Exploitation of Accelerometer for Rehabilitation Process

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Abstract—This paper proposes a post-stroke rehabilitation system for hemiparetic-arm based on the application of accelerometer. The study focuses on designing, developing and simulating the results. The result is recordable and stored for post-processing and progressive status tracking. The subject needs to wear a set of sensors over the wrist while performing a few basic arm movements. Nevertheless, the sensor may also be worn to other body parts. In order to achieve the goal, the use of an accelerometer for rehabilitation is introduced. The data will be carried out to a computer where it will be converted into series of readable data. 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, monitoring.

I. INTRODUCTION

The motivation for this paper was derived from the rehabilitation of stroke patient in Malaysia itself. For years, it is a norm to apply local traditional medicine and medicine as the alternative treatment for post-stroke patients [1], [2], [3]. The reason behind this is that the access of the subject to those medications is easy, relatively cheap, and convenient and less hassle compared to the one provided in the hospital. The question is how to measure the success of the traditional treatment? Will there be any record or data logged for progress? How about the potential side effects produced by the herbs which are yet to be scientifically proven? [4].

II. LITERATURE REVIEW

It is interesting to learn that studies have been made in rehabilitation of stroke patients using accelerometer. They have discussed the better way to convey 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 physiotherapists via Internet [5]. There might be a chance to face packet loss during the therapy due to instability connection. The therapist will misjudge the results. The patient must ensure that there will be an Internet connection available regardless where he go.

Another related contribution that is R. Ambar, M. S. Ahmad, A. M. Mohd Ali and M. M. Abdul Jamil [6]. We notice 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, an accelerometer; to capture the acceleration raw data 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.

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TABLE I. SELECTED EXERCISES

<table>
<thead>
<tr>
<th>Experiments</th>
<th>Execution Of Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm movement</td>
<td>Able to move the palm clock-wise and anti clock-wise.</td>
</tr>
<tr>
<td>Raising hand</td>
<td>Able to raise hand as high as possible</td>
</tr>
</tbody>
</table>

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 raising and stabilize his hand.

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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 as shown in Fig. 2.

A. Arduino Uno

Figure 3 is the Arduino Uno, which 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.

![Fig. 3. Single board microcontroller: Arduino Uno](image)

B. Triple Axis Accelerometer MMA7361

While in Fig. 4, the MMA7260Q of Freescale is a sensor with easy analog interface. The MMA7260QT is a 3.3V part and outputs an analog voltage for each of the three outputs. This voltage is in ratio to the measured acceleration and to the supply voltage. It has selectable sensitivity by dip switch. Extra hardware is needed to convert this analog signal to a usable digital. The Arduino is really good option for it. This break board is especially designed for Arduino which has 3 Japan Solderless Terminal (JST) connector that can be easily plug into our IO/Sensor expansion board.

![Fig. 4. Triple Axis Accelerometer](image)

C. MicroSD Shield

Communication with microSD cards, as shown in Figure 5, 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.

![Fig. 2. Design of System](image)
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. 6.

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 7 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.

B. Exercise 1: Palm movement

During this experiment, the activities were (i) stand still (idle), (ii) tilt to the right, (iii) tilt to the left and finally (iv) back to idle position. Focus to Fig. 8(a), it can be seen that the healthy subject is producing a unique waveform for all axes which indicate ability to tilt the palm.

As for the simulated results for post-stroke patient in Fig 8(b), all segments produced almost the same pattern from beginning to the end of the experiment. It means that, the patient is facing the difficulties in doing the respected experiment.
C. Exercise 2: Raising hand

Figure 9 is the results for the second experiment, i.e., raising the hand as high as possible. As for this experiment, only three segments involved: (i) idle and resting the hand on top of a table, (ii) starts raising the hand and (iii) halt at the highest point as in Fig 9(a).

As expected, the documented data showed at all segment in Fig 9(b), 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 using accelerometer in rehabilitating post-stroke patients. Experimental results show that the prototype system successfully documented the movement of one's hand in the microSD and further more the system also able to save the data in different filenames.

Based from the experiments, it can be foreseen the application of this device can be extended to other area of physical rehabilitation walking analysis, gait analysis, etc. Thus can be done by replacing the glove with a velcro strap which the device will attach to it.

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