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FEEDBACK ICANE FOR STROKE PATIENT

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ABSTRACT

Rehabilitation can restore function and prevent permanent deformities in patients with stroke. There is, however, only very few study on cost-effectiveness of rehabilitation. Our objective was to evaluate the low cost-utility for rehabilitation for the stroke individuals. The proposed system is called a biofeedback cane. The system consists of the gait analyzer and the iCane. The gait analyzer is designed for determining the maximum force that stroke individuals can apply on cane during walking. The iCane is an audio feedback cane which provides sound when stroke individuals lean their weight over the setting limit. The iCane is set with the weight bearing to each specific stroke individual by a physical therapist utilizing the gait analyzer to set this maximum weight bearing. In this paper, we present the designing of the iCane. The force sensitive resistor is used as the sensor for detecting the applied force on cane. The detailing of the hardware and the software are discussed.

Key words: Biofeedback Cane; Stroke Individual; 10MWT

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1. INTRODUCTION

Stroke is one of the leading causes of long-term adult disability, affecting approximately 7, 95, 000 people each year.

The very word "stroke" indicates that no one is ever prepared for this sudden, often catastrophic event. Ischemic stroke and haemorrhagic stroke are the most common type of strokes.

Rescuing and rehabilitation at early stages can improve functions and sometimes remarkable recoveries for someone who suffered a stroke. Cost of hospitalization and rehabilitation per individuals with stroke is critical for each family. The prospective cohort study of economic evaluation of rehabilitation services stated that the individuals with stroke who underwent rehabilitation had perspective about rehabilitation costs (medical expense related to stroke). Thus, the low-cost technology that can help in rehabilitation for individuals with stroke is needs to be invented.

To support the requirement as mentioned previously, the biofeedback cane system for practice walking for individuals with stroke has been developed. The system consists of two main parts, the gait analyzer and the iCane. The gait analyzer is designed for the real time observation that how the stroke individual applies force on the cane. The iCane is the biofeedback cane that provides the alert sound to warn the individual with stroke when they are walking. It is based on checking the applied force on cane is over the limit or not. If they walk with leaning too much force on the cane, they may develop the abnormal gait patterns and the complications. The physical therapist used the gait analyzer to determine the maximum force that the patient can apply on cane while walking. Then, the maximum value will be set as the reference force on the iCane. Individuals with stroke can bring the iCanes for practice walking by them at home. By using the iCane, stroke individuals can practice walking without seeing the physical therapist or going to hospital every day. Consequently, the cost of rehabilitation may reduce.

In this work, the designing of iCane part is presented. The authors organize the paper to be three sections. In section I, the background of problem is mentioned. In section II, the designing of the iCane, both the hardware and the software are detailed. In section 3 is the discussion of the immediate effects of practicing walking with the iCane in preliminary study.

2. FEEDBACK ICANE SYSTEM

A. System

The simple system diagram of the iCane is below. The system consists of 5 main parts including a Aurdino, a force sensor, a fall detection sensor, a reference force, an audio feedback, and a cane. The force sensor for measuring the applied force from the stroke individual is installed on the cane handle. The value of the applied force from the sensor will be fetched by microcontroller. The microcontroller processes the data by comparing to the reference force that stored in the EEPROM memory of the microcontroller. The alert sound is generated by the audio feedback unit if the value of the applied force is higher than the reference force. As the iCane have to use in mobile manner, the lithium battery is used as the power source of the system.

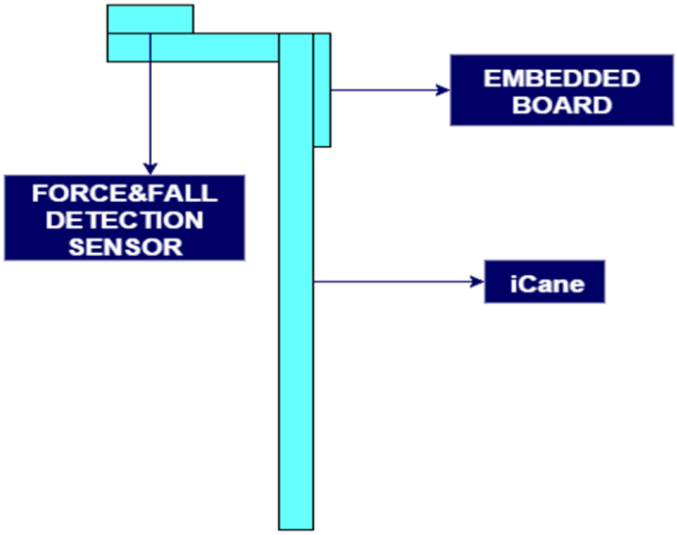

Figure 1 I-Cane feedback Cane

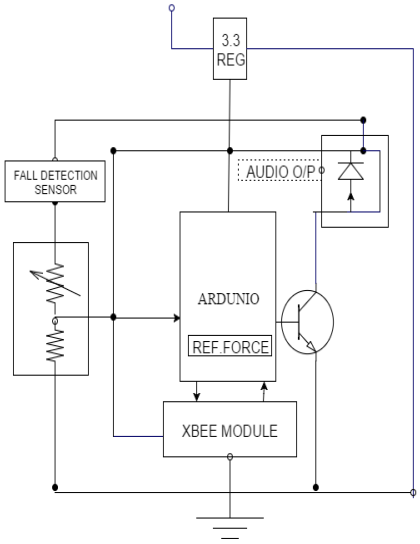

Figure 2 Embedded Boards

B. Ardiuno Unit

Arduino is a physical open source computing platform based on a simple input and output board and a development environment that implements both the Processing and Wiring languages. Arduino can be used to develop interactive objects or can be connected to software on your computer.

C. Force Sensor

The force sensor is made by connecting the round force sensitive resistive (FSR) as the voltage divider circuit. The electrical characteristic of the sensor was tested by using the Universal Testing Machine at the Impact Testing System Laboratory of Mae Fah Luang University. It shows the experimental setup and the output voltage of the force sensor as the function of the applied force. It provides the analog voltage signal in the range of around 2.8 - 3.2 V which it is corresponding to the applied force to the sensor in the range 0– 20 Kg.

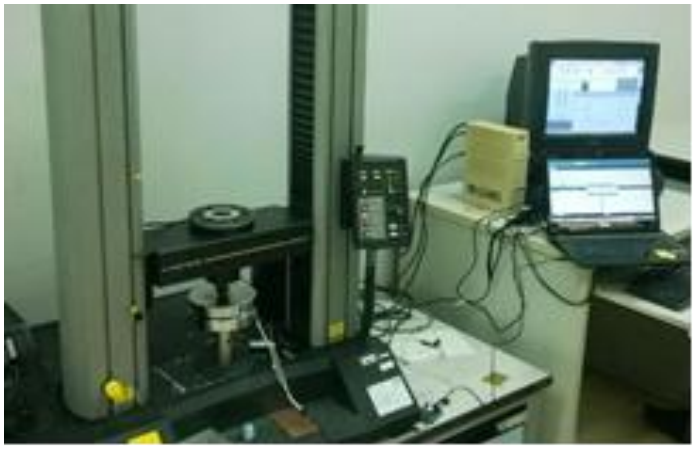

Figure 3 Force sensor testing

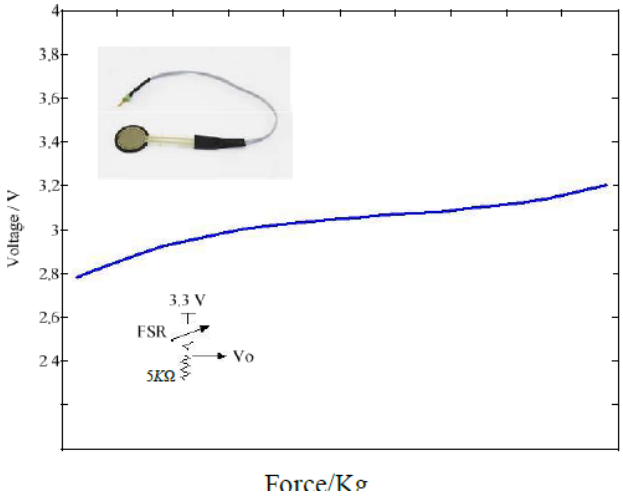

Figure 4 Output voltage of force sensor

D. Fall Detection Sensor

The fall detector sensor can say if you are just lying down or if there is a sudden change in direction because of a fall. Fall detectors use accelerometers and gyroscopes to measure the changes in direction or acceleration in the movement of the patient. These detectors use careful calculations that enable a sensor to tell the difference between a fall and other movements. Another feature included in this technology is movement-monitoring, which monitors your movement up to 30 seconds after an unexpected change in direction. If after 30 seconds the device does not detect movement, it will alert both the patient attender and physiotherapist. This 30-second window reduces the occurrence of wrong alerts. If this monitoring is not used, then the device may alert help every time whenever you drop the iCane down or bumped against any surface.

E. Reference force and Audio feedback

Another important block for the iCane is the reference force unit. It provides the information of maximum force value that the stroke individual can apply on the cane before putting the excessive weigh on the cane. The EEPROM memory of the microcontroller is used for this. The value of the reference force is received directly

from the gait analyzer. Thus, the wireless data transfer technology is employed. The XBee modules with the frequency of 2.4GHz are installed on the gait analyzer and the iCane.

On the iCane side the XBee is installed as plug. Thus, it can be removed after the reference force from the gait analyzer is written to keep in the EEPROM memory of the iCane. The audio feedback system includes the buzzer and the transistor switch. It generates the alert sound towarn the stroke individual if the applied force is higher than the reference force

F. Software

The Pseudo codes given below controls the operation of iCane. The Program starts by configuring the internal registers, ports and modules of the microcontroller, involving the operation of the iCane. Then, the program reads the reference force value from the EEPROM memory and run into the endless loop. The reference force value can be updated new value via the UART interrupt. Within the endless loop, the microcontroller reads the applied force from the sensor then compares it to the reference force. The alert sound is generated if the value of the applied force is higher than the reference force. As the lithium battery is used as the power source of the system, the battery voltage has to check periodically. It is responsibility of the function battery checking which running under the timer interrupt.

Main Function

Begin

{

1. Configure the internal registers
2. Configure the ADC, Timer, UART and the Interrupt
3. Read the reference force value from EEPROM [Can be updated the new value from the interrupt UART]
4. Read the applied from value from the sensor
5. Compare the applied force value to the reference force value.
6. Generate the alert sound if the applied force value is higher than the reference force value.
7. Go to step 4.

}

End

Timer Interrupt

Check the voltage level of the battery.

Alert sound if the voltage level is lower or higher than the defined value.

UART Interrupt

Read the new reference force value from the buffer Write the new reference force value to the EEPROM

Figure 5 Pseudo code

3. RESULTS

According to our preliminary study, the sensor position on the iCane handle was found to be suitable under the palm of each individual with stroke. It can sense the applied force while less destroys the sensor. The accurate position was set for each patient by the physiotherapist. Participants should be asked to perform 10 MWT with their own walking speed with their normal canes for three times. Then, they should practice walking with the iCane for three trails (10 meter walk/trail). After that, participants are asked to perform 10 MWT with their preferred walking speed with the iCane for three times. The average walking speed is analyzed. However, after considering the walking alignment of the participants, participants walked with trunk upright and straight after using the iCane. The initial study indicates long-term walking with the feedback iCane is needed for individual with stroke. Furthermore, walking with cane is a motor skill that requires motor learning. Individual with stroke has to have time to learn how to walk with cane. Thus, to obtain the effect of using this biofeedback cane system in stroke individual, the longer period of using the iCane should be conducted in the future study.

4. SUMMARY

This paper presents the designing of feedback iCane for practice walking of the stroke patient. The implementation of the embedded board and the sensor was detailed. Also, the software that used for control the operation of the biofeedback cane was explained. To verify the validity of the proposed work, the 10MWT was conducted in individuals with stroke in this preliminary study. The result was shown that the proposed biofeedback cane may improve the rehabilitation effectiveness of the stroke individual.

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