Interactive Gesture Chair

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Abstract— **Nowadays, computer operators and office workers have a sedentary lifestyle. Technology is continuously improving, but our actions become more mechanic. Office employees have to stay in front of the PC almost all the day long and this sedentary behavior is not good for their health. As a consequence, people of all ages suffer through health problems which are related to ergonomic factors. Doctors always suggest to take breaks and move during work hours to decrease the probability of a chronic disease. We are proposing a system to interact with the PC using a chair. By equipping a chair with motion sensing, the movement gesture of a user can be detected which can be used as input device for the PC. We have applied a machine learning algorithm to calculate the threshold for detecting three types of gestures (tilt backward, rotate right, rotate left) to control Windows Photo Viewer. The user evaluation shows that more than 80% of the users found it interesting and they achieved around 92% accuracy while controlling the application.**

Keywords—sedentariness, gesture chair, Ergonomic factors, HCI, MPU-6050

I. INTRODUCTION

During everyday office work, we generally control our computers with keyboard and mouse sitting in front of them. When we work in our office in front of computer, we spend most of our work time in a sedentary way. We remain seated when we are on our way to the office by car, during meetings, during lunch, etc. This sedentary behavior is considered as an important ergonomic factor which may lead to a variety of chronic diseases for people of all ages [23]. Due to prolonged seating, people may suffer from back pain, neck pain, etc. Therefore, many proposals have emerged to keep people moving during their work day. However, for most of the office workers, it is difficult to achieve a considerable reduction of the time spent seated within the office environment. To promote physical activity even in such sedentary situations, this work explores the possibilities of using an interactive office chair to smoothly integrate physical activity into the daily working routine. By equipping a flexible chair with a motion sensor, the movements of a person sitting on the chair can be tracked and transformed into input events that trigger various actions on a computer. Besides, interacting with computers for a long period of time is tiresome also, so there is a need of an alternate way to do the tasks other than regular mouse and keyboard operations. This way, the "Interactive Gesture Chair" becomes an input device that is ubiquitously embedded into the working environment and provides an office worker with the possibility to use the movements of his body for rotating, tilting or bouncing a chair to intuitively control operations on desk computers. . Considering health issues, in our proposed architecture, the user has to move his body which is at least better than staying a long period of time in the same position. Recently, Massachusetts Institute of Technology (MIT) have started working on chair gesture [11][14][15]. Utilizing these chair gestures into a frequently used application is challenging. The success of this 'interactive gesture chair' depends on proper integration of the gestures with a frequently used desktop application. We can see that 'Windows Photo Viewer' is an application which is frequently used to view photos by the people of all ages and professions such as teachers, students, researchers, office workers etc. We have integrated our 'Interactive Gesture Chair' with a customized Windows Photo Viewer to watch pictures considering the ergonomic issues, which will reduce the probability of developing chronic disease.

We have collected data from sensors attached with the chair and labelled them with gesture names (tilt backward, rotate right, rotate left). We applied decision tree algorithm to automatically calculate threshold values to determine gestures. Afterwards, these gestures are mapped with windows commands to control the photo viewer application.

The rest of the paper is structured as follows. In Section II, we present the related work. In Section III, we describe our system design. Section IV discusses the implementation and Section V presents the evaluation of our proposal. We conclude in Section VI.

II. RELATED WORKS

Nowadays people are trying to design some natural ways to interact with computers instead of mouse and keyboard. To follow that, people are equipping sensors with frequently used things to establish communication with a PC. A chair is one of the frequently used pieces of furniture to be equipped with sensors to use as input device of computer. In the previous works of Media Interaction Lab [14][21] they have used Gyroscope and Accelerometer to detect movement of the chair and controlled multimedia player by some defined gestures. Another chair based gesture detection [15] uses Lumia smartphone for getting sensors data which performs both music player control and Web browsing. The Unadorned Desk [22] is an example for this kind of interaction. It uses physical space around a desktop computer for mouse input. Internet Chair [6] was used for performing tilting, rotating gestures for browsing and

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navigation through Web pages. ChairIO [1] introduced chair based gaming control like joystick. The ChairMouse [3] translated natural chair rotation into cursor movement for effective navigation through large displays.

In all existing works, thresholding approach is applied to detect gestures. Thresholding does not work properly because the threshold was empirically determined which has some problems in case of gesture variation produced by various users of different weight and height. Thresholding does not give a universal threshold value that will work for every user. We have collected data of the people of different regions of the world such as Africa, Middle East and Asia and then we applied a decision tree algorithm. The decision tree would give better result than a threshold.

III. SYSTEM DESIGN

To detect the movements of the chair we need to equip the chair with accelerometer and gyroscope. For that we need a Magnetic Pickup Unit (MPU), MPU-6050 sensor. MPU-6050 is an Inertia Measurement Unit (IMU) sensor. Among many IMU sensors, we found that MPU 6050 to be the most reliable and accurate IMU sensor. Apart from being significantly cheaper than the other sensors, the MPU 6050 performs much better too. The MPU 6050 is a 6 DOF (Degrees of Freedom) or a six axis IMU sensor, which means that it gives six values as output: three values from the accelerometer and three from the gyroscope. The MPU 6050 is a sensor based on MEMS (Micro Electro Mechanical Systems) technology. Both the accelerometer and the gyroscope are embedded inside a single chip. This chip uses I2C (Inter Integrated Circuit) protocol for communication [23].

The MPU 6050 communicates with the Arduino through the I2C protocol. Arduino [24] is an open source framework, a mega board to read inputs from sensor such as MPU 6050. The MPU 6050 is connected to Arduino as shown in Figure 1.

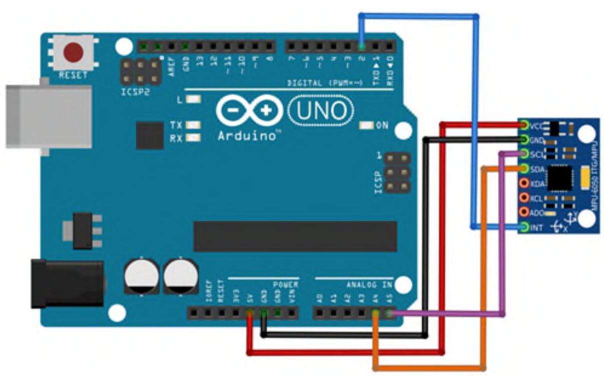

Figure 1. MPU 6050 interfaced with Arduino Mega

IV. IMPLEMENTATION

Our proposed system is shown in Figure 4. It is a portable system because we can move the chair anywhere while the sensors are accoutered at the back side of the chair. We have collected the data from the accelerometer and gyroscope for the people of different weights and ages for rotating right, rotating left and tilting back. Values have been passed through a Bluetooth device to PC from Arduino to analyze. We have used a machine learning algorithm which is a decision tree to find out the threshold value for 3 gestures (tilt backward, rotate right, rotate left). To apply a decision tree on our collected data we had to label our data by left, right, back and steady (no gesture). Before labeling our data we have discarded the first 200 data points from every gesture instance to remove noise. The main functionality of a machine learning algorithm is to classify the input data into a class. If an input data cannot be classified into any class then that input data is classified into no class. As ‘no class’ we have used ‘steady’ to define that the current input data cannot be classified into rotate left, rotate right or tilt back. After labeling the data, we made a file that includes only labeled data. We used that file as an input file for Weka [25] to run the decision tree on that labeled data. After running the decision tree on the labeled data, it generates a threshold value for every gesture as shown in Figure 3. We used that threshold values to define gestures. Using these defined three gestures, we have controlled Windows Photo Viewer. Rotate Right gesture is used to view next photo, rotate left gesture is used to view previous photo and Tilt Back Gesture is used to turn ON/OFF the slide show, as shown in Figure 2. The tabular representation of gesture mapping is shown in Table 1.

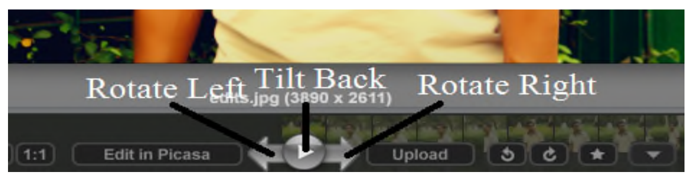

Figure 2. Definition of gestures

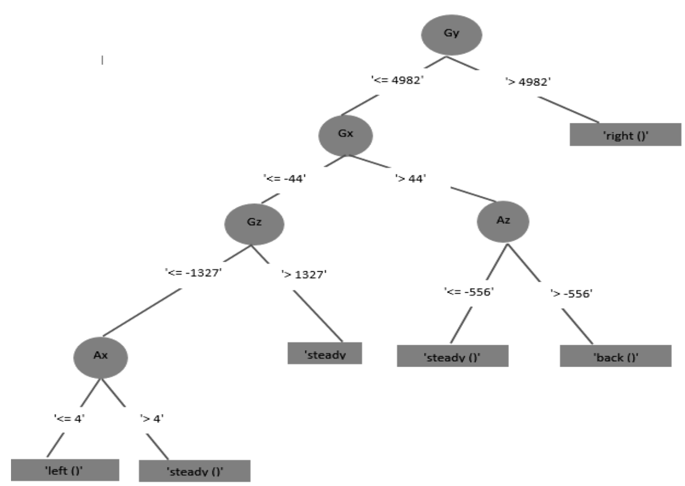

Figure 3. Result of decision tree

Figure 4. Back View of Chair

TABLE 1: TABULAR REPRESENTATION OF GESTURE MAPPING

Rotate left	To view previous photo
Rotate right	To view next photo
Tilt backward	To ON/OFF slide show

V. EVALUATION

The primary purpose of our evaluation was to evaluate the current system by end users to facilitate future change. We chose 10 users as participants to evaluate our system to different extent. They were selected based on their weight and height. Their weight was 46 to 146kg and height was 60 inch to 80 inch. Our experiment also shows that threshold depends on height and weight. That is why height and weight are important factors in gesture recognition. Participants were randomly assigned to perform some gestures from the set of defined gestures. We have defined so far rotate left, rotate right and tilt back gestures. For now we experimented with Windows Photo Viewer of Microsoft Windows 7. Some photos were selected and kept into a folder for this evaluation purpose. One of these photos was opened by Windows Photo Viewer. Then Windows Photo Viewer was controlled by the gestures, such as ON/OFF slide show, view next photo, view previous photo. Users performed various gestures in random order. Each of them performed different gestures for a specific duration of 300 seconds. During this time, the number of gestures detected for each user was slightly different. For example, one performed 70 gestures but another performed 56 gestures in 300 seconds. Also, we counted correct and incorrect detection of gestures. The error rate was around 5 per 60 gestures. There was another challenging issue of detecting tilt back gestures, people having more weight felt easy to perform the tilt back gesture. Users had to fill out a small questionnaire with various aspects of the experiment. We found almost 70-80% had found it interesting, 10-15% found it somehow cumbersome. Questionaries' also include some open ended questions about improving our system. Some said, it would be better if the program would have good graphical user interface. Some pointed out that, unintentional movement sometimes triggers meaningless gesture events. Participants seemed to be concerned about accidentally triggering actions on the computer through naturally occurring movements (e.g., fidgeting, stretching). Indeed, since users are constantly moving while seated on chair, a major challenge for chair-based interaction is how to effectively distinguish chair gestures from natural body movement that may occur unconsciously during regular work. An easy approach to avoid such unintentional input is to let the user decide when gesture input started by providing mechanisms to toggle gesture start or stop dynamically when they need. Some more manual mode-switching (e.g., pressing button on UI or maybe some voice controls) will be part of our future research. Moreover, some participants had bitter comments regarding the chair gestures as they became annoyed or tired when performing over a longer period of time. Since moving the whole body to perform gestures with an active chair involves more muscles than standard mouse or keyboard use, a certain level of fatigue may occur with frequently giving gesture input. However, we still can consider potential positive sides (i.e., breaking up the monotony, relaxing) over negative effects (i.e., fatigue, distraction) of the proposed gestural chair interaction.

VI. CONCLUSION AND FUTURE WORK

We designed a system considering the chair gestures as optional input modality so that people can use these gestures occasionally when they prefer to interact with computers. To do that a chair is accoutered with accelerometer and gyroscope sensors. These sensors data provides us the opportunity for real-time interaction with various types of computer applications. We applied decision tree to find a universal threshold on the sensor data to define gestures and we found a universal threshold for every gesture. For that we faced some challenges. One of the challenges was to detect tilt back gestures, people having more weight felt easy to perform the tilt back gesture but the people having less weight faced some difficulties to perform tilt back gesture. We have overcome this challenge by using decision tree algorithm. Another challenge was to distinguish chair gestures from natural body movement that may occur unconsciously during regular work. Therefore, in the future, we will attach an indicator which will tell the system when to apply gestures. Another challenge was to remove noise from sensor data. In the future, we will approach some other machine learning algorithms for improving detections of such gestures.

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