LOAD CELL AND FSR BASED HAND ASSISTIVE DEVICE

ABSTRACT

Hand disability in today's world is one of the most common problems because a person's freedom of actions are restricted which means that he or she is unable to move his/her hands freely. The hand disability [10, 11] is caused by head injury, stroke etc. Strokes [12] lead to weakening to hand muscles because of which the patient is unable to hold an object properly [7]. These types of problem are treated by physical therapy and its recovery is assessed by the devices such as load cell and Force Sensing Resistor (FSR) sensor.

In this project load cell and Force Sensing Resistor (FSR) sensors are used for assessing the patient recovery. The load cell and FSR sensors are connected to the Arduino Uno and Nano respectively. Here the patients are asked to apply the force on both these devices one by one and the values of these forces are recorded in the system with the help of PLX-DAQ software.

After collecting the data in computer with the help of PLX-DAQ, these data are transferred to a data mining software called RapidMiner for obtaining the maximum value of force. By determining the maximum value of force one can infer that the patient is recovering by comparing its present and previous values. In the RapidMiner Studio one can also see the graph of force vs time which will give a clear picture of the patient's recovery.

INTRODUCTION

Human interaction cannot happen due to the restriction of the freedom of action. One of the most common problems in today's world is hand disability [1]. As hand plays a major role in eating, grasping, writing etc. the malfunctioning of the hand may be caused due to head injury, strokes etc. Another factor which leads to hand disability is stroke. Strokes [2, 3] usually affect the weakening of specific muscles and the movement of hand. The complication of these diseases can be treated by surgery or physical therapy [8, 9]. Hand recovery is essential for improving the quality of life, even though not perfectly normal [4]. Most commonly the hand grip strength [6] is used to determine the performance of forehand muscles [5]. The test is usually carried out by a strain gauge which determines the grip strength of a person. This project helps to determine the grip strength of a hand disabled person in order to compare the present and previous results and see the improvement in the person. In this project the strain gauge helps in obtaining the data which is displayed on the computer.

The FSR sensor model is also required which is used to determine the net force that the person will be applying on the FSR sensor which is kept at the circumference of a circular can-shaped bottle. The FSR sensor is attached to Arduino Nano which is kept inside the can and the data is transferred to the system with the help of a Bluetooth module wirelessly.

SYSTEM DESIGN

Fig. 1 shows a hand dynamometer which consists of hardware and software unit [1]. The hardware has a main unit and a sensing unit. The voltage displacement obtained from strain gauges bonded on the bending beam is measured using a half-bridge Wheatstone configuration. The small voltage is amplified with the help of an instrumentation amplifier and is transferred to the Arduino microcontroller and then wirelessly to the pc.

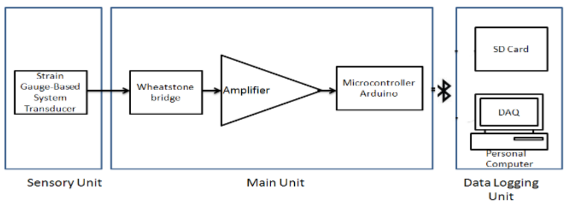

Fig 1: Block diagram of load cell

Fig 2 shows the interfacing of the force sensing resistor (FSR) with Arduino. Here when the force is applied on the FSR sensor there is a change in resistance which is directly proportional to the force applied on it. The voltage reading is converted to force by using Kirchhoff's Laws. Thus the maximum force reading of the patient is stored in the computer systematically by using the data mining and graphical user interface tool called Rapid Miner.

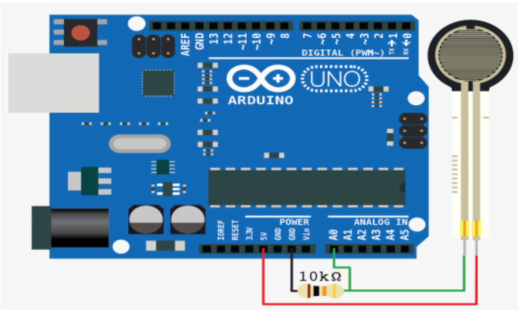

Fig 2: Interface of Arduino with FSR

THE HAND REHABILITATION SYSTEM

In fig. 3, equal weights are added one after the other on the load cell calibration setup. When the weights are being put on the load cell it will give certain reading for a specific weight in grams. The up and down readings should match with one another approximately. So that one can infer that the device will work correctly for any amount of force applied. Since it is a 40 kg load cell, the force should not apply more than 40 kg of weight, otherwise the readings will be out of range.

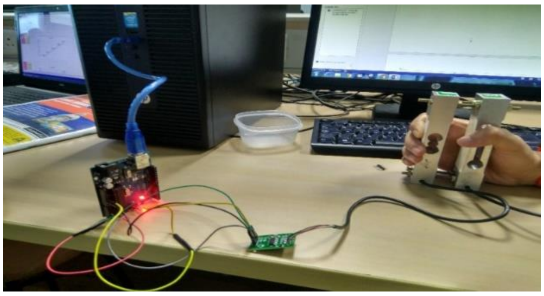

Fig. 3: Load cell setup

Fig. 4, shown is the model of a FSR sensor which is used for assessing the patient recovery. The patient applies force on the cylindrical model which consists of FSR sensors at the circumference. This gives the value of force in newton which is recorded in the system and is compared with the previous records of the patient to see whether the patient has recovered.

Fig. 4: FSR Model

RESULT ANALYSIS

Analytics of force readings is done using the Rapid Miner Studio. Rapid Miner is a data mining tool which is freely available on the internet. The force obtained from Load cell and FSR sensor via Arduino is stored in Ms Excel. The data from Ms Excel is stored in Rapid Miner and graphs are plotted using these data. Fig. 5, shows the block diagram which obtains the maximum value of a data set of force. The block diagram obtains the maximum value of force obtained by 2 subjects.

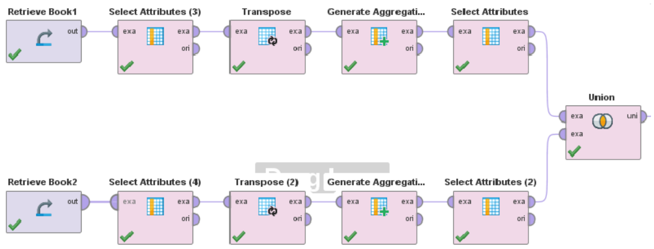

Fig. 5: Block diagram of rapid miner

In the table, the force values obtained by load cell/FSR is stored and the graph is also stored in GUI. The block diagram used saves the highest value of the force. In the Rapid Miner GUI, the retrieve block obtains the data from excel. Then the 'SELECT ATTRIBUTE' block is used to obtain only those attributes which are needed. The unnecessary attribute is selected and the 'REVERSE SELECTION' check box is checked. So only the useful attributes are selected. Then the 'TRANSPOSE' block is used which displays the table in transpose. Then in the 'GENERATE ATTRIBUTES' block the maximum value of all the data is stored under the max sub column. After that in the 'SELECT ATTRIBUTES' block we select only the max sub column and it is displayed in the 'UNION' function.

GRAPH/TABULATED COLUMN

The graph and the tabulated column of the FSR and load cell are shown below. After uploading the data in rapid miner the maximum value of the force from the tabulated columns are founded with the help of the software.

row	force
Dec 31, 1899 11:10:19 AM IST	1.740
Dec 31, 1899 11:10:19 AM IST	1.400
Dec 31, 1899 11:10:20 AM IST	1.410
Dec 31, 1899 11:10:20 AM IST	1.190
Dec 31, 1899 11:10:20 AM IST	1.350
Dec 31, 1899 11:10:20 AM IST	1.210
Dec 31, 1899 11:10:20 AM IST	1.050
Dec 31, 1899 11:10:20 AM IST	1.030
Dec 31, 1899 11:10:20 AM IST	1.590
Dec 31, 1899 11:10:20 AM IST	2.540
Dec 31, 1899 11:10:20 AM IST	3.650
Dec 31, 1899 11:10:20 AM IST	4.060
Dec 31, 1899 11:10:21 AM IST	5.080
Dec 31, 1899 11:10:21 AM IST	5.640
Dec 31, 1899 11:10:21 AM IST	4.690
Dec 31, 1899 11:10:21 AM IST	4.140
Dec 31, 1899 11:10:21 AM IST	3.610

Fig 6: Data of load cell

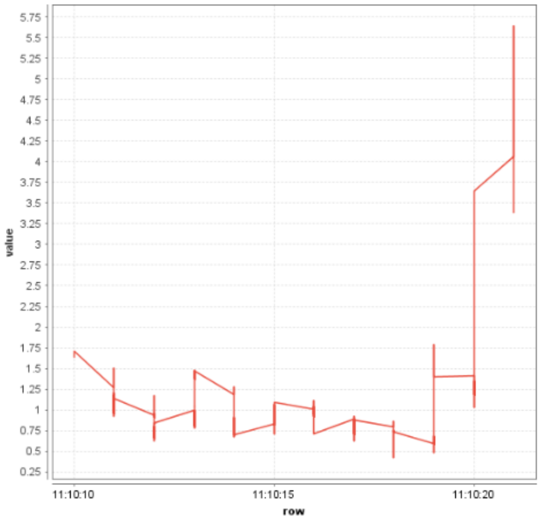

Fig 7: graph of load cell

Row No.	id	Max
1	force	5.640
2	net force	9.080

Fig 8: Maximum value of force from subject 1 and subject 2

Row No.	Computer_Time	Force_in_Ne...	Force2_in_N...	Net_Force_i...
1	Dec 31, 1899 10:24:41 AM IST	4.530	4.030	8.560
2	Dec 31, 1899 10:24:42 AM IST	5.080	4.310	9.380
3	Dec 31, 1899 10:24:43 AM IST	5.010	4.280	9.290
4	Dec 31, 1899 10:24:44 AM IST	5.210	4.430	9.640
5	Dec 31, 1899 10:24:45 AM IST	5.690	2.940	8.640
6	Dec 31, 1899 10:24:46 AM IST	4.120	3.760	7.880
7	Dec 31, 1899 10:24:47 AM IST	5.010	4.240	9.250
8	Dec 31, 1899 10:24:48 AM IST	5.170	3.350	8.520
9	Dec 31, 1899 10:24:49 AM IST	4.260	3.540	7.800
10	Dec 31, 1899 10:24:50 AM IST	4.640	3.900	8.540
11	Dec 31, 1899 10:24:51 AM IST	4.810	2.480	7.280
12	Dec 31, 1899 10:24:52 AM IST	2.980	2.630	5.620
13	Dec 31, 1899 10:24:53 AM IST	3.820	3.100	6.920
14	Dec 31, 1899 10:24:54 AM IST	3.970	2.940	6.910
15	Dec 31, 1899 10:24:55 AM IST	3.500	2.090	5.590
16	Dec 31, 1899 10:24:56 AM IST	3.900	3.300	7.200

Fig. 9: FSR output

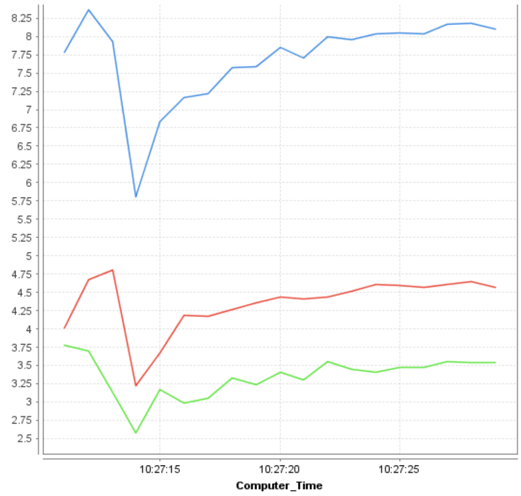

Fig. 10: FSR graph

Row No.	id	Max
1	Net_Force_in_Newtons	9.640
2	Net_Force_in_Newtons	8.360

Fig. 11: Maximum value of FSR

CONCLUSION

The study is a success because the objective are completed and the device can be used wirelessly. Furthermore, the hand assistive device such as load cell and FSR are used for measuring the grip force of the patient. These devices are activated by applying the finger force on it and then the net force is displayed on the system. In the FSR sensor values are obtained which is real time force values of the patient which can help the patient to get the output in a shorter interval of time unlike load cell.

The devices which are being used in the project have a very simple form of structure. Hence these devices have a very low cost as compared to other hand assistive device which is currently present in the market. These device are capable of providing huge contribution to the patients who want to retain their actual hand function. Nevertheless, these kind of devices still need some kind of improvement for being a better alternative as compared to other hand assistive device.

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