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Microcontroller based smart shoe using FES by AOT technology

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ABSTRACT: Drop foot syndrome is the general term for difficulty in lifting the front part of the foot from the ground which is a common problem that can lead to falls and injuries in human life. It is a neuromuscular disorder where there is the loss of communication between the peroneal nerve and central nervous system which enables the foot to make dorsiflexion. Foot drop correction is generally achieved by electric stimulation of the common peroneal nerve by sending a series of pulses at a given amplitude, duration and frequency. For this purpose, a wireless programmable microcontroller based, low-power, low-cost, battery operated, high performance and portable electronic stimulation device has been developed. The cost of the developed overall system is very low, because we have used standard wireless components which are easily found in the market.

KEYWORDS: Drop foot syndrome, drop foot, drop foot correction, peroneal nerve stimulation and FES device.

I. INTRODUCTION

Functional electronic stimulation (FES) is one of the most rapidly growing areas in biomedical engineering. FES has been developed to help patients with neurological disorders, including foot drop, to move more easily and comfortably. FES is a technique that causes a muscular contraction through the use of an electric pulse. The human body naturally uses electrical currents to make body parts move. When a part of the body needs to move, the brain sends electric pulses to the nerves. The nervous system, acting like electrical wires, relay these pulses to the muscles, directing them to contract (muscle contraction). This muscle contraction causes the body parts to move in a controlled, deliberate way.

Paper is organized as follows: Section II describes the various previous works of the authors. The principle and working methodology of our device is explained in Section III. Section IV presents experimental results and the images during testing. Finally, Section V presents conclusion.

II. RELATED WORK

Functional electronic device was initially referred to as Functional Electrotherapy by Liberson in 1961. He designed portable FES device to treat foot drop by stimulating the peroneal nerve of hemiplegic patients suffering from drop foot during gait, which is basically an electronic device that can generate pulses with the correct amplitude, frequency and duration in order to stimulate the damaged nerves externally [1]. In some applications, the actual stimulation device may also be implanted under the skin. Although this is suitable for long term use, it has the disadvantages that as with the percutaneous FES, qualified medical staff is required to implant the device and as with any type of surgery there is

always the risk of infection [2]. The effect of FES on gait in spastic cerebral palsy. Clinically significant improvements occurred in three of the eight children [3].

III. METHODOLOGY

Pulses at the required frequency and pulse-width are generated by the microcontroller and these pulses are used to switch the MOSFET ON and OFF.

➤ Stand: The two force sensitive resistors are placed inside the patients sole which is transmitter part. In the stand state if any force is applied on any of two force sensitive resistors, receiver sends signal to the microcontroller so that stimulator turns to OFF position.

➤ Walk: In this state if patient lift his/her foot from the ground or foot-rise is detected by the device, system is activated so stimulator becomes in ON position. In other words, while patients try to walk and lifts his/her foot, the transmitter sends Rf signals to the receiver part. In foot-rise position, receiver generates 5 volts otherwise 0 volts, then this generated signal is sent to the microcontroller-based controller therefore controller sends a stimulus signal to the patient's peroneal nerve at the feet so that patient can walk. After the foot strike is detected, device automatically turns to the stand state and the stimulation is stopped by the microcontroller.

➤ Sleep: While in the Stand state inactivity of FSR or pre-specified duration has occurred. System reached to sleep state. In this state system gets self-protection to minimize energy expenditure so that the 58microcontroller is virtually shut down and system operates with a low current.

IV. EXPERIMENTAL RESULTS

The Wireless FES device has been tested at the Near East University Training and Research Hospital. The Near East University Training and Research Hospital as the first and only private university hospital in North Cyprus and also the largest hospital in Middle East.



Figure 1: A Photograph During the Hospital Trials

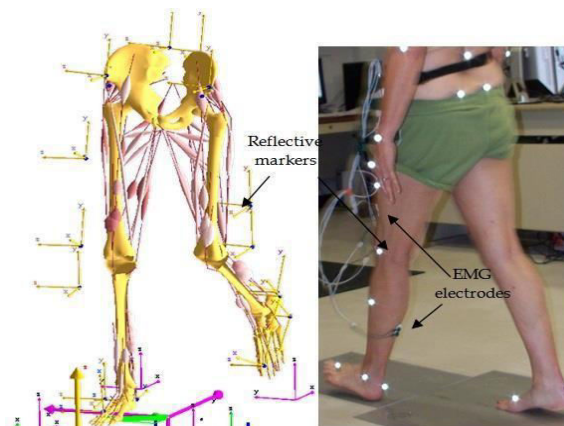


Figure 2: Model of the Lower Extremity with Muscles Included and Actual Subject with EMG Electrodes Attached.

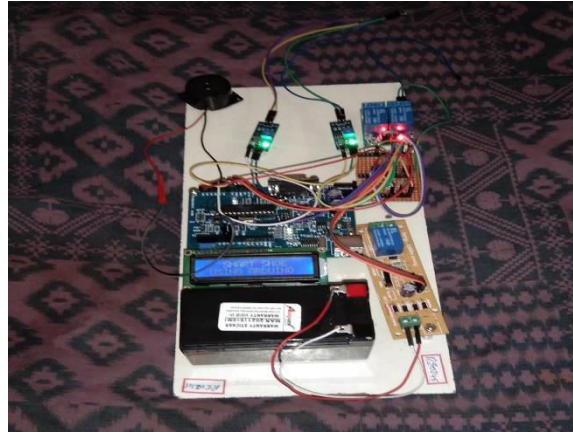


Figure 3: Microcontroller Based FES Device

V. CONCLUSION

The designed microcontroller based wireless FES device has been successfully applied and tested on real patients suffering from foot drop at the NEU Training and Research Hospital by using a Ready for PIC board based on PIC16F887 and arduino wireless unit based Atmega 328 microcontrollers. The wireless FES device has been solved the cable complexity and foot sensors wire discomfort with the design of wireless system.

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