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Arm Rehabilitation Monitoring System using LabVIEW

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Abstract: Paralysis typically involves injury to the central nerve, especially the brain stem. In physical therapy, the development of an arm rehabilitation monitoring system with LabVIEW focuses on mobility, which helps to maintain and strengthen the resilience of a wounded organ. The unique feature of this arm rehabilitation monitoring system is the patient and practitioner can observe the patient's progress. LabVIEW can display data of how much the patient is able to hold and lift the arm. An electromyogram sensor to measure muscle contraction and force sensitive resistance to the hand was used in this project. Then, the LabVIEW software was utilized as an interface of the system and to display the output. The project was tested on two males and two females with different body mass indices (BMI). The results concluded that the grip strength for males and females is different. Factors that affect the results are age, gender, nutrition, and BMI. The experimental results show that a person with a normal BMI puts high pressure on the grip, where the grip strength indicates a measure of muscle strength. In conclusion, the development of an arm rehabilitation monitoring system is crucial since it shows the patient's healing progress and allows the expert to understand how long does it take for the patient to recover fully.

Keywords: Paralysis, Rehabilitation, LabVIEW, Monitoring System

1. Introduction

To date, many people in hospitals are suffering from arm-related diseases. These diseases may induce semi-paralysis, prevent their arms from functioning normally, and prevent the movement and control of the limbs due to muscular or sensory system problems. Paralysis is a loss of strength and power over a bodily part of a muscle or a muscle group [1].

In order to aid people in rehabilitation, the Arm Rehabilitation Monitoring System using LabVIEW was designed and developed to monitor the patients' arms progressively. The unique part about this arm rehabilitation system is both the patient and physician can observe the progress of the

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patient's arm recovery together. LabVIEW is a software engineering programming language for visual programming. LabVIEW is extensively used in data collection, instrument control, and automation. This project can track the success of patient’s movements from low arm mobility due to stroke or partial paralysis. A single handle, comprising two sensors: the Sensitive Sensor Force (FSR) was used for monitoring the changes in the arm, and an electromyography sensor when a force or pressure applies to measure the muscle tension produced by the bicep and carpi radialis was also used. These sensors were then connected to the analogue site by a single processor called Arduino Mega to obtain the force value on the finger and to compute muscular contraction. The computer was connected to Arduino, and all measurements were displayed using the LabVIEW software via a graphical interface. The system's performance is important since it shows the patient's healing progress and allows the expert to understand how long does it take for a patient to recover fully.

1.1 Previous study

1.1.1 Arm physiology and abnormalities

The upper limb, which includes the area between the shoulder joint and the elbow joint is part of human anatomy. The arm is made of skeletal muscles, and tendons of the connective tissue that binds muscles to the bone. Paralysis is an example of arm abnormalities. Rehabilitation of patients with stroke is performed using arm and hand control regeneration treatment. The rehabilitation devices stimulated electrical measurements of the arm muscles. Muscle contractions may be described based on the length and tension of two variables. If the muscular tension changes, but the muscle length does not change, then the skeletal muscle is classified as isometric. In contrast, if the muscle length changes, the muscle tension does not change, then the muscular contraction is isotonic. When the length of the muscle is shortened, the tension is concentrated. The component of the arm involved in this research is the biceps brachii.

1.1.2 Electromyography probe placement

Integrated motor regeneration of the upper extremities, including wrist and finger expansion, elbow extension, and shoulder abduction, is facilitated by neuromuscular stimulation paired with bilateral gestures. Subjects flexed their damaged and deteriorating muscles while simultaneously shifting their other arm. Microcomputers and surface electrodes attached to the injured muscles controlled the activation levels. The microprocessor supplies neuromuscular stimulus and motion as soon as the muscle activity reaches the required strength level. Disabled muscles can make simple gestures owing to the combination of bilateral motor preparation. EMG is used to activate neuromuscular stimuli that aided voluntary movement initiation in the upper extremity, as well as to analyze EMG activation levels during testing to see if these patterns revealed rehabilitative effects of coupled bilateral movement training on the three joint movements [2].

1.1.3 EMG Pattern Recognition Approach in Post Stroke Robot-aided

The aim of this study was to observe if the EMG pattern recognition algorithm based on statistical classifiers that could decipher a subject's desire to move in a specific horizontal direction. A horizontal gesture was made by nine stable right-handed participants and seven right-handed stroke survivors. The approach performed extremely well when EMG data were recorded and used to categorize the expected direction of motion of subjects with normal subjects. The approach did not perform effectively with stroke sufferers. The findings showed the drawbacks of using this technique in robotic-assisted neurorehabilitation, and suggested that instead of using EMG signals to discriminate the patient's motivations, it should be used to create an online protocol that provides guidance on muscle activation patterns errors [3].

1.1.4 Grip strength

Grip strength is a measure of a patient's strength used in physical and rehabilitation medicine. Grip strength can be used therapeutically in various ways, including determining how an individual's injuries compared to those who are healthy or determining whether a person's reading deviates from the established norms [4]. Many repeated grip strength assessments are commonly used to calculate grip strength, with the mean score from many trials as the most common method [4]. The Jamar Hydraulic Hand Dynamometer [5][6] was used to assess the grip strength. The selected dynamometer provides the most accurate measurement of grip strength, it is widely used in rehabilitations and has a uniformed test procedures.

2. Materials and Methods

2.1 Materials

2.1.1 Arduino Mega

An Arduino Mega is an ATmega2560-based microcontroller board [6]. It has 54 digital input/output pins, 16 analogue inputs, a 16 MHz quartz glass, a USB connection, a power connector, an ICSP header, and a Reset Button. Arduino requires a basic user experience and it is easily accessible. It is also extremely simple for novices to comprehend. In addition, among the benefits of Arduino are it is easy to use, and it has a lot of useful sample codes, with many Arduino communities on the internet.

2.1.2 Force Sensitive Resistor (FSR)

The Force Sensitive Resistor can detect physical pressure, squeezing force, and weight. This sensor is essentially a resistive value (ohm) based on how far the sensor is pushed, and how much it has no polarity. Besides, the sensors are low-cost and easy to use but seldom precise. FSR is frequently used when integrated with Arduino. It is achieved by connecting one leg with VCC 5 jumper wires, and connecting the other leg with a 10k resistor in the centre to the A0 output, and connect to the ground port. A few examples of FSR are a pressure sensitive touch interface, robotic tactile sensor appendages, and customized glove finger pad.

2.1.3 Electromyography Sensor (EMG) v3.0

EMG Muscle Sensor Module V3.0 measures the filtered and rectified electrical activity of a muscle, and its output is 0-Vs Volt based on the amount of activity in the chosen muscle, where Vs denotes the power source voltage. A minimum of +-3.5V Voltage supply is required. The Muscle Sensor v3 detects, filters, rectifies, and amplifies the electrical activity of a muscle and generates an analogue output signal that can be read by a microcontroller, allows the creation of new muscle-controlled interfaces for projects.

2.2 Methods

Figure 1 shows the block diagram of the developed system. Electromyograms (EMG) and force sensitive resistors (FSR) serve as the input. Arduino is the processor, which reads FSR's analogue value. LabVIEW is the output. The platform displays the FSR input signal using a graphical approach. EMG is used to show the muscle activation throughout the rehabilitation process.

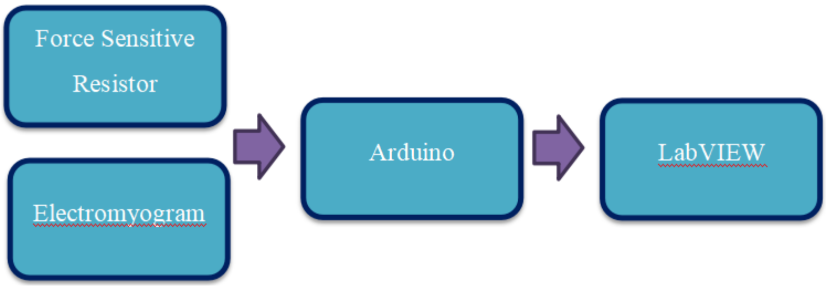


Figure 1: Block diagram of Arm Rehabilitation Monitoring using LabVIEW

Four subjects were selected to conduct this experiment. The subjects wore the rehabilitation glove, and then it was connected to the LabVIEW. The subjects squeezed a therapy ball for five seconds, and the data was displayed at LabVIEW. It was then recorded. The experiment was repeated three times to get the means value.

3. Results and Discussion

3.1 Results

Figure 2 (a) – (c) below shows a complete prototype of the arm rehabilitation device. The Force Sensitive Resistors (FSR) were placed on four fingers, namely the Index Finger, Middle Finger, Ring Finger, and Pinky Finger. They were attached to the special glove using thread. The Arduino Mega was placed on the top of the prototype.

(a)

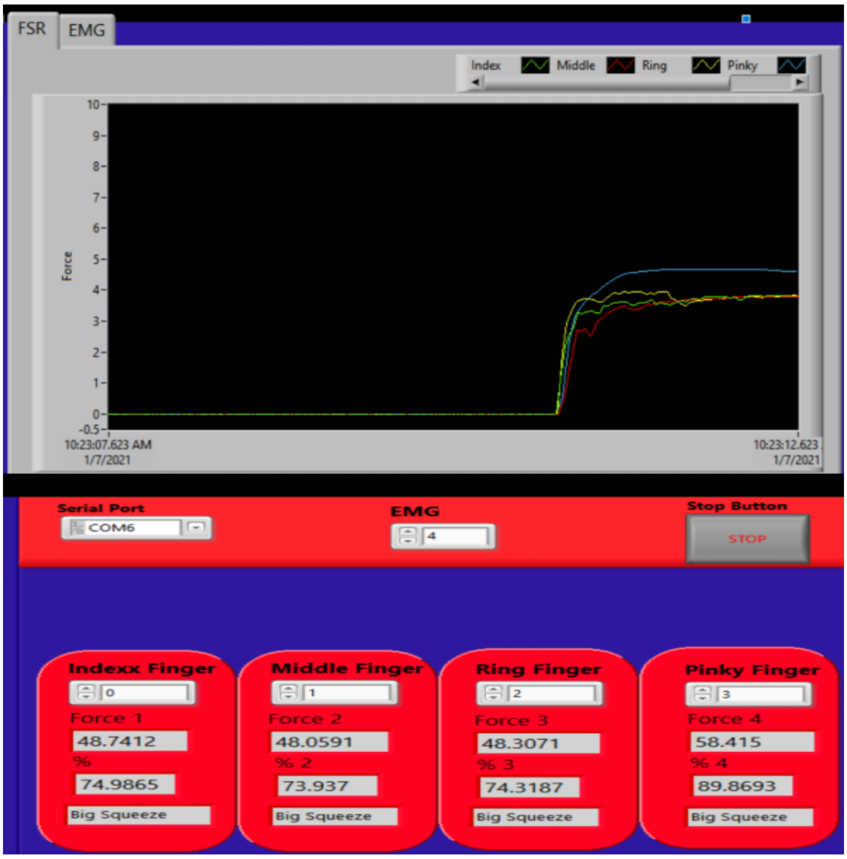
(b) (c)

Figure 2: A complete prototype of the Arm Rehabilitation Device with (a) all connection settings during experiments, (b) FSR attached to the glove using thread, and (c) Arduino Mega connection

Figure 3 depicts the front panel of LabVIEW. It shows the interface of the system and also the output graph. The experiment was performed by squeezing fingers onto the force sensitive resistor. A waveform graph is displayed on the front panel once the force sensitive resistor presses the rehabilitation ball.

Figure 3: Front panel

Figure 4 shows the FSR result of the third subject. The subject is a male aged between 20 and 25 years. The mean for Index Finger, Middle Finger, Ring Finger, and Pinky Finger is 48.9479 Nm, 52.2345 Nm, 48.3278 Nm, and 54.9010 Nm, respectively. The outcomes indicate that the graph for all fingers is almost the same when the subject squeezes the ball. The grip strength for this subject is normal.



Serial Port: COM6
EMG: 4

Indexx Finger	Middle Finger	Ring Finger	Pinky Finger
0	1	2	3
Force 1: 48.7412	Force 2: 48.0591	Force 3: 48.3071	Force 4: 58.415
%: 74.9865	% 2: 73.937	% 3: 74.3187	% 4: 89.8693
Big Squeeze	Big Squeeze	Big Squeeze	Big Squeeze

Figure 4: FSR result of the third subject

Figure 5 shows the EMG result of the third subject. It indicates that the subject was squeezing the ball because of the increasing waveform of muscle formed on the graph. It means the muscle is active. When the subject squeezes the ball, the FSR graph increases, and the EMG graph also increases. It indicates that muscle strength affects grip strength. The more strength provided by the muscle, the stronger the grip.

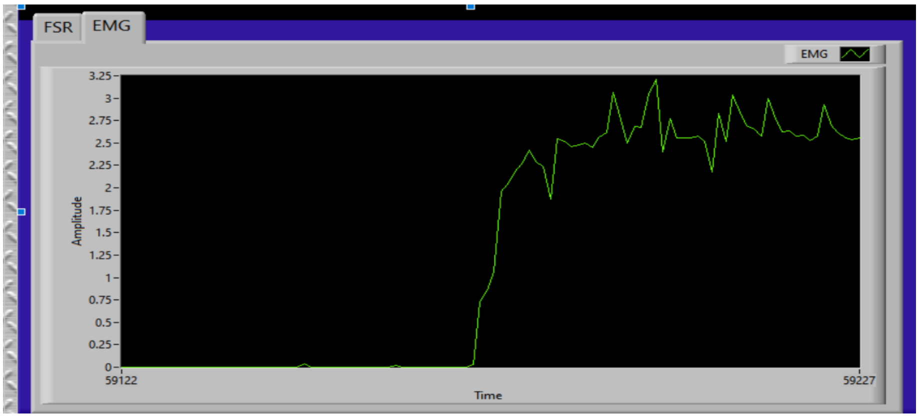


Figure 5: EMG Result of the third subject

3.2 Discussions

LabVIEW is a program that users can create a customized graphical user interface. It acts similar to Arduino but is more advanced. However, it works by placing different icons, unlike Arduino. Two types of connections between Arduino and LabVIEW are the LabVIEW master and Arduino slave, and the Arduino master and LabVIEW slave. Master-slave means the master is in control, and the slave is the one that does the work. In this project, LabVIEW is the master, and Arduino works to collect the data and send it to LabVIEW to be displayed. LabVIEW can be connected to Arduino in several steps. Before the programming run, the user must select the com port at the serial port. Next, the user must select the analogue channel in LabVIEW based on the analogue port, where the sensor is located, from A0 to A4. The analogue channel on LabVIEW was renamed Finger 1. Three icons from the maker's hub are required to connect to Arduino. It is called Linx. Linx is an integrated software to control Arduino. Basically, three icons in Linx are open Linx, analogue read or write, and close Linx. Open and close Linx serve to open and close the Arduino and LabView connections, while the analogue read and read function, read the input data from Arduino and display the data on the front panel. After the coding was completed, the serial port was selected to run. The serial port is similar to the com port in Arduino. It shows which com port the USB is connected from Arduino to the computer. Next, the number in the ai channel or analogue channel was selected. The sensor connected to Arduino analogue read was checked to determine which channel to be used. Once this step was completed, the run arrow or continuous loop was clicked, to run the program.

Force Sensitive Resistor (FSR) was used to determine the strength of the handgrip. The age range of the participants of this project is between 20 and 25 years. Four subjects were involved in this project. It is difficult to find subject candidates due to the Covid-19 pandemic. Thus, family members were recruited as participants of this study. The project requires participants to squeeze the therapy ball. The subject had to squeeze the treatment ball for five seconds to measure the pressure. It was repeated three times to obtain the mean value. The assessment of the grip strength is a crucial component in hand rehabilitation. The patient's initial limitations were evaluated, and progress throughout the treatment was quickly assessed. Several studies have identified different conditions affecting grip strength. The strength of the muscle is a variable in those who formed the capacity. The synergistic action of bending and extending muscles and the interplay of muscle groups is a key factor in the overall strength of the resulting grip [8]. Age, hand dominance, diet, body mass index (BMI), gender, and sensory loss are the variables that affected a man's strength. The mean value for the first two subjects is 46,3123Nm, while the third subject's mean value is 51,1028Nm. The first and fourth subjects' BMI is under the underweight category. The mean value for the first subject is 38,3439Nm and 42,7661Nm for the fourth subject. People with low-calorie intake have less grip strength. There is a significant difference between male and female grip strength throughout the entire finger. The mean difference is 7.9684Nm for females and 8.3367Nm for males.

4. Conclusion

In conclusion, the development of this arm rehabilitation monitoring system by using LabVIEW can be used to help a patient in the healing process by displaying the patient's arm muscle contraction performance and force value. The project was also designed to strengthen the arm of the patient. This project uses two sensors, namely Force Sensitive Resistor (FSR), which was placed at the fingertips, and the EMG sensor, which was positioned at the brachioradialis or the biceps brachii. Arm brachioradialis and biceps brachii provide the highest indicator of muscular contractions. The resistance sensor was used, and it works by producing a unique value that produces voltage data. Then, the voltage data from these two sensors were collected by the Arduino Mega microcontroller at the analogue site. Subsequently, the Arduino board was connected to the computer, and with the help of LabVIEW, the output was displayed in a graphical form that shows the patient's performance to recover fully. Furthermore, this project helps doctors or physicians learn the development of muscle contractions in the patient's arm.

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