Decoding wrist gesture with combinational logic for the development of a practical EMG electrode sleeve

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ABSTRACT - One of the reasons why EMG still lags as a machine input signal is because EMG is a physiological signal and differs between individuals. As a result, EMG devices also require training regardless whether it is a single user or multiple users. It is hypothesized that although the EMG signals are different among individuals, they still contain some similar traits that have potential for cross-user reusability. The characteristics of an EMG signal are studied across a sample of subjects. These signals are recorded and analyzed for similarities.

1. INTRODUCTION

An Electromyography (EMG) signal is an electrical signal that is generated when a muscle contracts. The EMG signal is a result of an electrochemical ionic exchange that takes place at the nerve-muscle junction during muscular motion. By using electronic pickups, these signals can be detected and utilized in various forms. Typical applications include motor-neuron medical analysis and more recently, gaining momentum as an input signal for computing and robotic systems.

As neural interfaces for machine input are increasingly studied, the EMG signal is an attractive alternative because EMG signals can be acquired from the skin surface. This form of EMG is known as surface EMG (sEMG) and it can be obtained via non-invasive means.

Although there are many researches on improving the acquisition and decoding of sEMG, commercial productization is still distant. The underlying reason is that sEMG is a physiological signal and variations exist among people. Even for a single subject, the sEMG recorded off the same muscle may deviate due to muscle fatigue, skin condition and also sEMG electrode placement [2]. Due to these reasons, sEMG machine input systems are not cross user applicable and even a single user requires a considerable calibration and training time [3].

2. METHODOLOGY

In order to make the sEMG system viable for everyday uses, it must be practical and user friendly. Unfortunately the sEMG system setup is complicated and the user needs anatomic knowledge of the target muscles, since precise electrode placement is critical [4-6].

The user of the sEMG system should not be burdened with clinical setup. In this research, the approach to the problem is to develop the sEMG system with minimal electrodes. In order to achieve this, fewer but significant forearm muscle were targeted, while maximizing the number of classifiable gestures.

A grid coordinate system was introduced for the lower forearm (Figure 1(a)). The target muscles were clearly mapped. For a single user, this system considerably cuts down initial setup time.

The grid system will be implemented onto a flexible material that would be constructed in the form of a wearable sleeve. This sleeve would stretch with the skin as the forearm rotates (Figure 1(b)).

(1)
algorithms are shown in Equation (1). The gestures are wrist flexion and extension, wrist adduction and abduction and hand open and close. Only major muscles close to the elbow were considered because they are large and less susceptible to shift during forearm rotation.

3. RESULTS AND DISCUSSION

A simple discrete logic relationship has been established for the wrist motion decoding. Based on Equation (1), logic circuits can be built to perform the functions. An example of the circuit to decode wrist flexion is shown in Figure 2. This is however, a simple circuit to serve as the foundation for the ensuing processing stage. The sEMG signals still have to be filtered and processed with feature extraction and classification algorithms to attain a satisfactory precision.

![Figure 2 Logic circuit for decoding wrist flexion](image)

The second phase of the will involve the development of a wearable electrode sleeve. The electrode sleeve will be tested on a sample of subjects that represent the target users. Basing on [7], the muscles in Equation (1) will fall in the same proximity. The larger surface size of these muscles will offset the anatomical difference between individuals. We expect the sleeve to speed up setup time for the user whereby the electrodes are already preset, as opposed to having to fix the electrodes individually.

The third phase of the research will focus on recording and analyzing the sEMG signals from the eight muscles listed in Equation (1). The target muscles are listed in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Major muscles and their functions</th>
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<td>FCU</td>
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<tr>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>Flex</td>
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<tr>
<td>Extend</td>
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<tr>
<td>Abduct</td>
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<tr>
<td>Adduct</td>
</tr>
<tr>
<td>Hand</td>
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The sEMG signal waveform will be acquired with the Noraxon EMG acquisition device. Waveforms from the sample will be compared among subjects and the variations will be recorded. An example of an EMG waveform is shown in Figure 3. Analysis will be done on the power spectrum, frequency, bandwidth and phase to identify possible similar traits that can be used as a platform for cross-user compatibility.

4. CONCLUSIONS

The aim of this paper is to propose an sEMG input system that is practical for real-world applications. The coordinate system proposed as a graphical recording system so users can speed up the setup process. The proposed logic gate decoding system is a conceptual platform for the future development of feature extraction and classification.

![Figure 3 Typical waveform of the sEMG signal](image)

Future research will be directed to analyzing the sEMG signals of various individual and also to the construction of the electrode sleeve.

5. ACKNOWLEDGMENT

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6. REFERENCES