The 4th Global Conference on Biomedical Engineering & Annual Meeting of TSBME (2020 Nov. 12 – 14)

Development of Wearable Internet of Beings (IoB) - Capable Surface Electromyography (sEMG) for Low Back Pain

Chun–Ting Chen[a], Yin Hsieh[a], Cheng–Li Lin[b], Cheng–Feng Lin[c], Jing–Jing Fang[a]

[a] Department of Mechanical Engineering, National Cheng Kung University, Tainan, Taiwan
[b] Department of Orthopedics, National Cheng Kung University Hospital, Tainan, Taiwan
[c] Department of Physical Therapy, National Cheng Kung University, Tainan, Taiwan

MOST 科技部 Ministry of Science and Technology MOST 108-2221-E-006-170-

Introduction

Motivation

Low back pain has caused substantial economic loss in many countries, the developed countries such as USA, UK, Germany, France put their medical insurance compensates for occupational low back pain. According to the statistics data, there are about 50 million people suffering cervical and lumbar back pain, i.e. one in every 4 people in USA. 7 billion US dollars in total was spend in both medical treatments which also causes economical loss from unable working. The medical cost for treating low back pain in the subjects between 20-60 years of age is even higher in many countries than that for treating cancers and heart diseases. It is a gradually developing process from long-term fatigue to chronic low back pain. Continuously low back sour and fatigue in long term is one of the major causes of low back pain.

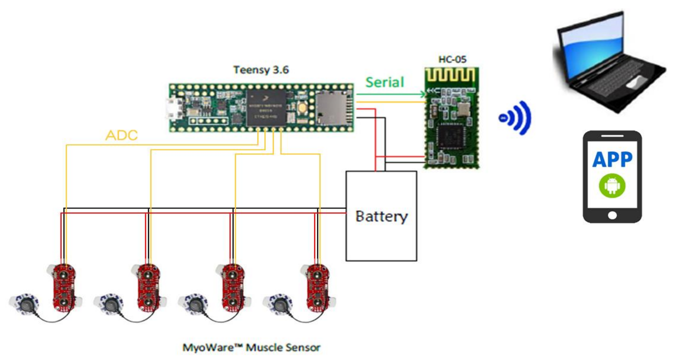
Purpose

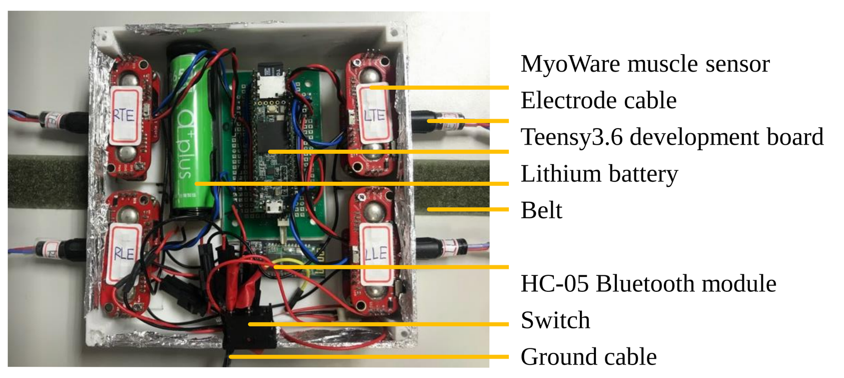
This proposal aims to develop a mobile monitoring device to prevent potential subjects in developing low back pain. The intelligent tight contains the wearable surface electromyography (sEMG)-embedded device, that also integrates internet of beings (IoB) technology to realize the electromyographic analysis detecting system and real-time feedback. Research work includes coding the electromyographic analytic software, developing the wireless electromyographic unit, collection of electromyographic norm pattern, testing the reliability and stability of the "home-made" sEMG system under prolonged use. Moreover, to setup an IoB server and norm database which include the work items of development of a transmission and alarming system on the Android platform.

System

Hardware

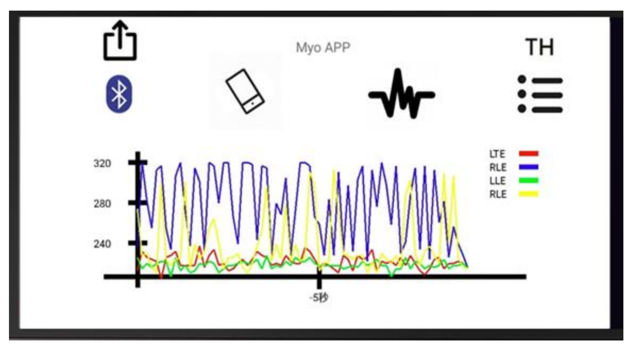
The main parts include Teensy3.6 development board, MyoWare Muscle Sensor, HC-05 Bluetooth module and 3.7 volt rechargeable lithium battery. The lithium battery is responsible for supplying power to the development board, and the switch is used as the main switch of the system. The development board is responsible for providing stable power for the 4 myoelectric sensors and Bluetooth modules. The data processing takes the development board as the core, storing and processing the myoelectric signal received by the myoelectric sensor, and then sending it to the computer or mobile through the Bluetooth module.





Software

The APP is for the fatigue judgment and warning of the lower back muscles. The wearable device will send the median frequency of the quadriceps muscle group, the APP will detect whether the median frequency is lower than the personal fatigue threshold, if so, taking RTE as an example, a warning window will pop up and display "Attention! The upper right back muscles are tired, please take a rest or change your posture! ".



Pre-processing

Since the EMG-signal is sensitive and easily affected by external use or environmental factors, it is necessary to do pre-processing before EMG-signal analysis. First, amplify the original signal range of 0~10mV to 10~50 times. The MyoWare Muscle Sensor is related to the first test to find out the suitable amplification. If the amplification is too high, the noise will obviously cause larger errors in the data. In the processing of noise, a digital band pass filter (10~500Hz) will be used to filter the noise. After pre-processing, it is necessary to find the independent component of the myoelectric signal, which is the representative feature of the muscle signal, and classify the muscle fiber of the twitch speed, so as to facilitate the establishment of the correlation between the muscle groups in the next step.

Experiment

Method

In order to establish the EMG-signal of the back muscles in certain specific movements, it is expected to enroll 5 healthy subjects without any back diseases or discomfort, aged between 20 and 65 years old. Specific muscle groups include thoracic erector spinae (LTE/RTE) on both sides, lumbar erector spinae on both sides (LLE/RLE).

Before attaching the sEMG electrodes, the electrodes and the surface of the skin should be cleaned with alcohol. Once the sEMG electrodes are attached to the correct position, the subject will be asked to perform several actions, contain

1. Bend forward when standing;
2. Bend forward right when standing;
3. Bend forward left when standing;
4. Bend forward and lift a 3 kg weight;
5. Sit-to-stand.

Each action will be asked to do 5 times randomly to collect the EMG raw signal. Calculate the signal measurement data through the developed analysis software, find the linear envelope of each group of muscle fibers to find the cross correlation between the trend and the curve, average amplitude, iEMG, and RMS EMG.

Result

In order to examine whether the stability of the system will be affected by different people's operations, a stability experiment is designed to examine the inter-rater reliability. Also this research uses Intra-rater reliability to verify the repeatability of the system. Then we used the Spearman correlation coefficient for analysis.

Actions	RTE (Stability / Repeatability)	LTE (Stability / Repeatability)	RLE (Stability / Repeatability)	LLE (Stability / Repeatability)
Bend forward when standing	0.96(0.01) / 0.94(0.02)	0.87(0.12) / 0.82(0.10)	0.97(0.03) / 0.97(0.01)	0.98(0.01) / 0.94(0.06)
Bend forward right when standing	0.83(0.15) / 0.90(0.12)	0.91(0.09) / 0.74(0.17)	0.94(0.06) / 0.90(0.12)	0.96(0.06) / 0.94(0.05)
Bend forward left when standing	0.89(0.05) / 0.82(0.15)	0.91(0.10) / 0.89(0.08)	0.97(0.01) / 0.85(0.12)	0.97(0.03) / 0.95(0.02)
Bend forward and lift a 3 kg weight	0.85(0.07) / 0.89(0.10)	0.77(0.16) / 0.91(0.07)	0.83(0.12) / 0.91(0.08)	0.83(0.16) / 0.86(0.07)
Sit-to-stand	0.95(0.10) / 0.87(0.14)	0.88(0.11) / 0.92(0.05)	0.93(0.06) / 0.95(0.08)	0.89(0.09) / 0.90(0.09)

Discussion and Conclusion

This research develops a wearable system for monitoring the fatigue of the lower back muscles and confirms the stability and repeatability of the developed system.

In the stability and repeatability experiment, some problems caused the EMG-signal of some lower back muscles to be unrecognizable. The actions designed in this research are mainly to simulate the actions that are often performed in daily life. However, these actions mostly rely on lumbar erector spinae to exert force, while thoracic erector spinae is relatively small. Unless it is a weight-bearing situation, the EMG signal of thoracic erector spinae is weaker than the signal of lumbar erector spinae. In order to avoid the electrodes falling off, the subjects were required to perform the actions as continuous but slow as possible, making the EMG signal of thoracic erector spinae weaker.

In the past 20 years, it has been mainly to detect the continuous decrease of the median frequency of the EMG-signal to judge muscle fatigue. Therefore, this research uses this as the basis for judging fatigue, and the median frequency in the fatigue state is used as the personal fatigue threshold. However, in one of 2019 conferences, a study put forward a different view.[1] In this study, the changes in the characteristic values of different EMG signals of the subjects were observed during fatigue, and the average strength of the subjects' biceps detected after fatigue was found the increase in the number of people accounted for 94.73% of the total experimental group, the increase in the amplitude of the amplitude accounted for 91.22% of the number of the experimental group, the decrease in the average frequency accounted for 80.70% of the total number of experiments, and the decrease in the median frequency only accounted for 57.89% of the total. On the contrary, the continuous decrease of the median frequency is a representative of poor effect among the four EMG characteristic signals. In the future, EMG-signals other than the median frequency may be used to assist in judging muscle fatigue.

[1]Aghamohammadi-Sereshki, A., Bayazi, M.-J. D., Ghomsheh, F. T., and Amirabdollahian, F., "Investigation of Fatigue Using Different EMG Features," in 2019 IEEE 16th International Conference on Rehabilitation Robotics (ICORR), pp.115-120, 2019.