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Design and Development of Active Physiotherabot for Stroke Patients

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Abstract— The paper describes about the research work carried out for design and development of a robotic glove that will be able to find out the finger movement in a mathematical form. Further, this data can be used for treating semi-paralysed patients. In Stroke patients where body parts movement cannot take place entirely or partially can take the benefit of proposed system. Flex Sensors have been used for each finger in order to design the proposed system. Arduino-UNO software is being used for the coding of sensors. Collected mathematical data can be stored for exercise selection criteria or to develop a passive exercise model.

Keywords: Physiotherabot, Flex sensors, Arduino IDE.

I. INTRODUCTION

1) Overview
The patient suffered from a stroke cannot move their figure like an average person. He/ she has a grasping weakness due to numbness of nerves in the body. This can be eliminated or can be reduced by rehabilitation exercises. Active and Passive -two types of exercised are generally used. In the active exercises, a patient can move their fingers but with little un-uniformity. While in the passive exercise, a human can not move any finger without the help of additional source. The physiotherabot must move these fingers in order to stop total disability. Moreover, data need to be collected extensively as every patient have different spreading movements. As a solution, a device can be developed with a combination of Robot and Physiotherapy (Physiotherabot). [1]

2) Motivation
The motive behind creating such physiothrabot is to develop existing work in the core area of physiotherapy for the exercise of stroke patients. There are huge chances that exercise with the active physiotherabot can result into a much-improved exercise of improvements in finger disability percentage. Many published robotic systems such as Virtools1 and WorldToolKit 2 broke the connection between visualization and exercise therapy. [3] This work may motivate other people to create and demonstrate a new design of robotic systems for physiotherapy exercises. After successful completion of the active physiotherapeutic system, passive rehabilitation robotics can be a good area to promote improved patients care. [4]

3) Previous Work
There is a huge development in the Rehabilitation robotic systems in past few years. First fully developed system was MANUS at MIT in 1994 to promote monotonous exercises published as a press release worldwide. The primary motive of MANUS is to reconsider moves of physiotherapist in a patient and a great graphical data of the interface has been developed in last couple of years and thus, the principle of extension of physiotherapist exercises virtually came in existence. [2]

Section I contains the introduction of robotic physiotherapy and previous work carried out in the same field, Section II contain the problem definition in terms of robotic therapy, Section III contain some objectives of the proposed design , Section IV contains The Design Of Flex Sensor Based Active Finger-Rehabilitation Robot, section V explains the results carried out after successful completion of final model, Section VI describes results and discussion , Section VII contain the conclusion of research work, Section VIII explains future directions possible in robotic therapy area, and Section VIII explains future directions possible in robotic therapy area.

II. RESEARCH PROBLEM

1) Reasons to use a Physiotherabot
The number of patients who suffered from stroke has been increased largely. Even with the ageing, this illness is very commonly found in many human beings and due to this physiotherapy assistance will be increased in a greater extent. In such cases, physiotherabot can be very useful for carrying out the physiotherapy exercises. Physiotherabot is very

popular with people who have suffered a stroke because the proprioceptive neuromuscular facilitation method is applied. [13]

2) Stroke rehabilitation
In the people who are suffering from stroke, their nervous system becomes damaged. This is due to disability of six months after the stroke. Physiotherabot will be able to perform the exercise with the patients that are not so easily carried out by the patients manually. The physiotherabot also helps patients suffering from a stroke in order to carry out repetitive exercises. [1]

3) Research Gap
Conventional methods used for healing of patient injuries with physiotherapy exercises are useful but they are time-consuming, and every time a human intervention is needed. This results in need of more physiotherapists for curing more patients. Both Manpower and Time can be saved if proper robotic systems are designed to perform those exercises as a substitute to the physiotherapists with more accurate and uniform exercises in comparison to conventional human aided workouts. This creates a tremendous demand for design and development of a Physiotherabot for the substitution to human physiotherapists. [4]

III. OBJECTIVES

1) Development of a conventional system
The key objective of this research work is to analyze the recent advancements in the field of Physiotherabot and their applications and then design and develop a new Physiotherabot to meet the current needs for more accurate exercise delivery of the stroke patients in the area of physiotherapy.

2) New Technology
From the literature review it has been noticed that in the field of robotic therapy, one must examine the current technologies available in the physiotherapy field and through the latest technologies, it can be possible to determine hand movements more easily. Detailed study of this technologies can be a critical approach when assuming future technologies. [2]

3) Cost & Maintainability
The technologies of the various devices can be useful in the determination of the successful approach of the physiotherabot. Furthermore, by keeping cost and maintainability in mind, the system will be rated after continuous use of 1 month. The exact cost is derived after the one-month continuous usage.

4) More accurate exercise delivery
By the inclusion of the latest technologies in terms of flex sensors and microcontrollers, the feedback system will be much powerful and in the end result will be obtained with more accurate data.Inturn the data obtained will be used for the perfect workout of the stroke patients.

IV. DESIGN OF FLEX SENSOR BASED ACTIVE FINGER-REHABILITATION ROBOT

Flex sensor works with the bending of the transducer in the radial direction that converts physical data in mathematical data. It is a resistive sensor that reflects movement or bend in voltage. The gradual change in the bend from 0^o to 90^o ideally can reflect from 45K to 75K. [10]

1) Human hand finger motions [10]:
Based on the human kinematic structure the design constraints are:

1. The system is based on finger flexion and does not communicate with the computer.
2. The system is lightweight (Approx. 550 Grams)
3. The patient should be able to move fingers while wearing a glove
4. The glove should be wearable for various hand size with minimal change.
5. Rehabilitation robot needs to allow minimum 6 degree of freedoms.

2) Methodology:
The development of a rehabilitation robot for the finger movement involves a design of a self-made five fingers hand glove. The idea of this research is to design develop and modify a mechanism that can calibrate the finger movements. The mechanism is fully functionating with a smart glove by using flex sensors and Arduino kit. This system can even store the radial movements of fingers in mathematical form.

The controller available in Arduino calibrates the movement of the all the five fingers including thumb in a straightforward way. The rehabilitation glove is interfaced with a computer for storing the mathematical data transferred by flex sensors. Sensed forces or feedback will be transferred to the computer system and will be visualized by using the graph in Arduino-UNO software. [12]
3) Components:
(1) Flex sensors (2) Arduino-Uno (3) Resistors and PCB
(4) Glove
3.1) Flex Sensors:
A sensor is a device to calibrate the movements in the transverse direction and give the respective output that can be converted in the mathematical form from the initial data. Different sensors are available to detect the movements and extensions of the hand fingers. Resistive Sensors, Pressure sensors, resistance and rotation sensors are the different types

of sensors available in the commercial market. The patients should be able to perform the exercise after wearing the glove and hence the flex sensor should be lightweight and flexible. [2]

In our research work, the exact design need can be satisfied with the use of resistive flex sensor. They are made up of carbon loaded polyethene with copper laminate on one side as shown in Figure 1. These sensors are available in the form of a strip that changes their resistance value with the change in bending amount as shown in Figure 2 and depicted from Table 1. [8]

Figure 1 Flex Sensor [8]

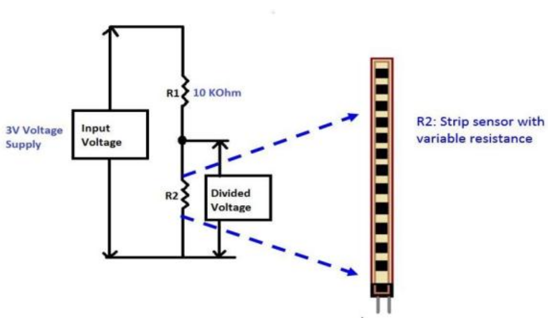

Figure 2 Flex Sensor Circuit Diagram [8]

3.2) Arduino-Uno:

A proper unit should be used to plot the sensor value and convert it into a useful digital output that can be used in the program, later on the program converts this logic and notifies extensions. [5] The circuit will have a unit for procession, output and input peripherals and internal memory to store the data as shown in Figure 3. The control unit should be optimum, lightweight and small that can be easily implemented on hand glove. Also, the shape being made after the control unit should not restrict the exercise movements during therapy. [11] Later on the circuit components will be required to calibrate the values of the resistance collected by the sensor to the digital voltage values. This values as mentioned in the Table 1 will be used by the computer program.

Table 1 Arduino-UNO

Position Arrow Finger	Angle v/s Resistant
0 degree	14.0 K Ohm
30 degree	19.03 K Ohm
60 degree	22.01 K Ohm
90 degree	24.89 K Ohm

Figure 3 Arduino-UNO [11]

5.3.3 Resistors And PCB:

A fixed resistor has been used with the value of 24kΩ as shown in Figure 4. Also, PCB has been used to connect the resistors in either parallel or series as shown in Figure 5. The reason for using 24kΩ resistor is that when the flex sensor is bent at a value of 90° or -90°, it can detect the resistor of value 24kΩ. [10]

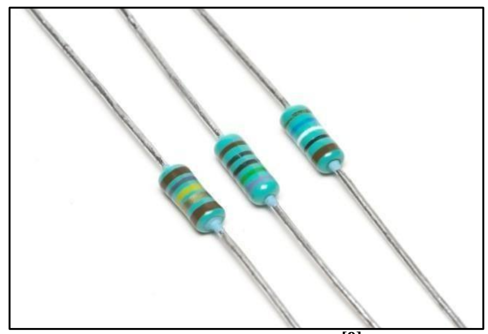

Figure 4 Resistors [9]

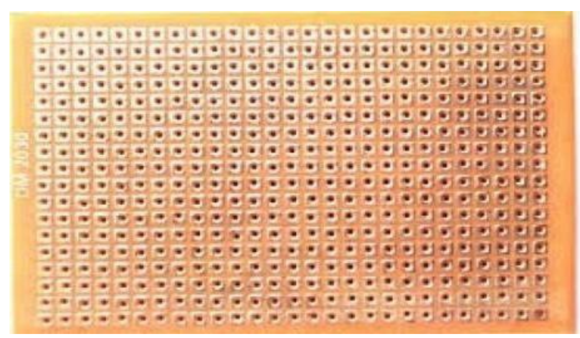

Figure 5 Printed Circuit Board

3.4) Glove:

The polyester glove as shown in Figure 6 has been used to embed the flex sensors into each finger. Due to flexibility of the material it will be able to stretch and contract sufficiently to provide better hand movements. It has also characteristic of absorbing high rate of sweat and can be suitable for long therapy sessions. It also serves as a good insulator that can be helpful during current and voltage leaks in the circuit. [16]

Figure 6 Glove

3.5) Software:

Arduino IDE is open source platform to create, write and upload code with in a real-time work environment. It is integrated development environment for the computer system. The inbuilt code available in the Arduino IDE Library is used for the derivation of interpreted data and the screen shot for the code is shown in Figure 7. [11]

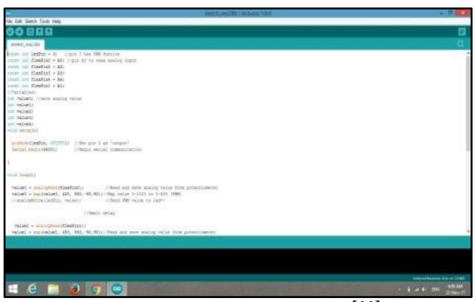

Figure 7 Arduino IDE [11]

4) Proposed System:

The target system majorly concentrates on study and execution of the hand finger movements data collected by the sensors until the full movement is available in the transverse direction. It comprises of the polyester glove where the flex sensors are used for the data acquisition with suitable arrangements. The data collected is then transferred to the PC by using Arduino software. The proposed system is depicted with the help of a block diagram as shown in Figure 8.

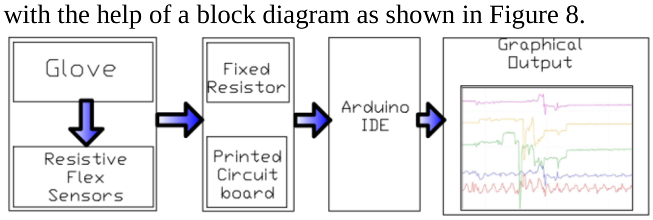

Figure 8 The proposed system

The transmitting system includes the smart glove with the five flex sensors each. These sensors are joined with the microcontrollers using appropriate hardware. The control management of the sensors is allotted to the microcontroller of the ARM to perform in various capacities. [5]

5) Final Model:

Figure 8 Final Model

The final model as shown in Figure 8 is derived after incorporating all the above-mentioned components and integration with the software. The prototype designed can be used for measuring the range of fingers by wearing onto the hand and deriving a e - diagram for the movement of the fingers as shown in Figure 9 and Figure 10. By using it, one can rehabilitee our hand fingers and get treatment as per the requirement of the patient.

V. RESULT AND DISCUSSIONS:

After successful completion of the design of the active rehabilitation robot, the therapist would be able to plot the hand movements in the serial plotter in Arduino-UNO. As shown in Figure 9. In the initial condition when there is zero movement in the hand fingers then graph plotted will be completely straight for all five fingers. Later, when a slight movement is made by the patient, then one can find out the change in the serial plotter due to the microcontrollers feedback from the flex sensor as shown in Figure 10.

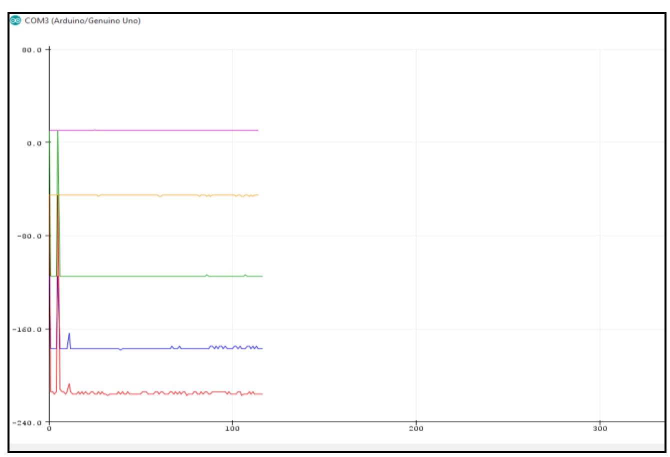

Figure 9 Output without finger movement

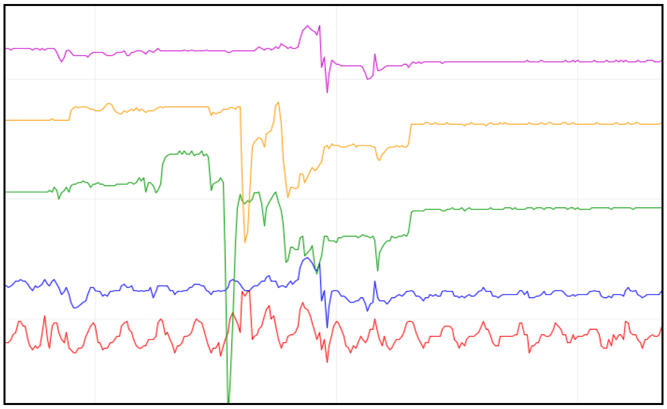

Figure 10 Output with finger movement

VI. CONCLUSION

From the research work carried out, data of the finger movement can be collected very accurately for each hand fingers individually. The resistance value in reference to the respective angle is between 14.0 K ohm to 24.89 K ohm. The gradual change in the finger bending can be observed in the graphical form. The data captured can be easily exported manually in excel and that will be useful for multiple purposes.

VII. FUTURE SCOPE

Active rehabilitation physiothrabot can be useful in the extended work of the same core area in the passive rehabilitation robotics. Passive rehabilitation physiotherabot can be useful for fully paralyzed stroke patients.

VIII. ACKNOWLEDGEMENT

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