Force Measurement in Patellofemoral Joint for Osteoarthritis Patients Using Labview

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Abstract- Osteoarthritis (OA), is a joint disease which is consider as incurable in nature. The OA causes results in joint damage. Knee osteoarthritis is one of the major disease which causes damages in the cartilage between femur and tibia. The patellofemoral region is mainly involved in knee osteoarthritis. The main aim of this study is to measure the forces during the walking movement in left and right part of patello femoral joint for OA patients and normal subjects. The objective is to design a circuit to measure forces and to test the difference between OA patients and normal subjects. The hardware circuit was designed using NI ELVIS (National Instrument Educational Laboratory Virtual Instrumentation Suite), which is used to interface the sensors with the labVIEW software. The labVIEW software is used to acquire data from the sensors. The circuit was designed using two FSR sensors (Force Sensitive Resistor) which are fitted to the upper part of the patellofemoral joint on right and left knee separately. The forces which are obtained by the walking movement within the duration of three minutes. The measured output shows a decrement in force compare to normal and OA subjects and it also has been identified that right knee force is greater than left knee force.

Keywords- Osteoarthritis, FSR sensor, NI ELVIS Hardware, LabVIEW Software.

1. Introduction

Osteoarthritis a kind of joint disease which causes the breakdown of joint cartilage[1]. The osteoarthritis results in joint pain and stiffness and its leads to abnormal joint[2,3]. It is generally considered as incurable in nature[4,5]. OA commonly occurs in hand, fingers, and knee. Diagnosis can be made by the Radiographic technologies.

Knee osteoarthritis is that prevalently occurs at the medial compartment which is a progressive chronic disorder[6] affecting the articular cartilage of the knee joint. knee osteoarthritis is one of the major disease which causes damages in the cartilage between femur and tibia[7,8]. The patellofemoral (PF) joint is involved mainly in knee osteoarthritis patient[9,10]. Generally knee braces are used to treat the patellofemoral joint osteoarthritis[11].

FSR is consider as a Force Sensitive Resistor which is used to measure the force and physical pressure[12,13]. The FSR sensor is fit into the knee brace which is placed on the patellofemoral portion of the knee. Here, two FSR sensors are used to measure the force[14] when the OA patients and normal subjects are undergone the walking activity. The FSR sensor used for the measurement of

Fig.1: Knee Osteoarthritis

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foot pressure scanner to detect the Diabetic foot ulceration [15]. This also used for the calibration of static and dynamic applications[16]. The further applications of the FSR sensor includes:

➢ Tool speed control
➢ Patient turning alarm sensor
➢ Dynamic Limit Sensor

The hardware circuit is connected in NI ELVIS which is a prototyping platform. The FSR sensor is made to interface with the hardware circuit. The circuit design is made in NI ELVIS hardware is connect with the LabVIEW software.

LabVIEW is considered as Laboratory Virtual Instrument Engineering Workbench. This software is generally used for the data acquisition and the control of the instrument. The LabVIEW consists of block diagram, a front panel, and a connector panel. This software acquires data information from the FSR sensor and displayed in the form of raw data. These raw data is then signal processed by mean and the standard deviation and the output obtained in the form of graph. This software is used to calculate the heart rate using the ECG feature extractor from the LabVIEW biomedical workbench [17].

2. MATERIALS

A. Subjects

In this study, the comparision of force between four normal subjects and osteoarthritis patients are taken. The osteoarthritis patients are considerably above 40 years of age. Generally patellofemoral joint involved mainly in knee osteoarthritis. We choose to measure the force in patellofemoral joint when the subject undergone the walking movement.

B. FSR sensor

The FSR sensor is used to measure the force. This made to fit into the knee brace on PF joint. This sensor is used to acquire the force in the patellofemoral portion of the knee when the patient undergone the walking activity.

Features

➢ Thin film technology
➢ Pre-conditioned analog output
➢ High signal to noise ratio.

Fig.2: Position of the sensor

C. LabVIEW Software

The NI ELVIS is interface with LabVIEW software for data acquisition. This acquires all the data information from the hardware circuit and processed. This software consists of block diagram and control panel. The outputs are obtained in the form of graph. The Data assistant is used
to acquire force data from the circuit and the two waveform charts are used to display the output graph for each sensor respectively.

Fig 3: LabVIEW Software

D. Hardware

The circuit connection is made in the NI ELVIS hardware. The hardware acquires the force from the sensor. The NI ELVIS is made to interface with the LabVIEW software. In this circuit, two IC OP07 is used for each sensor respectively.

Figure 3 shows the circuit connection which is made in NI ELVIS hardware. This is used to interface with the FSR sensor. Here, two inverting amplifiers are used for each sensor respectively. The operational amplifier OP07 is used in this circuit. This hardware is used to acquire the force of patellofemoral region from the sensor and the interface with the software.

Fig 4: Circuit connection in NI ELVIS

3. METHODOLOGY

- Design a hardware circuit
- Measure the force in right and left patellofemoral joint using FSR sensor
- Results are obtained from LabVIEW software
- Compare the result for normal and OA subjects
Fig. 5: Flow Chart

The two FSR sensors are fit into the knee brace which is placed on the patellofemoral portion of the knee. These two sensors are considered as the sensor 1 and sensor 2 respectively. These sensors are fitted to right and left knee separately. The patients are made to undergone the walking activity for the duration of three minutes. During this activity the forces of knee joint are measured by the NI ELVIS hardware in which the circuit is connected. The data of measured force are acquired by the LabVIEW software and then processed. The output of the software which is the raw data are then signal processed by using mean and standard deviation.

Fig 6: The whole experiment set up

4. RESULTS

The results obtained from the LabVIEW software which is then signal processed by mean and standard deviation. The below table represent the mean and standard deviation for each normal subjects and osteoarthritis patients respectively.

| SUBJECT | SIDE    | MEAN  | STANDARD DEVIATION |
|---------|---------|-------|--------------------|
| 1       | RIGHT   | 2     | 0.0202             |
|         | LEFT    | 2     | 0.0192             |
| 2       | RIGHT   | 3     | 0.0253             |
|         | LEFT    | 3     | 0.0264             |
| 3       | RIGHT   | 4     | 0.0284             |
|         | LEFT    | 4     | 0.0292             |
| 4       | RIGHT   | 5     | 0.0252             |
|         | LEFT    | 5     | 0.0264             |

Table 1: Mean and standard deviation value for normal subjects and OA patients

In this work, the force is measured for different subjects using two FSR sensors which is connected with the NI ELVIS hardware and obtain the results in labview software and compare the results with normal subjects and osteoarthritis patients.
Fig 7: Mean value for sensor 1 and sensor 2

From Figure 6 shows the mean value for normal subjects and OA patients of force measurement in right knee.

Fig 8: Mean value for sensor 1 and sensor 2

From Figure 7 shows the mean value for normal subjects and the OA patients of force measurement in left knee.

Fig 9: Standard deviation value for sensor 1 and sensor 2

From Figure 8 shows that the standard deviation value for force measurement in the right knee.
Fig 10: Standard deviation value for sensor1 and sensor2

From figure 9 shows that the standard deviation value for force measurement in the left knee.

5. DISCUSSION

In this study, the comparison of force between normal subjects and osteoarthritis patients has been made. The results are obtained by the LabVIEW software in the form of graph. In various studies the LabVIEW software also measures the ECG signal by using feature extractor which picks up from the different dry electrodes[17]. Here, these results are then signal processed by mean and standard deviation. FSR sensor is used for the force measurement. This FSR sensor also used for the further application to detect the Diabetic foot ulceration. This sensor helps to track the location system[18]. Since, this sensor is considered as low cost, it is used in many other application. This sensor also known as the flexi force sensor. FSR sensor is consider for force control application in robotic or biomechanical application[19]. In other method, this sensor is made to fit into the unloader knee brace in order to measure the kinematic data.

In this work, the force measurement has been determined by using two FSR sensors (S1,S2). The sensors fit into the knee brace and allow the subjects to undergone walking activity within the duration of three minutes. The outputs are measured in the patellofemoral region of right knee and left knee separately shows the decrement of force in OA patients when compared to normal subjects.

The obtained value can be compared by using the mean and standard deviation value of force measurement in two sensor. In this, the statistical analyse shows that standard deviation obtained the greater value. These results are obtained by the walking movement of the normal subjects and the OA patients.

6. CONCLUSIONS

In this work the forces in the patellofemoral joint was obtained by using FSR sensor, the results suggests that OA patients has a high decrement of force when compared to the normal subjects. Since OA is consider as incurable in nature it also decreases the force in human walking movement.

The future research will involve in developing customized knee brace model which can be an comfort fit to OA patient in order to reduce the pain in joints.

7. REFERENCES

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