Analysis of Sitting Posture Recognition using Pressure Sensors

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***Abstract*—The sitting posture is one of the most common posture a human being performs. It is usual to see that most of the time, human sit down while doing their activities such as studying, desk work and meetings. Researchers study sitting postures by using sensors such as piezoelectric resistors, fiber optics or even gyroscopes. For our study, we utilize pressure force resistive sensors (FSR) to investigate the sitting posture of students in a lecture environment (classroom). At first we design setup of sensors for measuring pressure during sitting position using pressure sensors, then we analyze sitting posture of the students by using force sensitive resistor sensor and later we investigate the efficiency of the pressure sensing system. We used 11 FSR which is the significantly small amount of sensors at the hipseat and backseat to identify the eight different sitting the posture of the subject at 1 Hz frequency of measurement. Even though the weight of the subjects vary from 40 to 100 kg, the accuracy was acceptable at 90%. Additionally we performed experiments in actual running lecture sessions and later performed quiz to relate the sitting posture with the focus/concentration of students in the class**.

***Index Terms*—Sitting Posture; Force Sensitive Resistors; Hipseat; Backseat; Pressure Sensors.**

I. Introduction

Sitting is one of most common posture everyone performs in their daily life. Students especially spend more time sitting while studying in the classroom. Most of the time students in class pose in inappropriate sitting postures due to the long hours of lectures or activities. There are many bad side effects due to poor prolonged postures such as neck and low back pain. If these conditions persist, students may face many medical ailments that may affect their present and also future life. The illness which comes from bad sitting posture also disturbs the student's focus on studies in the classroom and indirectly affects the student's result.

Currently, pressure mats are a useful device to display pressure exerted at certain points of the body in contact. It is widely used in hospitals to measure bed-ridden patients sleeping posture on the bed to determine their wrong and inappropriate postures. Pressure mats were also used on floors to measure forces exerted on a human subject while walking. In these mentioned applications, a large amount of array of sensors and a processing unit (computer) is required.

Several researchers developed a specific arrangement of sensors and portable controllers that could measure sitting postures. Researchers in [1] developed a model to detect sitting postures using a gyroscope and the system is controlled using a mobile device. The system is controlled by Kinect and Piezoelectric sensors. The kinect sensor captures the person's lateral image and detects the head middle position of the body. 49 students participated in the experiments. The piezo sensors located at thoracic, thoracolumbar and lumbar positions were placed in a suit worn by the subjects. Another research [2] was done using piezoresistive (flexible force) polymer film. Researchers investigated the force distribution by using a three-by-three sensor array with 100 Hz sampling frequency. In another research [3], eight pneumatic bladder was used which shows a classification score of 89% for 11 postures, with an 8 Hz frequency. Other research includes pressure mat measurement with 256 sensors were tested with 4 different sitting postures at 2 Hz frequency [4], Hetero-Core Fiber Optic sensor measurements of 4 sitting postures at 10 Hz and 256 pressure sensor measurements at hipseat for 7 sitting postures at 10Hz which resulted in 85.9% accuracy.

While there are many types of research being done on posture detection and recognition [5]-[9], the numbers of sensors vary from 3 to 256 sensors. The larger the number of sensors will usually result in higher accuracy but also incur higher cost. However, it is also a fact that the controller/processor also contribute to the speed and accuracy of the recognition system.

In our proposed system, our goals are to design setup of sensors for measuring pressure during sitting position using pressure sensors, then to analyze sitting posture of the students by using force sensitive resistor sensor and to investigate the efficiency of the pressure sensing system. We further performed actual measurements of students in class and later gave quiz questions to assess the focus of the students.

This paper is organized as follows: Section II explains the measurements and tests of the force sensors on the hipseat and backseat, also describes the postures to be identified in the classroom environment. The results are presented and discussed in Section III while Section IV gives some concluding remarks on the research.

II. Measurements and Tests

The force sensor used in the experiments is the force sensing resistor module which has only two connections that represent resistor outputs. Thus, the sensor has to be placed in a voltage divider configuration (next to a 10k resistor) to represent the analog reading of force at the sensor, represented as in Equation (1);

$$A_{out} = \frac{FSR}{FSR + 10K\Omega} \times 5v \tag{1}$$

A. Initial Tests

The initial step was to observe any value of resistance at zero force, then giving different levels of force by fingers until it reaches the maximum value. The values are classified into light touch, medium squeeze and large squeeze. This experiment was done on one sensor only.

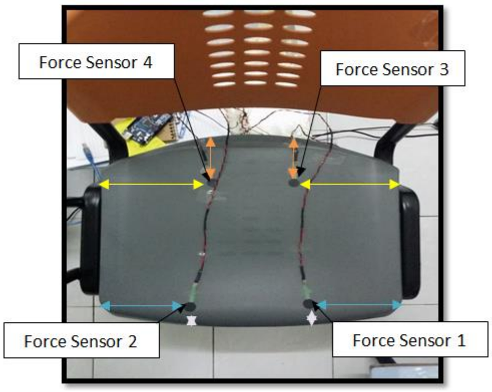

Figure 1: Posture test using four sensors

Next, four different postures were tested to ascertain the whether the correct threshold level was taken at the earlier experiment. The four postures are leaning right, leaning left, reclining and stooping. The experiment was done by only using four sensors at the hipseat as shown in Figure 1. Table 1 shows the location of the four sensors from the edges of the chair.

Table 1
Location of the four sensors on the hipseat

Length	Distance (cm)
Side of chair to back hipseat sensor	14.2
Side of chair to front hipseat sensor	12.5
Back of chair to back hipseat sensor	9
Front of chair to front hipseat sensor	5

B. Experiments using hipseat and backesat

At this stage, the force sensors were tested to function with threshold values to be obtained from a different range of weight of students. This time, 11 sensors were placed at both hipseat and backseat. The number of sitting postures was 8 and three different students with different weights ranging from 40 to 80 kg were tested. To ensure reliable values were measured, the experiments were repeated three times to obtain an average value. The highest and lowest values for each of the sensors were recorded at each sitting posture test before changing to another posture. Figure 2 shows the placement of the sensors on the backseat (3 sensors) and hipseat (8 sensors).

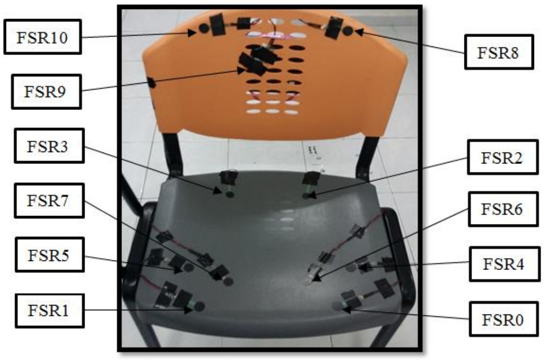

Figure 2: 11 sensors placement on chair.

When the threshold values are obtained, the system is set again to identify a certain sitting posture with the obtained threshold values. The sensors were properly placed in the hipseat and backseat and covered by soft fabric for the comfort of the user. The continuous reading of the sensors was later done at 1Hz frequency Then, the efficiency was tested by performing experiments on other students with more varied weights. Figure 3 shows the location of the controller and the image of the chair with fabric covering the sensors.

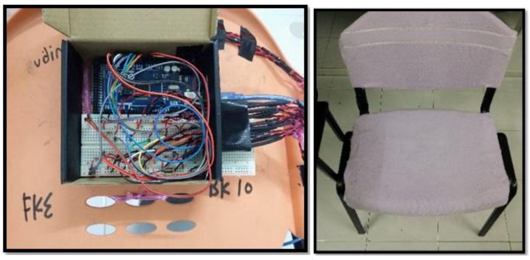

Figure 3: Controller placement and fabric-covered sensors.

Figure 4 shows the eight different postures tested for experiment B.

Figure 4: Eight postures tested for the experiment B.

C. Classroom experiments

With the prototype setup used in the previous experiment, the chair was brought into an actual lecture before the lecture starts. Then the system in a run once the lecture enters the room. While the student is listening to the lecture, the behavior (sitting posture) of the student and the displayed output is observed. The posture is confirmed by the images captured while the readings of the sensor were taken.

At the end of the lecture session, students were given a quiz to test their concentration on the materials in class. It is desired to investigate the relation of the sitting posture of students with their concentration in class. We assume that the relation between focus and correct answers are directly related.

III. Results and Discussion

For experiment A (initial force measurement test), the analog value read by the controller shows a linear relation between force (N) and resistance (Ohms) of the sensor, as shown in Figure 5. This shows that an increase in the resistance of the sensor corresponds to increase in force.

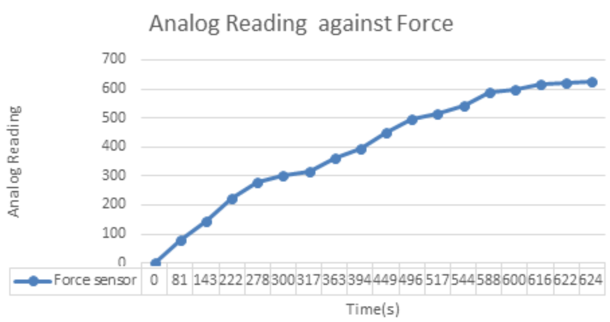

Figure 5: Analog reading against the force

For the experiments on sitting postures using four sensors, the results are shown in Figure 6 to 9. The analog values represented shown are average values of the sensor readings for each second of reading (1Hz sampling). FSR1 and FSR2 are front sensors while FSR3 and FSR4 as back sensors. All sensors were mounted on the hipseat.

It can be clearly seen which sensor shows higher reading due to the sitting posture. A left sitting posture would incur higher pressure on left sensors (front and back) on the chair and vice versa. Similarly if the human subject is leaning backward, the pressure is higher at the back sensors. The result of the readings shows that the measuring system is consistent and reliable.

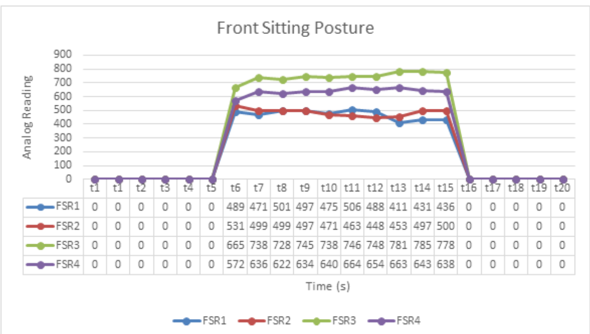

Figure 6: Front sitting posture result

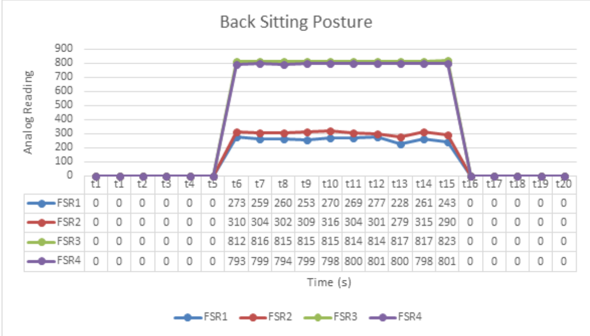

Figure 7: Back sitting posture result

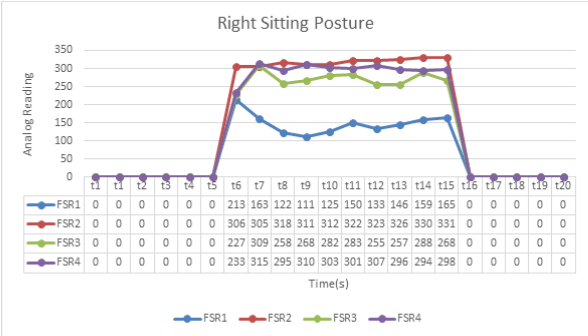

Figure 8: Right sitting posture result

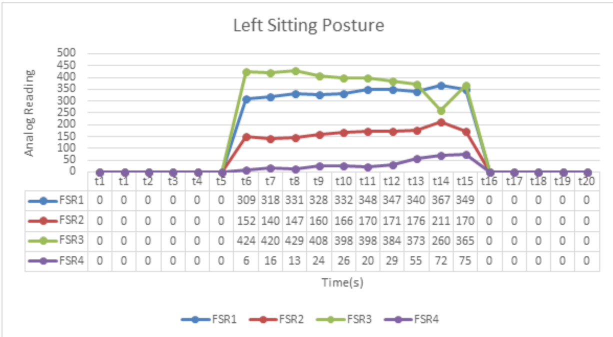

Figure 9: Left sitting posture result

For the next experiment (classroom environment), a sample of three subjects weighing 42kg, 50kg and 78 kg was taken during the lecture session. The efficiency of the eight sitting postures is shown in Figure 10 to 12.

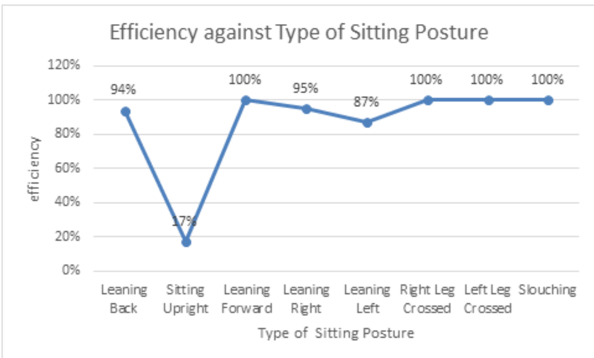

Figure 10: Efficiency results for 42 kg subject

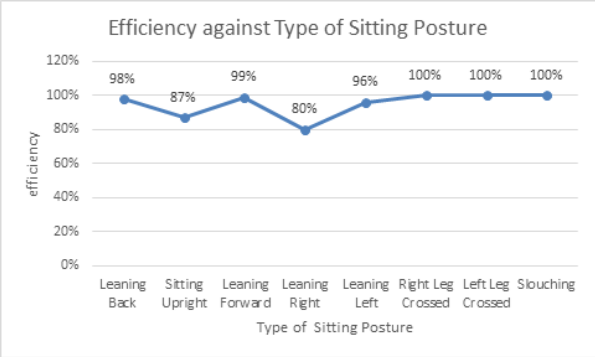

Figure 11: Efficiency results for 50 kg subject

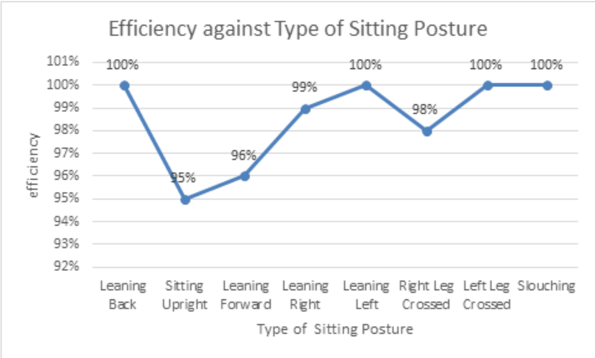

Figure 12: Efficiency results for 78 kg subject

The overall efficiency of the tests conducted for this experiment is shown in Figure 13. It can be summarized that sitting upright posture is difficult to achieve high efficiency because of different weights of the human subjects. Logically a person with higher weight has a larger hip size and will incur more pressure on almost all sensors, as compared to a person with less weight.

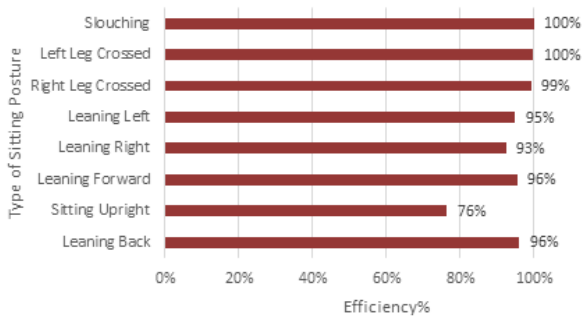

Figure 13: Overall efficiency of Experiment B

For experiment C on concentration/focus, the results are shown in Figure 14. From the results shown, the subject with the highest score (focus) was obtained from a person with a sitting upright position while the person with a slouching and leaning forward posture obtained lower results of focus. The other postures show a high score of focus.

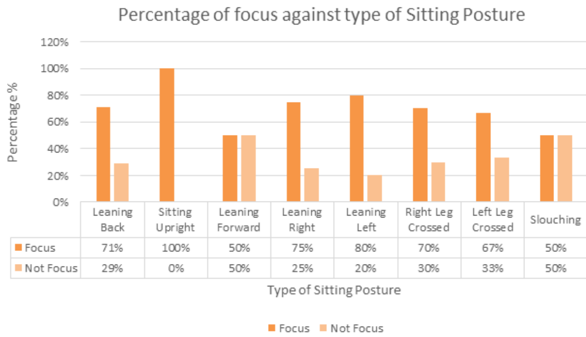

Figure 14: Sitting posture experiment for focus/concentration

IV. CONCLUSION

This research shows the implementation of a force sensor based measurement system to determine the posture of a person sitting in a classroom chair in Universiti Teknikal Malaysia Melaka. The initial experiments proved the success of recognizing the posture of the subject sitting on the hipseat with only four sensors. Next, the experiments continued with an increase in the number of sensors, which include both hip seat and back seat. It was shown that the controller was able to identify eight (8) different sitting postures, which were then tested on different weights of the subjects (from 40kg to 80kg) and later measured in real lecture (classroom) environment. A set of questions related to the lecture were given to each subject to assess their focus in class, in which we assume a direct relation between the results of the test conducted and the focus of the student.

As a future work, we intend to investigate further on the comparison of this method with other techniques of posture measurements and its relation to the human subject as one of the main indicators of the focus of the subject in a formal class environment. However, it is undeniable that other factors also affect the focus of students in the class. The significant of this study would benefit the teaching and learning instructors and administrators as they would know when the students start to lose focus and will plan for adjustments of teaching methods in the class.

ACKNOWLEDGMENT

Authors would like to acknowledge the funding given for this research, from Universiti Teknikal Malaysia Melaka, with the short term high impact grant PJP/2017/FKE/HI8/S01524. Authors would also like to express our gratitude to Robotics and Industrial Automation Research Group under the Center for Robotics and Industrial Automation.

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