Monitoring of Rehabilitation Process Via Gyro and Accelerometer Sensor

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***Abstract*—This paper proposes a post-stroke rehabilitation system for hemiparetic-arm based on the application of both gyro and accelerometer sensor. The study focuses on designing, developing and simulating the results. The result is documented for the purpose of post-processing and progressive status tracking. The subject needs to wear a set of sensors over the wrist while performing a few basics arm movement. The data will be converted into series of readable data and saved into a microSD card then carried out to a computer for analyzing the pattern. The experiment demonstrates the capabilities of the sensors to produce extended information regarding arm movement activities. It is believed that the system offers more information than conventional method and also the ability to improve training quality, results and patients progress. For initial proof of concept, the system will be tested to a healthy normal subject.**

***Index Terms*—Post-stroke, hemiparetic-arm, rehabilitation, accelerometer, gyro, monitoring.**

I. INTRODUCTION

Post-stroke patients in Malaysia always turn to traditional massage and medicine as the alternative treatment [1], [2], [3].

The easy access, relatively cheap, convenient and less hassle compared to the one provided in the hospital that makes them go for the traditional. The question is how to measure the success of the traditional treatment? Will there be any record or data logged for its progress? How about the potential side effects produced by the herbs which are yet to be scientifically proven? [4].

II. LITERATURE REVIEW

It is learned that studies have been made in rehabilitation of stroke patients using gyroscopes and accelerometer. They have discussed the better way to covey the data to the computer for post-processing, how to correspond effectively between the sensors and the microcontroller and so on.

A web-based system for stroke patients have been developed which allow the result to be transmitted real time from the patient's home to their physicists over the Internet [5]. The chances of packet loss during the therapy may happen due to instability connection, resulting incorrect analysis by the therapists.

Another related contribution was done by R. Ambar, M. S. Ahmad, A. M. Mohd Ali and M. M. Abdul Jamil [6]. We notices that there are a few similarities between these system with ours. However, it is not comfortable to wear since too many sensor to hook up and a tedious to wear.

A wearable sensor which will be able to document the data during rehabilitation process, need to be considered. The proposed system is secured to a hand glove. The wearable sensor consist of a low-cost single-board microcontroller i.e., to handle data flow from the sensor, a gyroscope sensor; measuring orientation and also micro Secure Digital memory card (microSD) for data logging. The data will be used as the evidence of the progress for rehabilitation process.

This paper reports the development of an affordable wearable device which is capable to capture the data produced during the post-stroke rehabilitation session for monitoring the progress of the patient.

III. EXPERIMENTAL METHODS

The experimental methods have been composed of two exercises which are part of the rehabilitation treatment. The experiments are listed in Table 1. Each experiment need to clock at least a minimum of 1100 samples for the first experiment and 600 samples for raising hand activity. The reason behind this is that, both samples are referred to the movement made by a healthy subject.

TABLE I: SELECTED EXERCISES

Experiments	Execution Of Experiments
Palm movement	Able to move the palm clock-wise and anti click-wise.
Raising hand	Able to raise hand as high as possible

In this study, the exercises were done by healthy person. The measured person also tries to simulate post-stroke movements during the suggested exercises. In Figure 1, the subject is in the motion of rising and stabilizes his hand.

Fig. 1. Picture of a subject testing Wearable Data Acquisition System (wDAQs)

IV. DEVELOPMENT OF THE PROJECT

The elements of the system consist of two parts: the wearable sensor with integrated microSD card and accelerometer, and also a computer for data manipulation.

A. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega32. It has 14 digital input/output pins (of which 6 can be used as Pulse Width Modulation outputs), 6 analog inputs, a 16 MHz ceramic resonator, a Universal Serial Bus (USB) connection, a power jack, an In-circuit Serial Programming (ICSP) header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

B. 6 Degrees of Freedom ITG3200/ADXL345

The details of accelerometer setup for this project are discussed in the previous research work [7]. The board comes with a full 6 degrees of freedom. The sensors communicate over I2C and one INT output pin from each sensor is broken out.

C. MicroSD Shield

Communication with microSD card is achieved over an Serial Port Interface (SPI) interface. The Serial Clock (SCK), Digital Input (DI), and Digital Output (DO) pins of the microSD socket are broken out to the ATmega168/328's standard SPI pins (digital 11-13), while the Chip Select (CS) pin is broken out to Arduino's D8 pin.

D. Prototype

The final prototype setup showed the device that was attached to a glove that contains a microcontroller with accelerometer connected. The data will be saved into the microSD and then transferred to a notebook for the results. The prototype can be seen in Fig. 2.

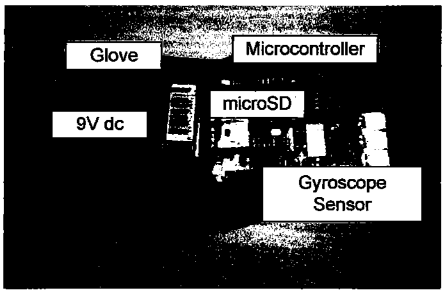

Fig. 2. The prototype Wearable Data Acquisition System

V. RESULTS AND DISCUSSION

From the experimental works, the followings are the recorded measurement for the developed device which has been segregated into three parts.

A. Managing the files in the microSD

Figure 3 represent the files in the microSD. Do note that the filenames are in order. It means that, every time the wDAQs is in use, it will not overwrite or amend the existing file, in fact, it will create a new file. The higher the number at the suffix, the new or latter the file will be. By having this system, the progress of every single treatment can be tracked and monitored easily.

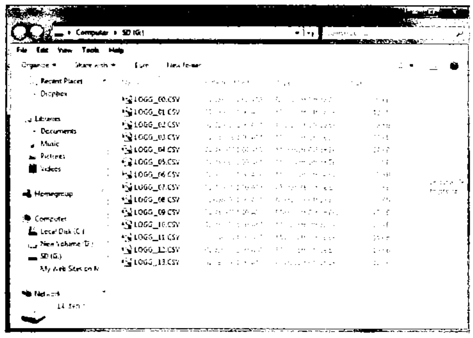

Fig. 3. Snapshot of files in the microSD

B. Exercise 1: Palm movement

During this modeling, the activities were resting right hand on top of a table, tilt to the right, then to the left and finally back to idle position. Focus to Fig. 4(a), it can be seen that the healthy subject is producing a smooth waveform for all axes which indicate ability to tilt the palm.

As for the simulated results for post-stroke patient in Fig 4(b), the pattern seemed distorted which indicated that the inability of subject to tilt neither to the right nor to the left.

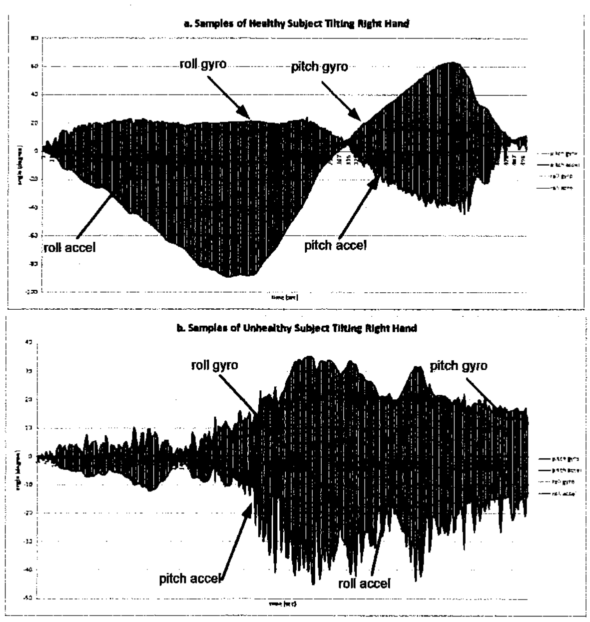

Fig. 4. Basic movement ability between (a) a healthy subject and (b) a simulated post-stroke subject

A. Exercise 2: Raising hand

Figure 5 is the results for the second modeling, i.e., raising the hand as high as possible. As for this experiment, only three segments involved; idle and resting the hand on top of a table, starts raising the hand and halt at the highest point as possible as shown in Fig. 5(a).

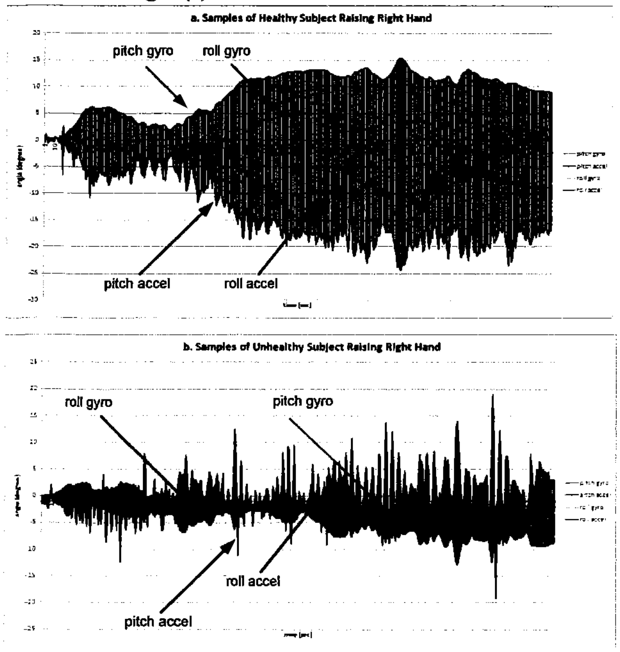

Fig. 5. Raising right hand activity between a (a) healthy subject and (b) a simulated post-stroke subject

As expected, in Fig 5(b), it can be concluded that the post-stroke subject unable to complete the task. This is due to the inability of either moving or raising his hands.

VI. CONCLUSION

In this paper, we have presented and evaluated the potential of combining accelerometer and gyroscope sensor for rehabilitation process of post-stroke patients. Experimental result shows that the prototype system successfully documented the movement of one's hand in the microSD. In addition the system also able to save the data in different filenames.

Based from the experiments, it can be seen that the application of this device can be extended to other area of physical rehabilitation such as physical movement and gait analysis. Furthermore, such system may also be used in evaluation of athlete's performance thus, the contribution of this study towards Sports Technology cannot be understated.

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