Wireless sEMG Monitoring System using Zigbee RF Module for Developing Knee Prostheses

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1. Introduction

A damper of above-knee (AK) prostheses developed by FIBO [1] was governed by walking phases calculated from force sensors and knee joint angle. The Zigbee RF Module is widely used as a low cost and low power wireless communication system for prosthetic applications. It communicates between systems using an ISM (industrial, scientific and medical) 2.4 GHz radio band which is suitable for medical uses. This study presents a wireless sEMG monitoring system using Zigbee RF module that will be implemented to capture a surface electromyography (sEMG) signal in order to vary the damper.

2. System Overview

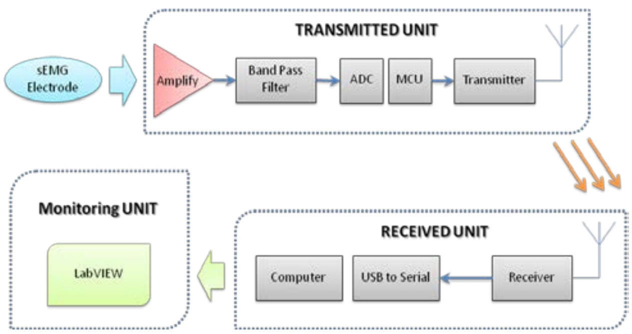

Fig. 1. System Overview for sEMG Monitoring.

The sEMG monitoring system is consisted of a transmitted unit, a received unit and a monitoring unit as shown in Fig. 1.

2.1 Transmitted Unit

sEMG signals from muscles were recorded, amplified and filtered in this unit, using the Zigbee RF module, an amplifier, a band-pass filter, a microcontroller, and a power supply. A Digi's Xbee was used in RF communication. A Texas Instruments INA128 instrumentation amplifier was selected to provide a very high linear gain by adjusting an external resistor. To reduce signal noise and to avoid aliasing effects, a band-pass filter (10 – 500 Hz), an integrated circuit and a voltage follower were implemented. As a result, the INA128 was forced to operate in an AC coupling mode, and a separation between circuit- and earth-ground was obtained. In this study, a dsPIC30F3012-16 bits microcontroller was chosen. The sEMG signal was sampled and converted from A/D with 1350 Hz sampling rate. Two 3.7V lithium ion batteries which were conducted the energy consumption by TLE2426, were used as a power supply for the transmitted unit.

Fig. 2. Transmitted Unit with Zigbee RF Module.

2.2 Received Unit

The processed sEMG signals were transmitted via RF module to this unit by Zigbee, and passed into a PC using a commercial USB to Serial circuit (XBee Explorer Dongle [2]).

2.3 Monitoring Unit

It shall be emphasized at this point that this unit is actually not included in the actual system when it is implemented on the developing knee prostheses. But, it is somewhat necessary for researchers to develop the algorithm of the system. Nevertheless, the processed sEMG signal can be displayed in real time. As shown in figure 3, a GUI was developed using LabVIEW.

Fig. 3. Graphical User Interface.

3. Methods

sEMG signals were recorded from Vastus Medialis (VM), Rectus Femoris (RF) and Biceps Femoris (BF) of a normal subject while he was instructed to walk on a treadmill at an fixed speed, approximately 6 km/hr. The experiment was repeated three times. The test reliability of the collected data was determined using intraclass correlation coefficients (ICCs) [3, 4] and Test efficiency of our system was determined using repeatability of maximum voltage [5] in each phase cycle.

4. Results

The ICCs values as shown in table 1 for VM, RF and BF are 0.9137, 0.7870 and 0.7414, respectively. And, the repeatability for VM, RF and BF are 96%, 96% and 95%, respectively.

Table 1 Intraclass Correlation Coefficients

Muscle	**ICCs**
VM	**0.9137**
RF	**0.7870**
BF	**0.7414**
Average	**0.8140**

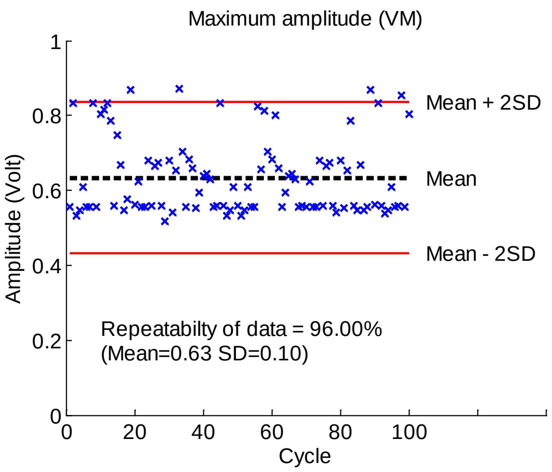

Fig. 4. Repeatability from VM

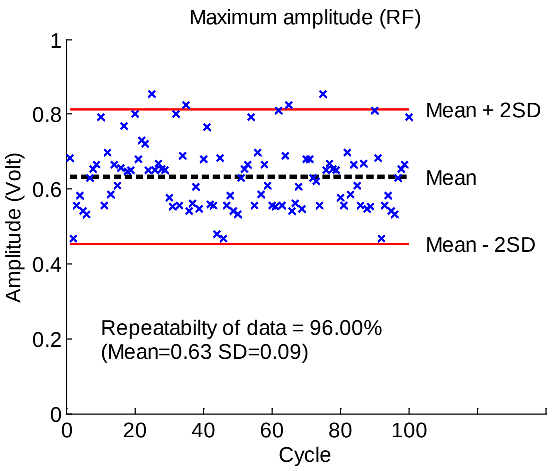

Fig. 5. Repeatability from RF

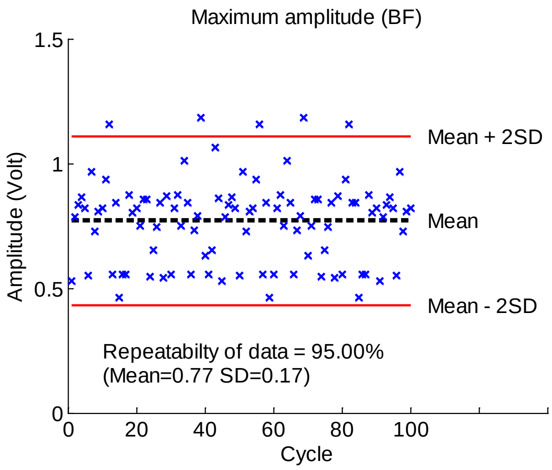

Fig. 6. Repeatability from BF

5. Conclusions

Since the values of ICCs obtained from the study are more than 0.8, this wireless sEMG monitoring system is highly reliable. Furthermore, the experiment was confirmed its repeatability since the values as shown in Fig. 4-6 are equal to or higher than 95%. Therefore, this device is recommended to be used in the developing above-knee (AK) prostheses for varying the damper. For future works, the system will be embedded in the AK prostheses and used in a real situation. And, it shall be multi-channel.

6. Acknowledgement

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