliminates human error. Usability and testability of the platform is reflected through the USB-powered PCB, with clearly marked buttons, LEDs, and connector labels.

8.5. FUTURE WORK

Studies will be carried out in the future on EMG decoding algorithms, advanced control structures and digital signal processing algorithms.

The literature suggests that an artificial feedback loop could also be implemented in prosthetics, and could be recommended for future studies. Prosthesis feedback to the patient, opposed to visual feedback, can be studied. Control theory issues can be studied, concerning the management of feedback from the closed loop of the sEMG controlled prosthesis to the natural feedback loop.

The use of multiple sensors will progress towards multiple finger control, rather than basic grip gesture sensing achieved in this study. The flexor and extensor muscles in the forearm are to control five fingers independently. If muscle sEMG signals can be isolated, multiple finger control will become a reality.

The accuracy of proportional control models depends on the combined accuracy of the proportional control model and the accuracy with which the patient follows the animation. Currently, separate evaluation of the accuracy of the position decoding algorithm has not been done. Future testing techniques can be applied to address this issue.

Not much research is done on force decoding algorithms. Further research needs to be done to exploit more possibilities.

8.7. CLOSING REMARKS

The development of the sensing platform to provide an HMI to the Matlab®/Simulink® environment and provide opportunities for testing proportional control algorithms, and research controllers for powered prosthesis. The cost of the design is low, but the performance compares to expected performance. The performance measures include SNR and frequency response.

The auto-calibration feature in the sensor allows researcher/developers with minimum knowledge about EMG to operate the sensor. The success of biomimetic devices is assessed through circumvention and acceptability. Circumvention indicates the user-friendliness of the substitute, compared to the natural human body. Acceptability is the psychological degree of approval of technology that follows after circumvention. Performance and user-friendliness will determine the success rate of the sEMG HMI method.

Marrying economics with ergonomics will result in the perfect match. Inexpensive human-machine interface between patients and the engineering environment achieved, paves the way towards new advances in prosthesis control.