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Acquisition of sEMG Signals During Human Ankle Movement

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Abstract—*This paper is concerned with studying human ankle movement based on surface electromyographic(sEMG) signals. The sEMG signals were collected from muscles of normal subjects when they moved their ankle flexion-extension. Two types of movement were designed including bending and extending. Analysis of sEMG(surface electromyogram) centered on two features; magnitude of activation & the degree of similarity of the sEMG distribution. sEMG is the technique for measuring levels of muscle activity. When a muscle contracts, electrical activity generated as action potentials propagate along the muscle fibers. There are two types of Surface EMG (SEMG)-Static scanning SEMG and Dynamic SEMG. In Dynamic SEMG, electrodes are attached to the skin and muscle activity is measured and graphed as the patient moves through various ranges of motion. The sEMG signals picked up during the muscle activity are interfaced with a PC system via cRIO for EMG acquisition. The acquired signals were processed and analyzed using filtering techniques. The results showed a marked variation in the amplitude level of EMG as the subject's ankle pace changed.*

Keywords — *sEMG, ankle joint, surface electrodes, tibalis anterior, gastrocnemius.*

I. INTRODUCTION

During muscle activation but prior to contraction and the production of force, small electrical currents are generated by the exchange of ions across muscle fiber membranes. The electric signal generated during muscle activation, often referred to as the myoelectric signal, can be measured through electrodes (conductive elements) applied to the skin surface or inserted into the muscle . The signal represents the electrical activation of the mechanical system of the muscle fibers and thus the activity preceding the mechanical events. The surface Electromyogram is a bioelectric signal that represents, in some filtered form, the aggregate activity of the motor units within a critical distance from the recording electrode.

For many decades surface electromyography has been studied by many researchers in the medical and biomechanical fields to get a better understanding of how muscles work internally and how and when they are activated. In recent years more and more studies have explored the relationship between single muscles and the complex movements of the human body. In contrast to that, only a few publications focused on using electromyographical signals in real-time to control biomechanical robots. The main reason for this is the difficulty to map the EMG signal into the force a muscle is producing[1]

II. MATERIALS AND METHODS

The ankle joint is formed where the foot and the leg meet. The ankle, or talocrural joint, is a synovial hinge joint that connects the distal ends of the tibia and fibula in the lower limb with the proximal end of the talus bone in the foot.

The articulation between the tibia and the talus bears more weight than between the smaller fibula and the talus. The term ankle is used to describe structures in the region of the ankle joint proper.

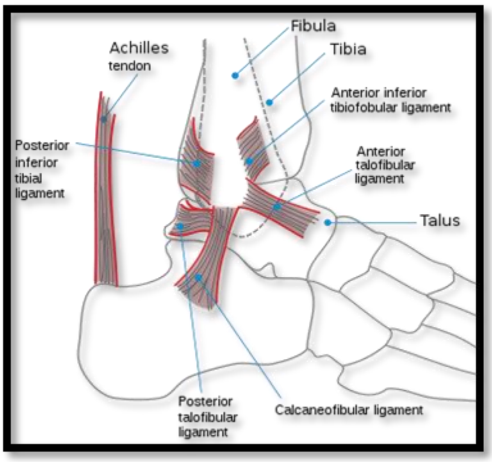

Fig.1 Structure Of Ankle Joint

The boney architecture of the ankle consists of three bones: the tibia, the fibula, and the talus Together, the malleoli, along with their supporting ligaments, stabilize the talus underneath the tibia. The boney arch formed by the tibial plafond and the two malleoli is referred to as the ankle "mortise." The joint surface of all bones in the ankle are covered with articular cartilage The boney architecture of the ankle joint is most stable in dorsiflexion. Dorsiflexion is the movement which decreases the angle between the dorsum (superior surface) of the foot and the leg, so that the toes are brought closer to the shin. The movement moving in opposite directions is called plantar-flexion.[6]

There are many muscles which control ankle joint including Gastrocnemius, Tibia, Peroneus longus (PER) .They are primary to ankle joint and they have strong sEMG signals which could be analyzed. The standard application of EMG (Electromyogram) is to analyze disabilities, to track progress in rehabilitation, more focus has been put on controlling arm and prosthetic ankle with EMG signals. Electromyography (EMG) is becoming more accepted as a standard tool in movement analysis. EMG is most frequently used as a clinical tool to identify the timing of muscle activation, to determine whether a muscle is “on” or “off,” and to a lesser extent, whether the activity is relatively “large” or “small”. A generic model could be developed so that individual ankle muscle moments (and by extension, muscle forces) could be determined during gait with an EMG approach. Hof et al and Olney and Winter were able to demonstrate a relationship between muscle forces and ankle moments.[12]

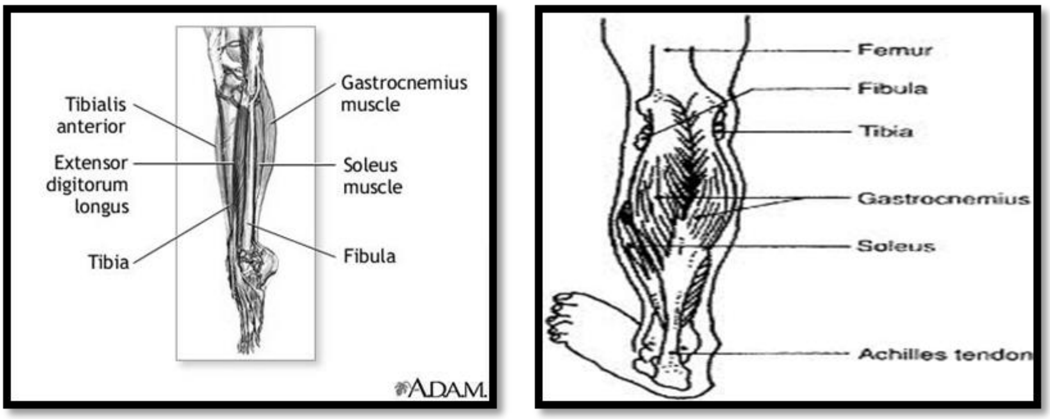

Fig.2 Primary Muscles Of Ankle Joint Control

Five volunteers participated in this study (two males and three females, age range 22-26). All subjects had been screened for no muscular disorders within one year. Within 24 hours before testing, all subjects have not done acutely activity.

A) sEMG Acquisition

Raw sEMG signals were acquired by cRIO (compact reconfigure input-output) from its analog module. The surface electrodes were used. The sEMG signal amplified by an operational amplifier. In this study, the experiments were performed which were**:**
Flexion and Extension of ankle joint

Experiment

flexion and extending of ankle joint – the subject was sitting on a chair and his/her leg was put on a chair horizontally and the foot was hung in the air. The subject moved his/her foot in the dorsi and plantar plane.

Fig.3 During flexion/extension

Gastrocnemius being one of the strongest human muscles, the triceps surae group needs very rigid (machine) resistance against the fixated hip. Perform an unilateral plantar flexion at 90° ankle position.

sEMG data analysis

The sEMG data analysis were performed using labview software. Readings were calibrated according to waveform displayed.

III. RESULTS

3.1 The sEMG signals of TA and Gastrocnemius are profitable during movement of ankle joint as shown on Fig4, Fig.5 after the subject (ZW) finished to bending/extending his ankle joint, the contrast of the sEMG signals' range of four muscles are given. When the subject bends his ankle joint, the range of TA's is great, and which of MG/LG's is relative weak. The sEMG signals of PER are unsteadily. When the subject extends his ankle joint, the range of MG/LG's is great, and which of TA's is relative weak. The signals of PER are still unsteadily.

3.2 There are some regularities of EMG signals in gait period. The characteristics of sEMG signals are favorable for using them for control purposes

sEMG of extension/flexion

After standardizing the RMS (root mean square) of sEMG signals , the flexing/extending signals are shown in Fig. TA and MG is a pair of antagonistic muscles, that is MG extends when TA bends and vice versa.

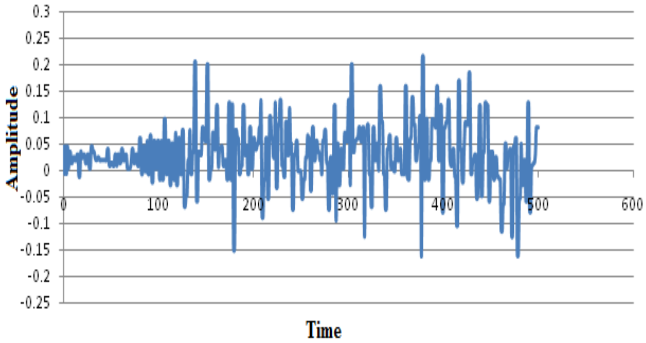

Fig.4 sEMG signals of ankle extension

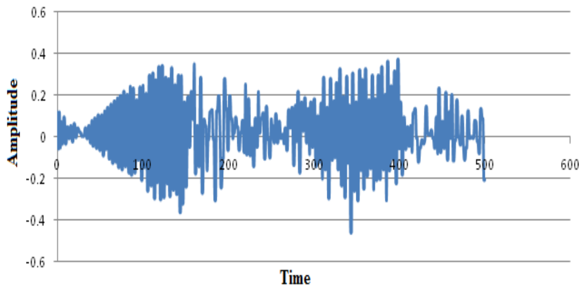

Fig.5 sEMG signal of ankle flexion

The muscle's strength is to keep balance of knee joint and to prepare for body's going forward. For the reason, MG is active. In swing period, MG is almost inactive. TA is active in all gait period. In the first of support period, TA is more active for keeping heel touch the ground first. TA keeps weak activity to keep balance of ankle at the rest of gait period.

IV. DISCUSSION

SEMG signals acquisition of human ankle joint

From the result of experiment, we find that the gait period could be described by the sEMG signal of TA and MG. So if four sEMG sensor channels to TA and MG are used, a sEMG sensor network of ankle joint is built. Because the movement of the ankle joint is controlled by the muscles of calf, there is some relationship between the joint angle and the sEMG signals . The relationship is nonlinear which was proved in previous studies . In future steps, the artificial neural network classifiers in labview will be used to build the relation between the ankle joint angle and the sEMG signals of TA and MG muscles.

V. CONCLUSION

Our results and analysis indicate that a PC-based system using Labview can be used in data logging applications. However, standard Labview on a Windows machine provides nondeterministic results and, therefore, is not suitable for hard real-time control experiments. The design options include using different Labview modules, such as Labview FPGA and Labview RT, or even utilizing a different operating system, such as RT-LINUX. While all of these options are feasible alternatives to a PC-based system using standard Labview, each design option offers a tradeoff between functionality and maintainability.

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