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ANDROID BASED CONTROL AND MONITORING SYSTEM FOR LEG ORTHOSIS

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Abstract: This paper focuses on the development of Android based control and monitoring system for leg orthosis. This study mainly focused on the designing an android application to control and monitor leg orthosis exercise system. The main function is to helps user or physiotherapist to control and monitor the leg orthosis during exercise session. Leg orthosis is an instrument used to help the paralyzed patient to move their leg during rehabilitation or mobility process. The Android application is deploy using MIT App Inventor 2 (BETA). In this project, Bluetooth communication has been used to communicate between the Android application and the controller. Arduino Uno R3 has been used as a controller to control the hardware. User can monitor patients pulse rate during exercise. The result shows that the Android application is successfully developed and can be used to control and monitor the leg orthosis.

Keywords: leg orthosis; MIT App Inventor 2 (BETA); Android; Arduino; Bluetooth; database; Tiny Web DB; pulse rate;

INTRODUCTION

Paraplegia is bilateral paralysis of the lower body including the two legs. It is commonly resulting from the Spinal Cord Injury (SCI) which communication between brain and the other part of body is blocked or loss. There are important parameters that doctor, physiotherapist and below the level of injury are unable to pass damage in the spinal cord. The leg orthosis instrument is introduced to help the paraplegic to perform regular exercise. Based on Dorland's Medical Dictionary for Health Consumers 2007, orthosis is an orthopedic appliance or apparatus used to support and align. Most of the paraplegics wish to be able to walk normally again. It is important for a paraplegic to perform a regular range of motion exercise program. Lack of exercise can result in increased muscle spasms and increase the chances of developing pressure sores. Failure to exercise on a regular basis can cause joints, muscles, ligaments and tendons to stiffen. If parts of the body stiffen, it will impact the ability to sit and maintain body posture. In some critical cases, it leads to urinary failure or completely paralyzed. Based on the previous study, the doctors have increasingly come to realize the importance of exercise for people with paralysis. It is important to get immobile limbs to move. Evaluation of performance for the leg orthosis had been made and it is proven to solve problems of paraplegic patients however the previous development of the leg orthosis is controlled manually where the leg orthosis will swing up and down by controlling on-off of the power button. Therefore during rehabilitation treatment plans, the physiotherapist (a specialist in physical) medical doctors need to monitor during the exercise period however this information is difficult to be available for the doctors.

This study mainly focuses on the development of a user-friendly control and monitoring system for leg exercise using leg orthosis. The motorized leg orthosis will be controlled using Android device which is connected wirelessly to the exercise system. The patient's pulse rate, date and time will be shown on the android device during the exercise session. The data of the previous exercise sessions also can be stored together with other patient's information. This information is important data needed by the doctor during rehabilitation plans.

METHODOLOGY

The development of Android application to control and monitor leg orthosis system consist of two parts which are the hardware and the software constructions. The Bluetooth, Arduino Uno controller, pulse rate sensor and leg orthosis have been used as the hardware for this study.

Hardware development

In this section, the development of communication system between Bluetooth, Arduino Uno controller, the pulse sensor and leg orthosis will be discussed in details.

Bluetooth: Figure 2 shows the DF- BluetoothV3 Bluetooth module used as a pair which provides a transparent serial data communication between Android device and Arduino R3 UNO controller. The Bluetooth module consists of 'STATE LINK' to display connection status, 2.4 to 2.48GHz unlicensed ISM band on-board antenna to provide high quality frequency signal and DIP switch to set module status (power saving mode and AT Mode). This module is compatible with any of the Android device.

Figure 2: DF-Bluetooth V3

Arduino Uno R3 controller:

Figure 3 shows the Arduino Uno R3. It is the microcontroller of the leg orthosis. It has 6 analogue pins (pins A0 to A5) and 14 digital input and output pins (pins 0 to 13). The 6 pins of the digital port can be used as the PWM outputs. In this study, the pulse sensor is an input and connected to the analogue pin. The Bluetooth module and motor driver are connected to digital pins port. The Arduino Uno R3 is recommended to be powered at 7 to 12V or connected to the computer via USB cable. The operating voltage for Arduino Uno R3 is 3.3V to 5V. This controller is used to communicate with the pulse sensor, Bluetooth module and 12V DC motor of the Leg Orthosis.

Figure 3: Arduino controller

Pulse sensor: Figure 4 shows the Pulse Sensor Amped. It is a plug-and-play heart-rate sensor. In this study, the pulse sensor will send reliable pulse rate reading in the Android device thru Arduino R3 Uno controller. Then, the pulse rate is displayed in the Android application.

Figure 4: Pulse Sensor Amped

Leg orthosis: Figure 5 shows the leg orthosis that used to develop the system. In this study the leg orthosis was previously developed. The leg orthosis is powered by 12V lead acid rechargeable battery and it is controlled by Arduino Uno connected to MD30C 30Amp DC motor driver

Figure 5: Leg orthosis

Software development

In this section, the development of Android based control and monitoring system will be discussed in details.

MIT App inventor 2 (BETA): The Android application for leg orthosis exercise is deployed by using a web based application, MIT App Inventor 2 (BETA) . App Inventor for Android is an open-source web application originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT). MIT App Inventor 2 (BETA) platform consist of Google App Server, App Inventor Designer and Blocks Editor. It is a beginner-friendly programming application for Android. It provides a free cloud-based service that programmer can access using web browser. Figure 6 shows the platform in the MIT App Inventor 2 (BETA) where the GUI such as control buttons, labels, image, bluetooth and TinyWebDB for the Android application are selected in the App Designer.

WORKING:

The android application is selected by the user then switch on bluetooth connection of the android device as shown in figure 8 (i). Secondly, click in the 'connect to loe' in figure 8 (ii) and a new window will pop-up. In the new window, there will be varies of available bluetooth connections detected. Find and connect to bluetooth_v3. By connecting to bluetooth_v3 means the android application can control the movements of leg orthosis. List picker is used to show filter bar of bluetooth connection available and allow the android device pair with a specific bluetooth connection. In this study, it is used to instruct the android device to pair with df- bluetooth v3. If the bluetooth connection is successfully paired with the df-bluetooth v3, a green colour text will notify, 'loe enable' and if the bluetooth bluetooth connection unsuccessfully paired with the df-bluetooth v3, a red colour text will notify, 'loe disabled Thirdly, the user have to verify the date and time. If each button is clicked, pop-up windows will appear. The date and time for this function is tally with the Android device date and time. User only need to verify the date and time but in case it doesn't tally user are allowed to edit it. There are three main control buttons for user to control the movement of the leg orthosis. There are stops, forward and reverse buttons. If the stop button is click, the leg orthosis will stop moving. If the forward button is clicked, the leg orthosis will move upward while if the reverse button is clicked the leg orthosis will move downward. The user can continuously exercise by clicking different buttons. The user can monitor their pulse rate reading by clicking the 'Check Pulse Rate'. A new window will appear. The pulse rate waveform is program in the Processing 2 platform. It is a programming language, development environment and online community. Processing 2 is an open source language and development tool for writing programs in other computers or Android device. Useful when programmer wants those other computers or Android device to communicate with an Arduino, for instance to display or save some data collected by the Arduino. Android Mode has to be installed. In this study, Arduino with Processing 2 is used to display the pulse rate data from the Arduino to an Android device. Users have to capture and insert manually the Beats per Minute (BPM) readings at the beginning and at the end of the leg orthosis exercise. User will have click the average BPM button to calculate the average of BPM readings. Equation below shows the mathematical calculation where,

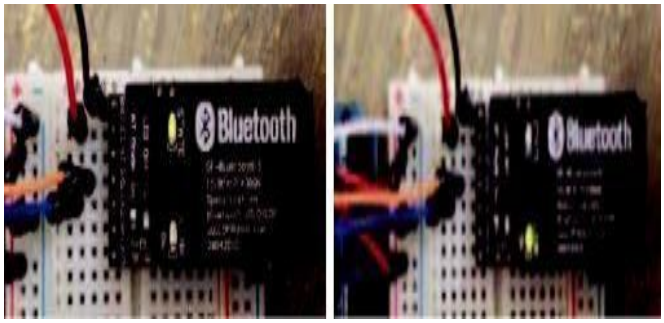
The user is able to click the Reset data to reset all of the data inserted. The average BPM, date and time of the exercise is needed by the physiotherapist and medical doctor. Thus, the data must be stored into a web based database. In this study, Tiny Web DB is used. TinyWeb DB is an App Inventor component which allows user to store data persistently in a database available on the web. This web data storage service is helpful for testing, but it is shared by all App Inventor users and it has a limit of 1000 entries only. Therefore, the data will be overwritten eventually. In this study, Tiny Web DB is used to test the database function for the leg orthosis. It is a temporary web based database where the submitted data such as average BPM, date and time of exercise will be stored. At the start-up, the Leg Orthosis Exercise (LOE) application will identify whether the tag is exist. The tag is a unique ID number and each paraplegic will have different tag numbers. The tag number will be used by the physiotherapist and medical doctor to follow up the rehabilitation plans of the paraplegic. There is a share button. The advantage of this control and monitoring system, user is allowed to save the data into any Android devices or sharing it online through available Android apps such as email, Evernote, Google Keep and Google Drive. Therefore user can also monitor their own rehabilitation plans.

RESULTS AND DISCUSSIONS

In this section, the result from the Android based control and monitoring system developed will be discussed in details. Figure 9 shows the Graphical User Interface (GUI) for leg orthosis exercise (LOE).

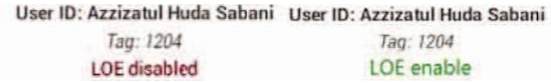
Figure 7: GUI for leg orthosis exercise on an Android device

Connect to LOE: User have to activate the Bluetooth function of their Android device. Figure 10 shows when the Bluetooth is not connected with the Android phone, LED at STATE condition will keep blinking if the Bluetooth is not connected with any phone. The GUI will notify 'LOE disabled' in red colour text. Figure 10 shows when the bluetooth is connected with the Android phone, LED at LINK condition will turned on while at STATE condition will continue blinking. The GUI will notify 'LOE enable' in green colour text.



(a) Disconnected (b) Connected Figure 10: The Bluetooth connection status

Send signal: The main control buttons are forward, reverse and stop. In this study, to control the leg orthosis, user has to send signal 'Stop', 'Forward' or 'Reverse'. When 'Stop' is choose, the leg orthosis will stop moving. When 'Forward' is choose, the leg orthosis will move forward and when the 'Reverse is choose, the leg will move reverse.



Check pulse rate: Based on Figure 12, user have to click 'Check Pulse Rate' button to check their current pulse reading. Once the button is clicked, a pulse rate screen will appear as shown in figure below. The large main graph on the left shows raw sensor data over time. At the right of the screen, a smaller data window graphs heart rate over time. This graph advances every pulse and the Beats per Minute (BPM) is updated every pulse as a running average of the last ten pulses.

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