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**KORINT**  
YAYINCILIK

## AUTOMATED ARM REHABILITATION MONITORING SYSTEM

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### ABSTRACT

Based on the latest medical information and technology in physiotherapy, there are some weaknesses in terms of monitoring rehabilitation treatment carried out for example such as patients are monitored manually and hospital staff is not enough to monitor all patients undergoing rehabilitation treatment in a hospital. Therefore, we have decided to assist medical institutions in providing training to stroke patients by creating a system called "Automated Arm Rehabilitation Monitoring System". The system works by using motion or angle scans in units of degrees of movement on the affected limb and will be recorded in computer control by a physiologist as well as display a calculation of how many times the patient moves the hand on the LCD display. We also recommend a wearable arm rehabilitation device equipped with a monitoring system for stroke recovery. The proposed system is easily mounted on the arm with minimal external assistance. It has a data logging system that can store data on a PC for a specific period of time that can be used by physical therapists for further analysis as well as calculation of the data displayed on the LCD. By using this device, doctors and physiotherapists do not have to assist patients in recovery at home. By using a Y-axis acceleration sensor, we were able to improve the recovery process that could measure the rotational motion of the arm joint could provide more accurate analysis such as patient performance and limits on any particular recovery exercise.

## INTRODUCTION

Stroke causes a person to lose the ability to control part of the body's metabolism and affects the daily activities of patients with the disease. Most treatment centers or hospitals use manual methods for patient monitoring for physiotherapy treatment, this results in hospital staff x insufficient to monitor or pay full attention to stroke patients. So I took this opportunity to make this issue the scope of our project which is the scope of stroke treatment that will undergo physiotherapy. The project is designed to measure the level of arm recovery by measuring the level of arm flexion against the time taken to reach that level and data will be recorded at each treatment to see the recovery process. Thus, the final project is very important because it recognizes the ability of students to create a project. The final project is ideal for training students. The "Automated Arm Rehabilitation Monitoring System" project is to meet the requirements of the Diploma in Electrical Engineering (medical) for the Course module (DEE40082) according to the requirements set by the Ministry of Higher Education Malaysia (KPTM). The main purpose of the Course module is to produce students who are able to apply for Polytechnic-based learning. It is also important to train students to become more proficient in their field of study in line. This Automatic Arm Recovery Monitoring System is a project I am excited to do. Despite the many problems I encountered during the implementation process, it was worth what I learned.

This project is very important to help patients who suffer from stroke nowadays who are doing less and less physiotherapy exercise. The structure of this project is able to help stroke patients to increase motivation in doing physiotherapy exercises. Without this Automated Arm Rehabilitation Monitoring System patients often despair in doing physiotherapy because they cannot know the improvement in recovery, stroke patients may be neglected and ignored when relying only on medication given to the doctor and only doing physiotherapy. when there is an appointment in the hospital only. With a tool like this, patients can also perform physiotherapy exercises at home on a regular basis and can record data on their level of recovery. In addition, it can also help inadequate hospital staff to monitor all patients undergoing treatment in government or private hospital rehabilitation centers. Stock patients can also increase focus and motivation by undergoing physiotherapy training. new rays to improve training effectively when they see an increase in the graph and the number of times they bend their arms so they will continue training for recovery in a short period of time. hope to recover because they feel heavy to deal with the problems they face.

Stroke may be a disease that's caused by the breakdown of brain cells in some parts of the body thanks to insufficient blood or oxygen supply to the brain. it's also called the "Cerebrovascular Accident" or CVA. Medical institutions have made numerous studies on this disease and even engineering institutions haven't missed the chance to help medical institutions by devising some tools or systems for treating the disease. Thus, the system is meant to observe the event of the stage of stroke patient recovery. Today, many medical institutions use manual equipment like employing a "Goniometer" to record and monitor the flexibility of stroke patients to bend their arms. That's where we came up with the concept to form an "Automated Arm Rehabilitation Monitoring System" that may display data on the event of stroke patient stages like the acceleration of the arms bend, the power development graph, and therefore the number of coaching reps that the patient was able to perform in an exceedingly given period. With the creation of this technique, physiologists can monitor and even take

appropriate action within the treatment of stroke patients and might also motivate themselves and increase their focus in training.

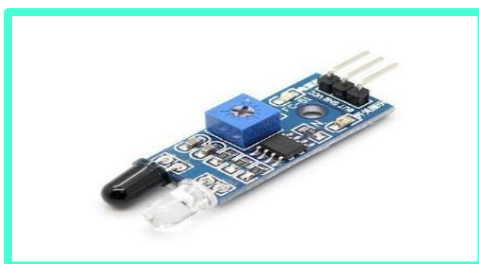
Therapy is the treatment of an individual physically without the employment of medicine or surgery. it's to heal an injured limb and reduce pain. Normally, movement therapy will enhance arm recovery but the effect varies consistent with the tactic used and timing. However, there are some problems that have happened rather than data, environment, equipment, and therefore the patient himself in health monitoring and rehabilitation. during this case, Sometimes the patient forgets to count the number of arm movements during therapy. So, they failed to get accurate data to understand the advance of arm movement. Besides that, the way of therapy that was done earlier could be a conventional method which is that they must count every arm movement during therapy. lastly, patients are inconsistent in making rehabilitation activities without using additional technology.

The main objective of the project is to develop an arm movement digital counter for therapy. To achieve the main objective, the work is divided into several components and carried out systematically with associated research objectives that have been identified as stated below.

- i. Designing a device that can measure the number of hand movements as well as developing an automatic movement counting system.
- ii. Assisting medical institutions in treating stroke patients and developing a system that measures the level of recovery and ability of stroke patients.
- iii. Increase patient focus and motivation to undergo physiotherapy training.

## METHODOLOGY

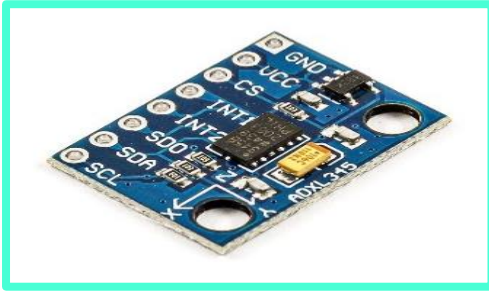
Various studies have been done to develop a prototype that can help control the development of physiotherapy. This study was done in terms of the sensitivity detected by the accelerometer sensor and IR sensor from the movement of the patient's arm. Hardware Products I use. It consists of an Arduino UNO microcontroller, an Infrared Sensor, an ADXL 345 (acceleration sensor), and an LCD I2 display. The Hardware Products I use. It consists of an Arduino UNO microcontroller, an Infrared Sensor, an ADXL 345 (accelerometer sensor), and displays an I2 LCD display.



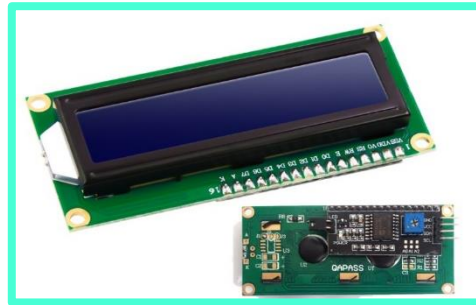
**IR sensor**



**Arduino UNO**



**ACCELERATION  
SENSOR GY-521**



**I2C LCD display**

### FLOWCHART

A flow chart can illustrate a process step. Figure 3.7 flow chart Figure shows a flow chart for an automatic arm recovery monitoring system. It consists of an acceleration sensor(ADXL 345) and an IR sensor as well as an Arduino that will transfer data to the PLX-DAQ excel as well as an LCD display.

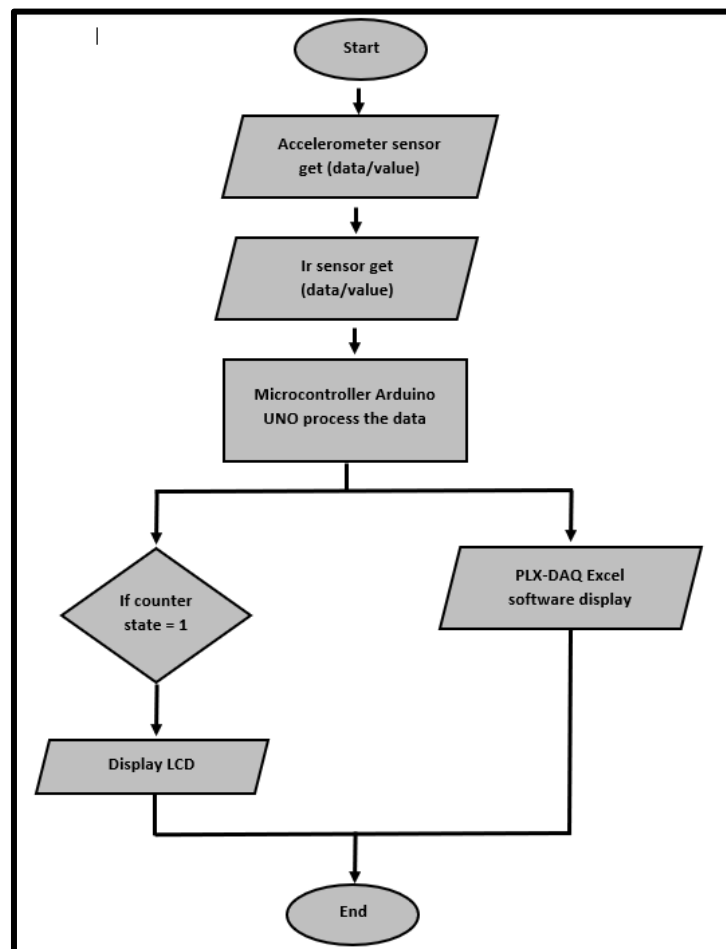
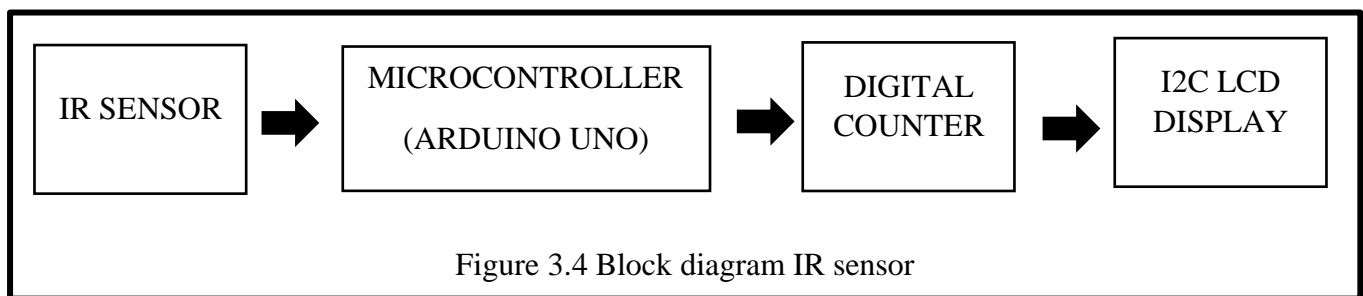


Figure 3.3 Flowchart of automated arm rehabilitation monitoring system

**BLOCK DIAGRAM**

A block diagram is especially focused on the input and output of a system. It cares less about what happens to get from input to output. Figure 3.5 show the block diagram IR sensor for the Development of the Arm Movement Digital Counter. There are 4 block diagrams consisting of an IR sensor, Microcontroller Arduino, digital counter, and LCD. Figure 3.6 show the block diagram shows the schematic diagram of The GY521 / ADXL345 acceleration sensor placed on the arm of the stroke patient. Every movement will be detected by the sensor, the measured data will be sent to the Arduino Uno. After receiving the Analog data from the accelerometer, it will be processed and converted to digital form by Arduino Uno. This data is then sent to excel using PLX to display the data and extract the graph. Analog data that has been measured by the sensor will be sent to the Arduino Uno and converted into digital form. This is the function of the microcontroller Arduino Uno. In PLX, simulation of the block diagram is used to show how to operate and achieve the goal. This diagram block will help explain briefly the fashionable Operandi of this system.



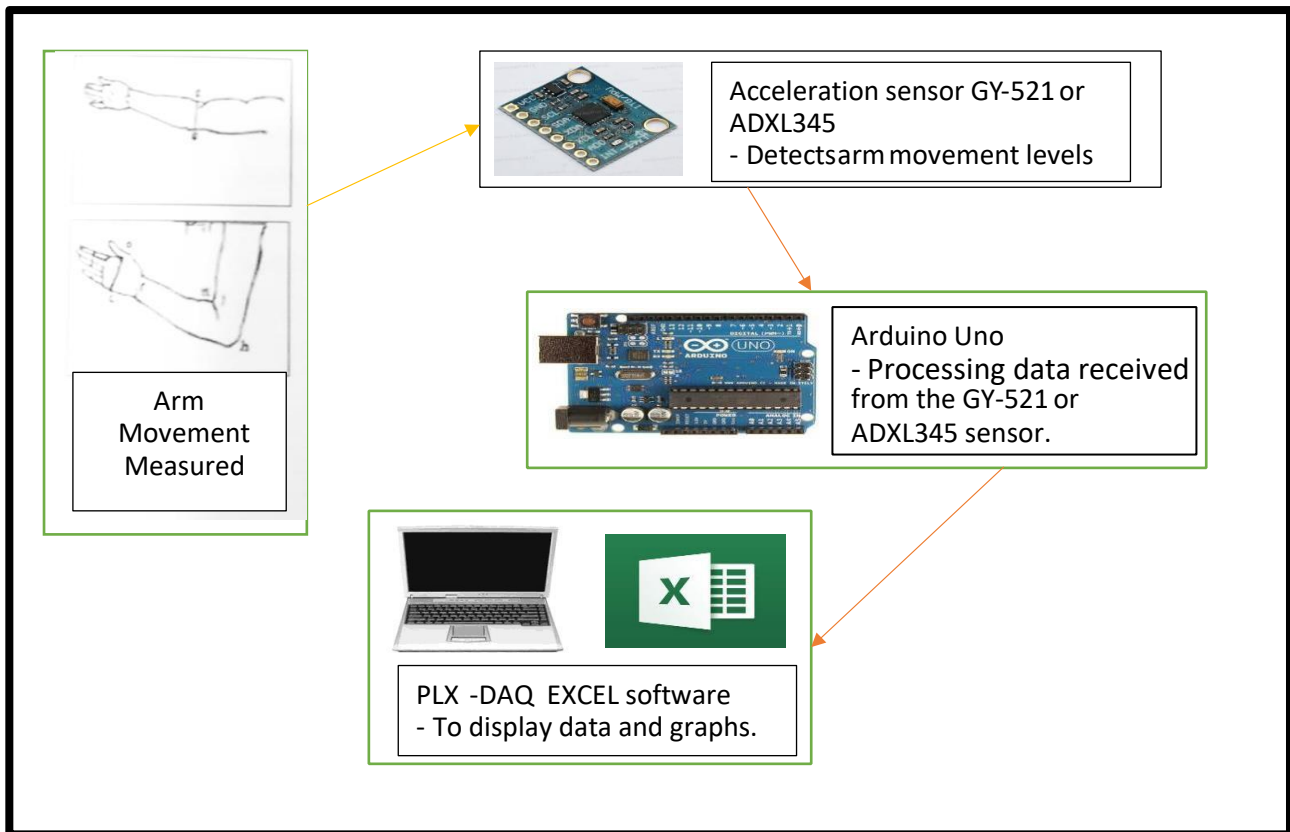


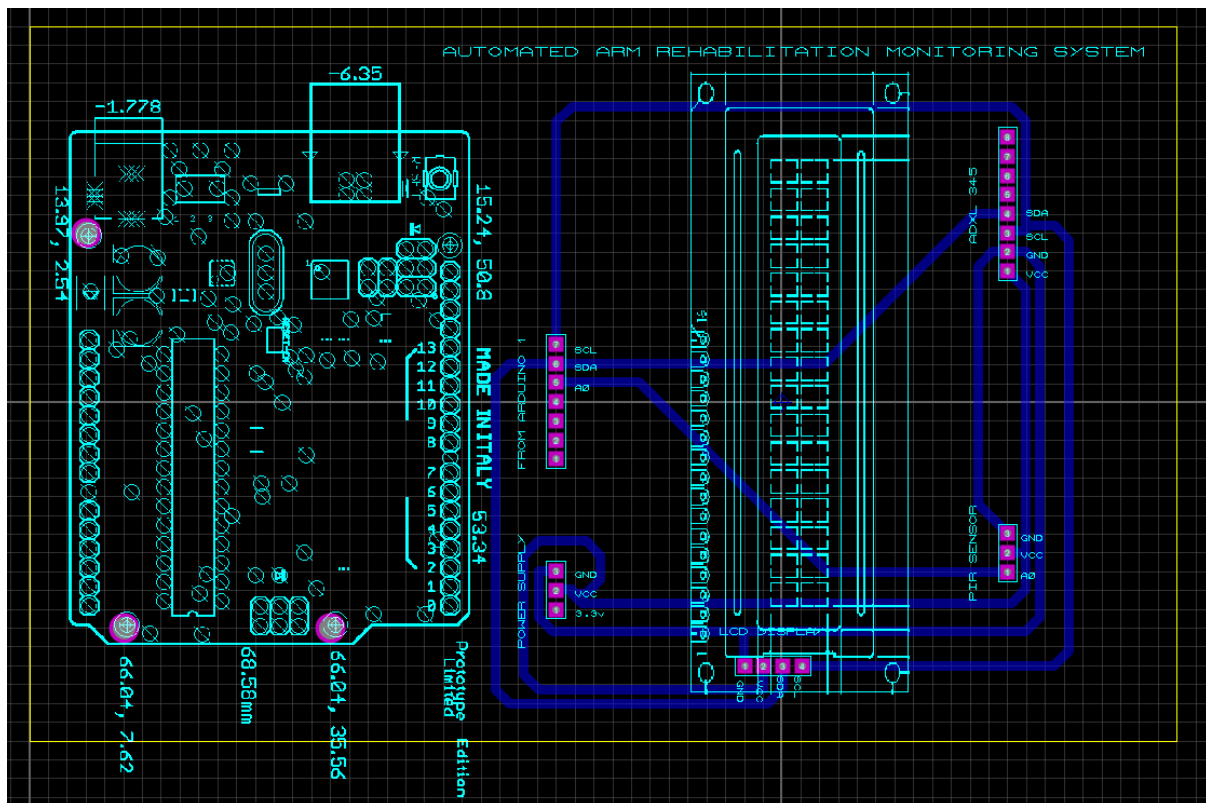
Figure 3.5 Schematic diagram of The GY-521 / ADXL345 acceleration sensor

#### The first stage is the GY-521 / ADXL345 acceleration sensor

- The sensor should be placed on the arm
- Measure the X-axis, Y-axis and Z-axis
- Generate analog data
- Send data to Arduino
- **The second stage is the Arduino Uno**
- Receive data from sensors in analog form
- Convert data to digital form
- Send to laptop
- **The third level is the laptop and the PLX-EXCEL**
- Receive processed data in digital form
- Using PLX-EXCEL software, import data
- Translate data in graph form.

## HARDWARE DEVELOPMENT

Figure 4.1 show the output of the circuit development design project that is ready to do the next stage, which will be assembling the component on the PCB after successfully testing the circuit by simulating the circuit. The entire schematic diagram is simulated using Proteus supported the flow chart and diagram that has been finalized. The Tinkercad Design Suite may be a suite of proprietary software tools used primarily for electronic design automation. Mainly electronic design engineers and technicians create electronic schemas and prints for the manufacture of computer circuit boards using the software. Figure 3.8 shows a schematic diagram simulation for an automatic arm rehabilitation monitoring.





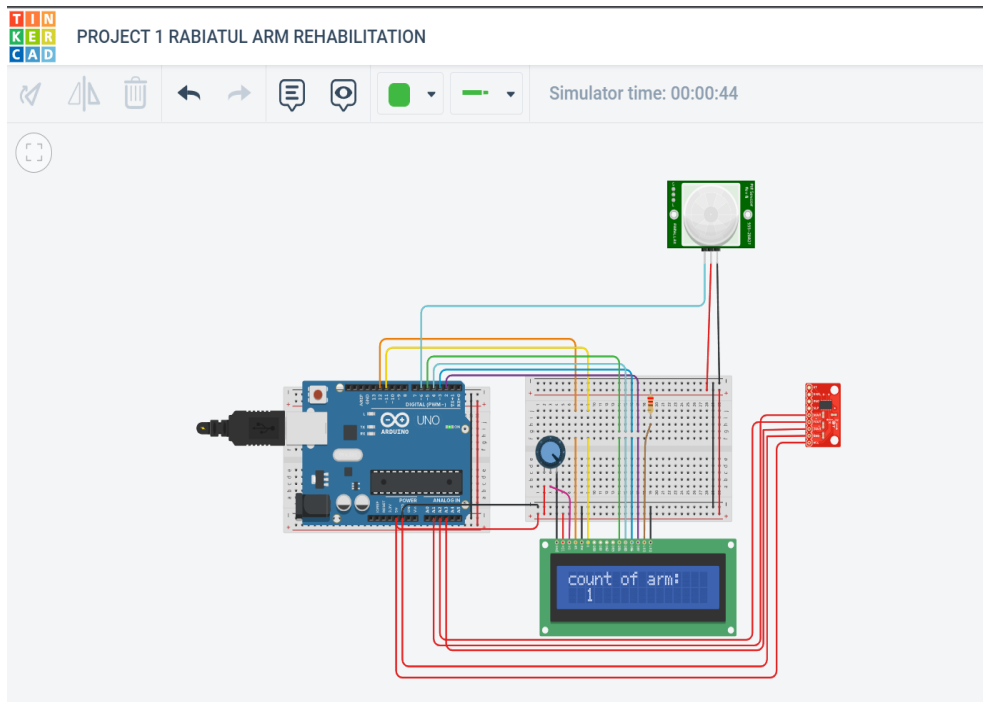
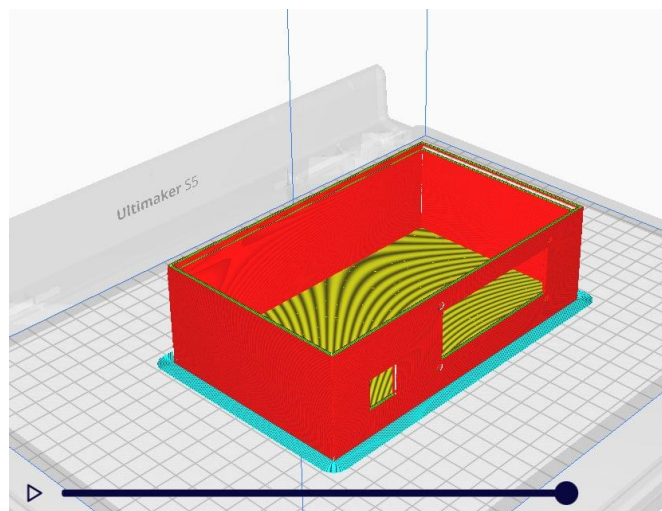


Figure 4.1 Hardware Development

### PROJECT DESIGN CIRCUIT

The process of design circuit can cover systems from complex electronic systems all the way down to the individual component within an integrated circuit. A systematic approach with intelligently guided computer simulation such as proteus, thinker Chad, AutoCAD, Ultimaker Cura and other. Figure 3.12 show that the 3D design of project that have been made in Ultimaker Cura to get the full description of the project. Figure 3.13 show the complete design of the project that can be use for arm rehabilitation monitoring system. First phase is the flowchart construction. This flowchart diagrammatic represents the illustrate designing and processing to Digital counter and IR sensor. The software system development can be divided as three parts, which are the schematic circuit, simulation circuit including Arduino coding and the Printed Circuit Board (PCB) Layout.



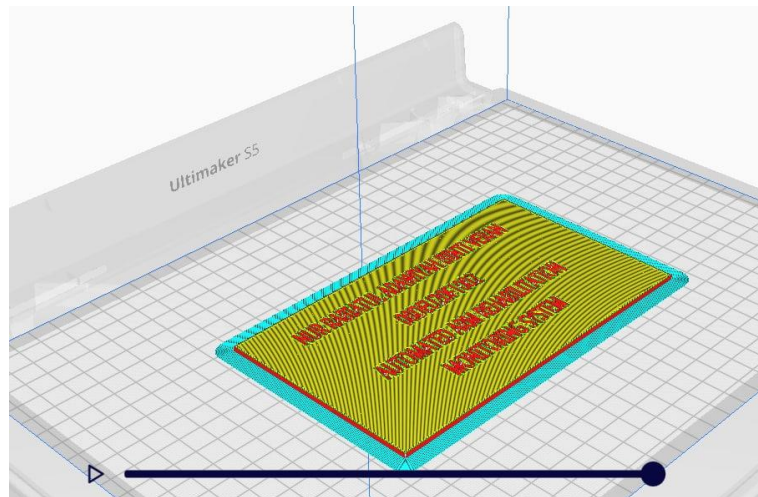


Figure 3.1 design circuit

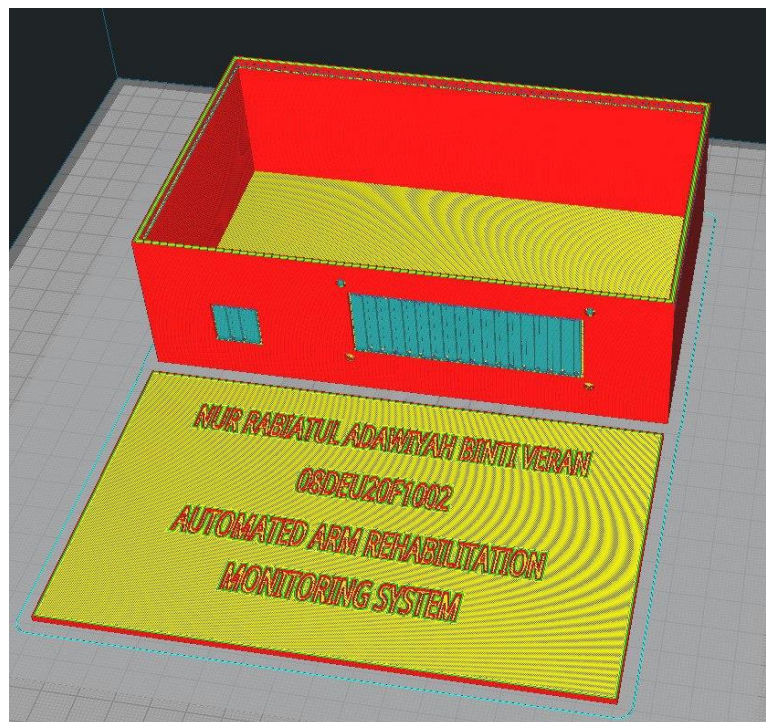


Figure 3.2 design circuit

## RESULT AND DISCUSSION

Table 1 and figure 4.2 shows the result of the rehabilitation therapy used for the patient during session therapy. The data, it will show that the capability of the patient's arm can be seen from the increase in arm angle performed each session. Therefore, patients and therapists can monitor improvement and see the progress of the patient's arm recovery. Data can be as evidence for analysis data the recovery process for the therapy session.

**Patient name:** Nur Ainul Mardhiah binti Omar

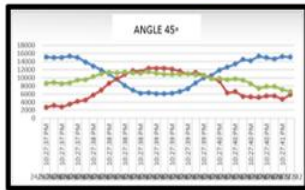


WEEK	SESSION	COUNTING ARM UP AND DOWN
1	1	6
	2	12
	3	18
	4	24
	5	30
	6	36
	7	42
2	1	6
	2	12
	3	18
	4	24
	5	30
	6	36
	7	42
3	1	6
	2	12
	3	18
	4	24
	5	30
	6	36
	7	42

Table 1: Result of rehabilitation therapy session

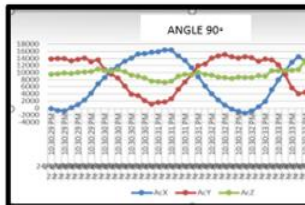
The process of measuring the acceleration sensor used in this project to analyze the readings taken for each axis (X, Y, Z) is shown in figure 4.3 below. The graph shows an increase as the position of the angle decreases. Readings will be taken at a time, during which any minor changes and movements will be recorded. The results of rough eye observation found that the results obtained were correct and realistic. The purpose of this project is to produce a Graph of a movement against time in seconds. Thus, patients and therapists can monitor that the patient is experiencing an improvement in the patient’s arm recovery progress. Finally, the data can serve as evidence for the analysis of recovery process data for therapy sessions.

**POSITION OF ARM AT 45 DEGREE, DATA AND GRAPH**



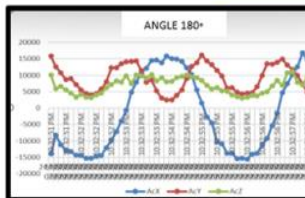
READING		
AcX	AcY	AcZ
15124	2696	8664

**POSITION OF ARM AT 90 DEGREE, DATA AND GRAPH**



READING		
AcX	AcY	AcZ
-188	13836	9468

**POSITION OF ARM AT 180 DEGREE, DATA AND GRAPH**



READING		
AcX	AcY	AcZ
-13912	15856	10048

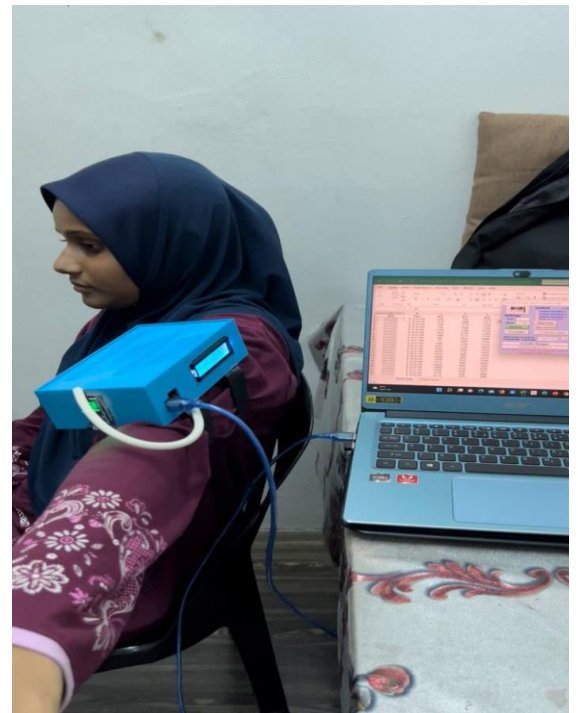


Figure 4.3 Graph Taken in Current Angle Graph of Accelerated Change Movement with Time

Then, Figure 4.4 show the position of an arm that apply for the rehabilitation therapy session. The arm must in the proper position. It is important to the patient that makes sure the position of the arm is in good condition and comfortable to get the accurate data to be analyzed and ensure the recovery process runs smoothly. From figure 4.4, equipment and hand position must follow the manual provided to ensure that the sensor used can detect accurately.



Figure 4.4 position of arm during rehabilitation therapy session.

Figure 4.5 shows the results displayed on the LCD that stroke patients and therapists can use for evidence to look at the recovery process. Therapists can analyze the data by getting results from LCD to know the arm recovery process by doing therapy sessions. Then, the data will be transferred into the therapy session results table according to table 1. Therapy sessions displayed by LCD can be done anywhere because the number of hand movements can be analyzed by connecting wires to a power bank. The project tool is also simple to be carried anywhere because of its flexible and light size as well as easy to carry during a vacation abroad.

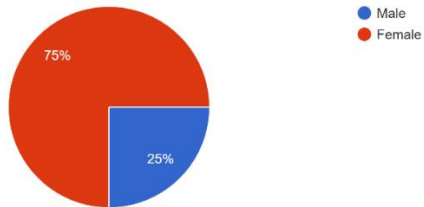


Figure 4.5: Results are displayed on an LCD and a project tool connected to a power bank

### NEED ANALYSIS / MARKET ANALYSIS

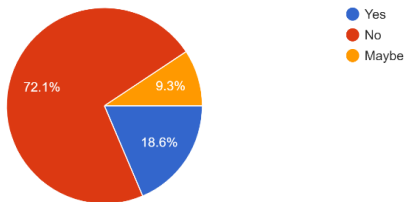
What is your gender?

44 responses



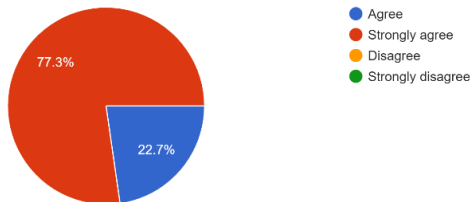
Is there an automated arm rehabilitation monitoring system on the market now?

43 responses



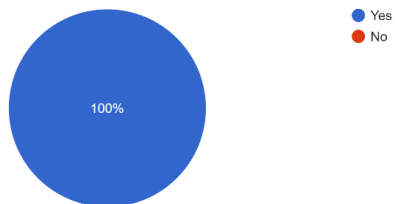
If not, do I need to make this product in the market?

44 responses

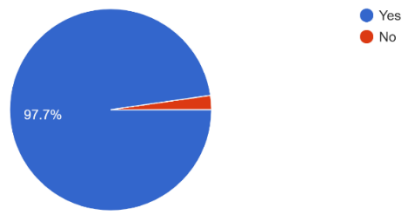


Does this product help people who have arm movement problems?

44 responses



Do you think this project can help medical institutions in treating stroke patients?  
44 responses



## CONCLUSION

In conclusion, this project proposes a monitoring recovery activity by using an IR sensor and accelerometer SENSOR(ADXL 345) to calculate arm movement. The project may be able to motivate patients in daily rehabilitation activities for the recovery process. The design of a device that can measure the number of hand movements will help patients perform therapy easily by getting help to measure movements from sensors. In addition, developing an automatic movement calculation system can help people, especially patients who are less motivated to do therapy to get energy for therapy sessions. Then, they can know the extent of the daily recovery activities for the recovery process. Next, analysis of the capacity arm movement data for the patient can be obtained from the LCD board as accurate data is then transferred into a table box showing the increase in the capacity arm. Next, the patient can know the steps and predict the recovery process by doing daily recovery. Finally, I have managed to create a system that can give the results we want that is the production of graphs for the movement of the arms of stroke patients. It has a log data system that can store data on a PC for a certain period of time that can be used by physical therapists for further analysis. By using the accelerometer sensor (ADXL 345), we were able to enhance the recovery process that could alter the rotational motion of the arm joint which could provide more accurate analysis such as patient performance and limitations to certain recovery exercises.

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