THE DEVELOPMENT OF SMART WRIST EXERCISE TOOLS FOR STROKE AND INJURED PATIENTS

NABILA BT MOHD GAHNI @ MOHD GHANI

POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

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NABILA BT MOHD GAHNI@ MOHD GHANI

THIS SUBMITTED IN PARTIAL FULFILLMENT FOR THE DEGREE OF

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DEPARTMENT OF ELECTRICAL ENGINEERING

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2017

ENDORSEMENT

I hereby acknowledge that I have read this report and I find that its contents meet the requirements in terms of scope and quality for the award of the Bachelor of Electronic Engineering Technology (Medical Electronic) With Honours

Signature : ....
Name of Supervisor : DR. HJ. ZUNUWANAS BIN MOHAMAD
KETUA PROGRAM
IJAZAH SARJANA MUDA TEKNOLOGI KEJURUTERAAN ELEKTRONIK (ELEKTRONIK PERUBATAN)
POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH
Date : 9/7/12

DECLARATION

I hereby declare that the final year project book is an authentic record of my own work carried out of one year Final Year Project for the award of Bachelor Of Electronic Engineering Technology (Medical Electronic) With Honours, Under the guidance of Dr. Hj Zunuwanas Bin Mohamad from 6 September 2016 to 15 May 2017.

Signature	: ....
Name	: Nabila Bt Mohd Gahni@ Mohd Ghani
Registration No.	: 08BEU15F3016
Date	: 21/6/2017................

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ABSTRACT

Stroke is a brain disease, which it causes spasticity and may occurs muscle weakness and also joint stiffness. Besides that, joint stiffness also will occur after joint trauma and with the Continuous passive motion (CPM) exercise, the joint stiffness can be reducing and also maintain the range of motion (ROM) of the joint. Physical training for stroke rehabilitation is an arduous process, because post-stroke rehabilitation programs are usually time-consuming and labor-intensive for both the therapist and the patient in one-to-one manual interaction. Recent technologies have made it possible to use robotic devices as assistance by the therapist, providing safe and intensive rehabilitation with repeated motions to persons after stroke. The most commonly reported motion types provided by developed rehabilitation robots are, continuous passive motion. Rehabilitation robots can be an assistance to the therapist, providing safe and intensive rehabilitation with repeated motions to persons after stroke such continuous passive motion(cpm). I improve this project by creating the product can help patient to make exercise continuously. Exercise after an injury or stroke can make it stronger and easier to move. The focus here is a robot for wrist rehabilitation designed to provide four rotational degrees of freedom. The normal range of motion of wrist Flexion 0° To 90°, Extension 0° To 90°, Abduction 0° To 25° Adduction 0° To 30. Movement should begin on the first day, should be very slow, and as much as possible it should be continuous. The purpose of this project is to develop of smart wrist exercise tool for stroke patient and injured patient to help stroke and injured patient can recovery faster. It is more comfortable to use, portable and easy to used anywhere. To develop this project, servomotor is use to move the wrist joint with controllable speed and the degree of movement by using Arduino. Furthermore, a rechargeable battery is added on the device that can bring the product everywhere.

Keywords—wrist exercise, continous passive motion(CPM),stroke

ABSTRAK

Strok adalah penyakit otak, yang ia menyebabkan kecacatan dan penyakit ini juga boleh berlaku kelemahan otot dan juga kekakuan sendi. Selain itu, kekakuan sendi juga akan berlaku selepas trauma dan dengan adanya senaman yang berterusan gerakan pasif (CPM), kekakuan yang bersama boleh dikurangkan dan juga mengekalkan pelbagai gerakan sendi (ROM). Latihan fizikal untuk pemulihan strok adalah satu proses yang sukar, kerana program pemulihan selepas strok biasanya memakan masa dan tenaga buruh diperlukan untuk kedua-dua ahli terapi dan pesakit dalam satu-sama-satu interaksi pengguna. Teknologi baru-baru ini telah dibuat untuk menggunakannya peranti robotik sebagai bantuan oleh ahli terapi yang menyediakan pemulihan selamat dan intensif dengan gerakan berulang-ulang kepada pesakit yang menghidapi strok. Jenis-jenis gerakan yang paling biasa dilaporkan disediakan oleh robot pemulihan maju adalah, gerakan pasif berterusan. Pemulihan menggunakan produk boleh dijadikan bantuan kepada ahli terapi serta menyediakan pemulihan selamat dan intensif dengan gerakan berulang kepada pesakit strok dengan gerakan pasif yang berterusan (cpm). Saya meningkatkan projek ini dengan mencipta produk yang boleh membantu pesakit untuk membuat latihan secara berterusan. Senaman selepas kecederaan atau strok boleh memberi kekuatan pada pergelangan tangan dan lebih mudah untuk bergerak. Fokus di sini adalah sebuah produk untuk pemulihan pergelangan tangan direka untuk menyediakan tiga darjah kebebasan putaran. Julat normal gerakan pergelangan tangan flexion 0 ° Hingga 90 °, Extension 0 ° Hingga 90 °, Abduction 0 ° hingga 30 ° Adduction 0 °hingga 30. Pergerakan harus bermula pada hari pertama, sangat perlahan, dan sebanyak mungkin ia perlu dilakukan secara berterusan. Tujuan projek ini adalah untuk membangunkan alat senaman pergelangan tangan pintar untuk pesakit strok dan pesakit cedera untuk membantu strok dan pesakit yang cedera boleh membantu pemulihan yang lebih cepat. Ia lebih selesa untuk digunakan, mudah alih dan mudah untuk digunakan di mana sahaja. Untuk membangunkan projek ini, servomotor digunakan untuk pergerakkan pergelangan tangan dengan kelajuan terkawal dan tahap darjah pergerakan dengan menggunakan program Arduino. Tambahan pula, bateri yang boleh dicas semula ditambah pada peranti bagi memudahkan dibawa kemana-mana.

Kata kunci— senaman pergelangan tangan, gerakan pasif berterusan (CPM), strok

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CHAPTER 1

INTRODUCTION

1.1 Background of the study

In Malaysia, stroke was the second leading cause of death according to the Malaysian National Burden of Diseases Study and study on vital registry system in 2000. Some strokes were reported as the leading cause of death in Indonesia, Myanmar, Vietnam and Thailand., However listed stroke as the third leading cause of mortality for males in Malaysia, in 2009, after ischemic heart disease and pneumonia [1].

Besides that, Stroke is a common and devastating disease. It is the second leading cause of death after coronary heart disease in developed countries and is the greatest cause of disability, leaving 50% of survivors permanently disabled. Identification of risk factors such as arterial hypertension, high cholesterol, diabetes and obesity [2]. Some progress has been made in effective rehabilitation following the acute stroke period) with evidence for improvements in motor recovery associated with high intensity and repetitive task-specific practice (e.g. constraint-induced movement therapy)

The patients who suffer movement problems in the daily life. Often, this problem experienced by the patient or an adult who is in critical condition such as stroke and injured in the Intensive Care Unit (ICU). This group requires great care so that they are in stable condition.

From journal Wolfgang H.R Miltneron January 25, 16, said that, Patients with chronic stroke were given Constraint-Induced Movement Therapy (CIMT) over an intensive two-week course of treatment and the results are consistent with the rehabilitation treatment having produced a use-d dependent cortical reorganization and provides additional credibility to the clinical data [3].

Therefore, " The Development of Smart Wrist Exercise for Stroke and Injured Patients" is a device that controls the part of body to do exercises. Doctors can know the improvement from the patients', Physical training for stroke rehabilitation is an arduous process, since post-stroke rehabilitation programs are usually time-consuming and labor- intensive for both the therapist and the patient in one-to-one manual interaction.

Rehabilitation robots can be an assistance to the therapist, providing safe and intensive rehabilitation with repeated motions to persons after stroke. I improve this project by creating the product can help patient to make exercise continuously. Exercise after an injury or stroke can make it stronger and easier to move. Von Riemke, in his presidential address to the Danish Surgical Society in 1926, stated that, "All joint affections should be moved. Movement should begin on the first day, should be very slow, and as much as possible it should be continuous." Salter, who invented the concept of continuous passive motion, which has come to be known as simply "CPM,"

1.2 Problem Statement

Based on survey obtained from physicians in unit of occupational therapy at Hospital, they used only manual therapy of wrist for stroke patients and injury. From what we can see, the lack of physiotherapy to maintain and monitor the patient's exercise in hospital because the are many patients to observation and do treatment at the same time. So, physiotherapy cannot give full attention to the patient.

In addition, patient is lack of motivation to do exercise to improve their health because a few people not believe to physiotherapy to do exercise .so with the product, it can increase confident level to do therapy.

Besides that, all the therapy devices are available in market are not portable. This will have caused the patient to do therapy session at hospital. A few patients not able to do physiotherapy at hospital and to speed up the recovery process of their twist. Patients need a device that will assist them in improving their hand in their daily living activities such as dressing, bathing and so on. This device will help patients to improve the movement.

1.3 Objective

The main objectives of this project are:

i. To develop smart wrist exercise tools to help stroke and injured patients can recovery faster.
ii. To design this product which is Portable and easy to used.
iii. To analyse usability of smart wrist exercise tools as therapy.

1.4 Study population

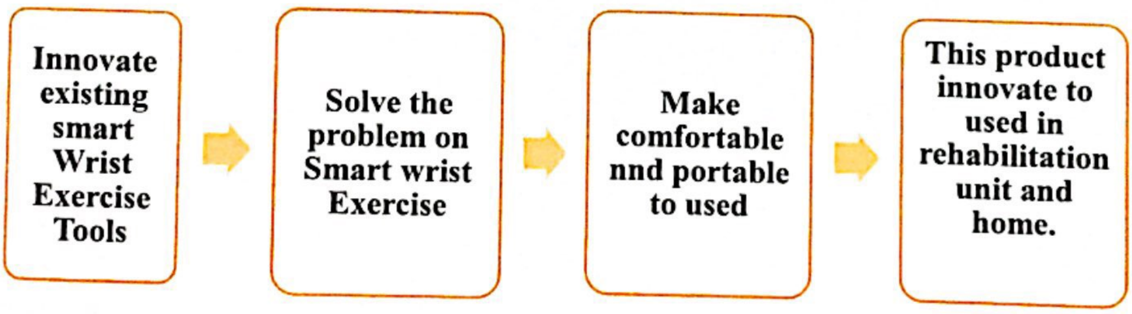
There are 3 types of stroke such as ischemic that caused by when artery to the brain is blocked. So, the doctor can give the stroke patient a blood thinner such as aspirin and warfarin. Then hemorrhagic stroke is caused by bleeding of blood vessels of the brain. While Transient Ischematic Attack(TIA) blood flow to part of the brain stops for a short period of time, these symptoms appear and last less than 24 hours before disappearing. The study population of my product are more focusing to hemorrhagic stroke.

1.5 Scope of study

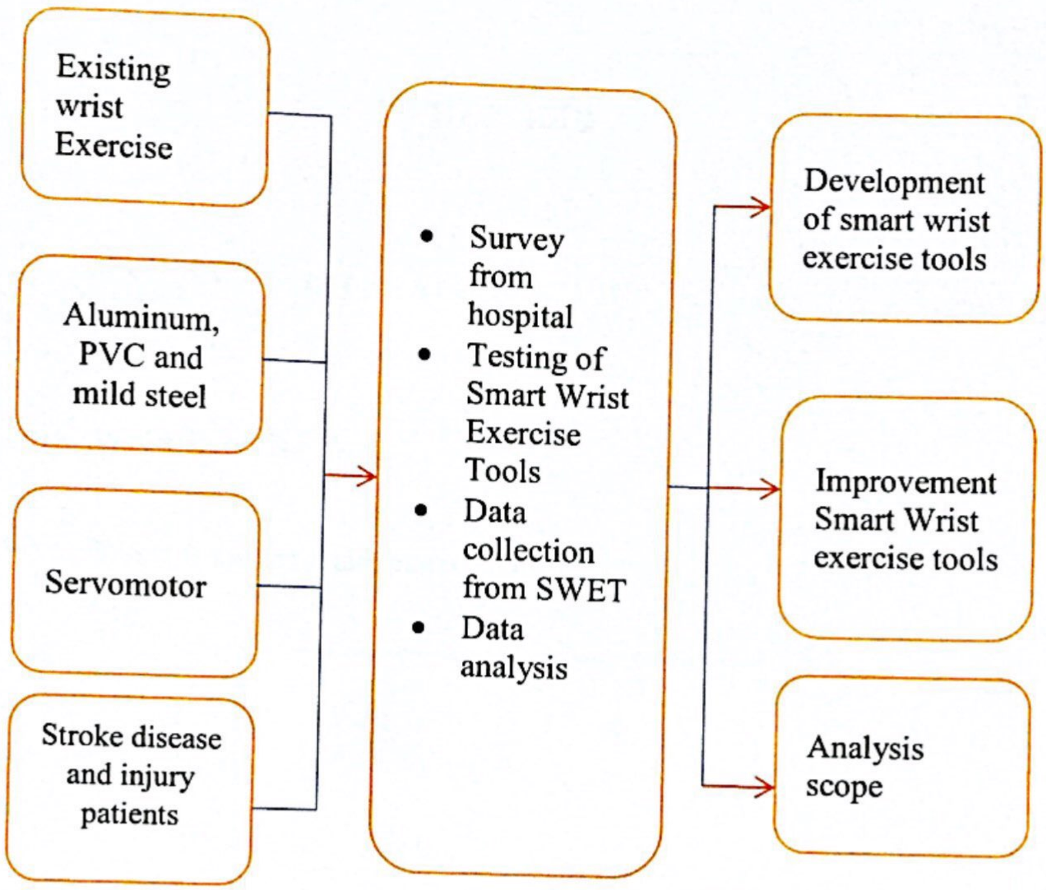
The scope for this project is to develop smart wrist exercise tools to help stroke and injured can recovery faster. Besides that, a portable smart wrist exercise tools can be easily carry and used at home. Both male and female patients will involve in the project analysis.

1.6 Significant Of the study

This study is to design the development of smart wrist exercise tools for stroke and injured patients. This project by creating the product can help patient to make exercise continuously. Exercise after an injury or stroke patient can make it stronger and easier to move and improve the movement. It also can help to short time recovery of them and can be used level of ages of human. And the project is to design which is Portable and easy to used.



1.7 Theorical Study



CHAPTER 2

LITERATURE RIVIEW

2.1 Smart Wrist Exercise Tools

2.1.1 What is smart wrist exercise tools?

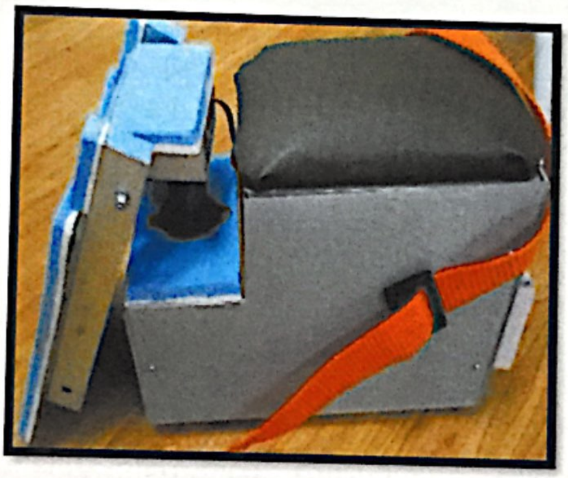


Figure 2.1: Smart Wrist Exercise Tools

Figure 2.1 showed the Smart wrist exercise tools are rehabilitation equipment that can be found and used in the physiotherapy unit and home. This exerciser is indicated for people with a problem at stroke disease and injured patients. It is used for wrist. Smart wrist exercise can perform the continuous passive motion to wrist for exercise to patients. The application of smart wrist exercise can be similar like movement of wrist.

This is a very helpful way to achieve exercise for human wrist when they are unable to move their hands. It is also being used to assist in repetitive movement practice following neurologic injury, providing insight into movement recovery and improve motor recovery [4] .

Rehabilitation wrist are gradually becoming popular for stroke rehabilitation to improve motor recovery, as robotic technology can assist, enhance, and further quantify rehabilitation training for stroke patients. However, most of the available rehabilitation wrist are complex and involve multiple Degrees-Of-Freedoms (DOFs). Rehabilitation robot needed to be useful but also should be cost-effective to be able to use in current rehabilitation process [5].

2.2 Stroke Disease (Disease That Can Be Help With smart wrist exercise tools)

2.2.1 What is strokes Disease?

A stroke is not a heart attack. A stroke happens when the supply of blood to the brain is suddenly interrupted. It also characterized by sudden onset of clinical signs related to the site in the brain where the morbid process occurs [6]. Some strokes are fatal while others cause permanent or temporary disability.

There are many different types of pain may experience after having a stroke. Weakness on one side of your body is one of the most common effects of stroke [7]. The longer a stroke remains untreated, the greater the chance of stroke related brain damage. Emergency medical treatment soon after symptoms begin improves the chance of survival and successful rehabilitation. Facial weakness, arm weakness and difficulty with speech are the most common symptoms or signs of stroke, but they are not the only signs.

The most common effects of stroke that leading cause of permanent disability in adults, with clinical symptoms such as weakness, spasticity, contracture, loss of dexterity, and pain at the. paretic side. Approximately 70% to 80% of people who sustain a stroke have limb impairment and require continuous long-term medical care to reduce their physical impairment [8].

2.2.2 Sign of stroke

A sign of stroke may include one, or a combination of:

i. Weakness or numbness or paralysis of the face, arm or leg on either or both sides of the body
ii. Difficulty speaking or understanding
iii. Dizziness, loss of balance or an unexplained fall
iv. Loss of vision, sudden blurring or decreased vision in one or both eyes
v. Headache, usually severe and abrupt onset or unexplained change in the pattern of headaches
vi. Difficulty swallowing

2.2.3 Types of Stroke

i. Ischemic" stroke (80% of strokes). This happens when blood vessels are blocked by a clot or become too narrow for blood to get through to the brain. The reduced blood flow causes brain cells in the area to die from lack of oxygen.
ii. Hemorrhagic" stroke (10% of strokes) The blood vessel is not blocked but it bursts and blood leaks into the brain causing damage.
iii. Transient Ischemic Attack (A mini-stroke) – the effects usually pass quickly but a TIA must be taken seriously as it can be a warning sign.

The figure 2.2 show the structure of stroke damaged from the Bruce Coull MD Is A faculty of The UA Department of Neurology at College of Medicine

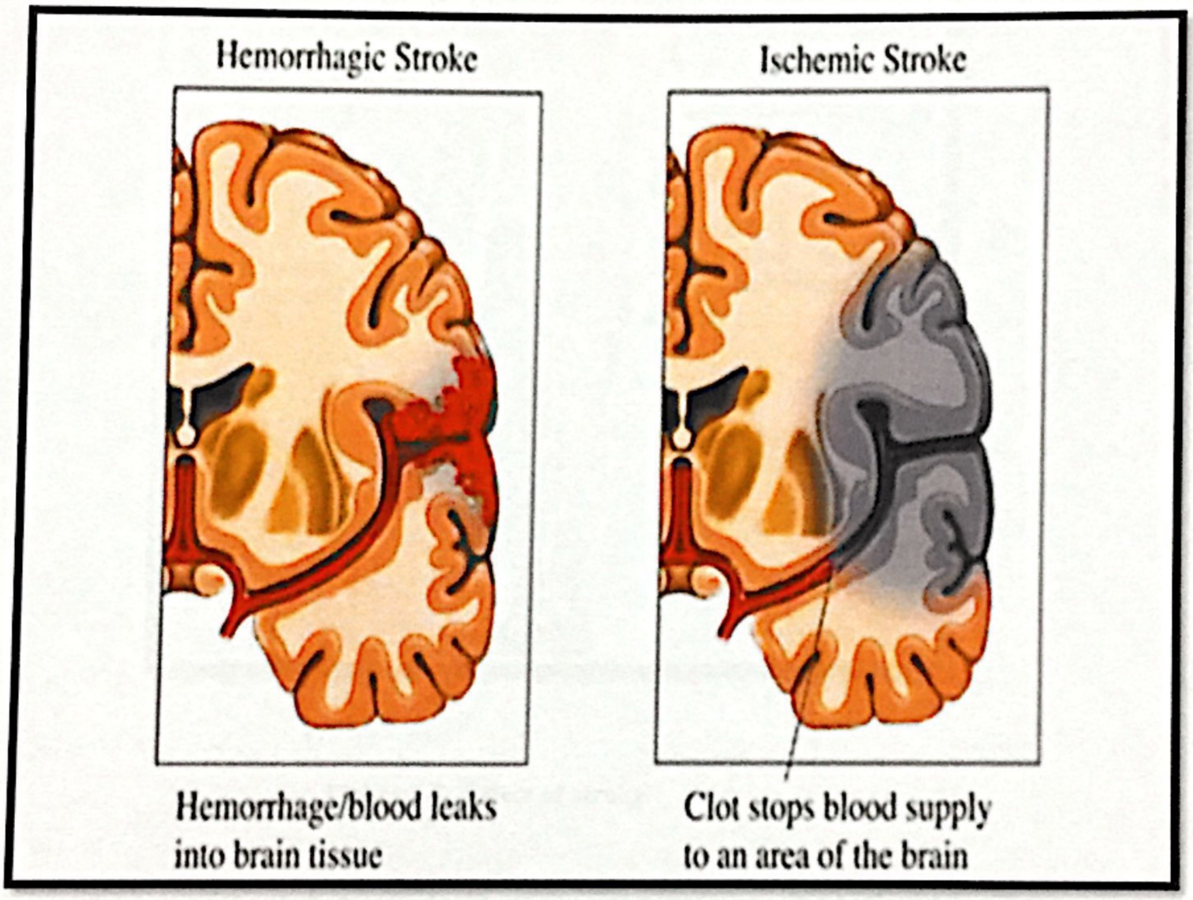


Figure 2.2: Structure of Stroke Damaged

2.2.4 Effect of stroke

The effects of a stroke vary from person to person, depending on which part of the brain is damaged and the extent of that damage. For some, the effects are relatively minor and short-lived; others are left with more severe, long term disabilities. Common problems include weakness or paralysis, Cognitive Problems, Problems Using Language and also Vision and Perception Problems

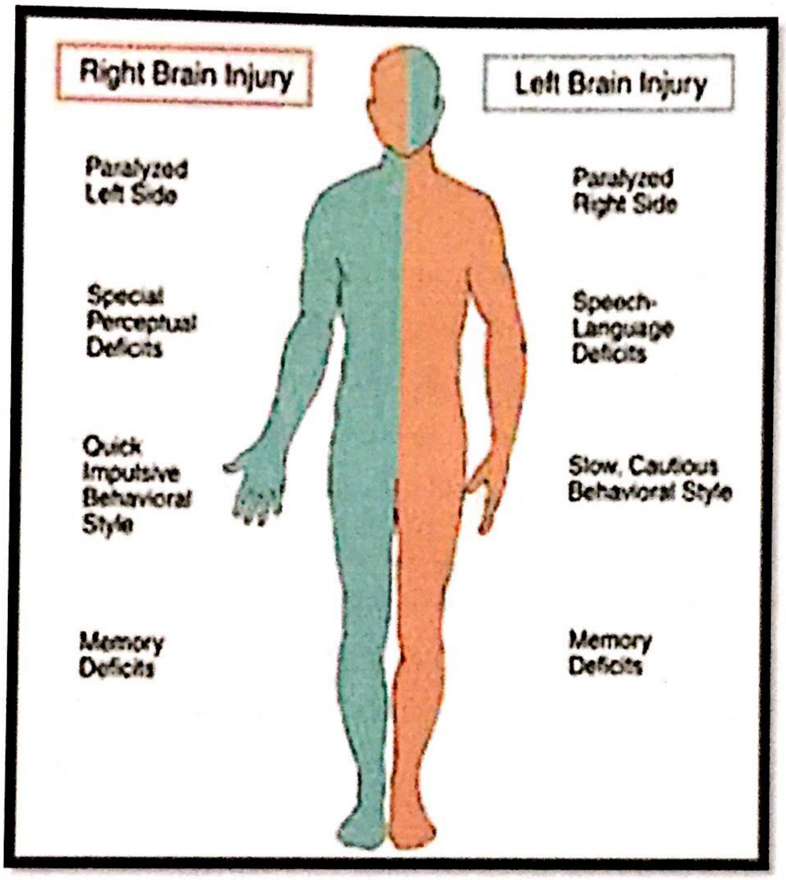


Figure 2.3: Effect of stroke

The most common effects of stroke are weakness or paralysis can have showed in figure 2.3. Weakness (hemiparesis) or paralysis (hemiplegia) may affect one whole side of the body, or just an arm or leg. The weakness or paralysis is on the side of the body opposite the side of the brain injured by the stroke. This leads to problems with balance or coordination, because the weight of the weak side pulls against the strong side. It can make it difficult for the stroke patients to sit, stand, or walk, even if his or her muscles are strong enough to perform these activities.

The second common effect is Cognitive Problems. Strokes often cause problems with memory, thinking, attention, learning, and other mental activities. For example, trouble following directions, may get confused if something in a room is moved, or may not be able to keep track of the date or time.

Furthermore, Problems Using Language also ones of the effects of stoke. Some of the stroke patients may have a problem in aphasia (a-FAY-zha), and trouble understanding speech or writing. They may understand but be unable to think of the right words to speak or write. A person with dysarthria (dis-AR-three-a) knows the right words but has trouble saying them clearly.

Vision and Perception Problems also often occurs in stroke survivors, because of vision and perception problems, will not turn to look toward their weakened side. For example, may not eat food from one side of the plate because he or she doesn't see it.

The most common physical effect of stroke is muscle weakness and loss/less of control movement of arm or leg. Brain damage due to stroke can cause an arm or leg to become paralyzed and/or to develop spasticity. Spasticity refers to the abnormal symptom of having muscle are stiff and resistance in the joints when patients try to make a movement. About 80% of strokes are ischemic, and 20% are hemorrhagic. Better preventive care is needed for the vascular diseases underlying stroke, including the detection of risk factors (hypertension, smoking, lack of exercise, overweight, and other risk factors), treatment with appropriate medications, and help with the necessary accompanying changes in lifestyle [9].

2.3 Wrist joint

The wrist joint is extremely complex, probably the most complex of all the joints in the body. The wrist is actually a collection of many bones and joints. These bones and joints let us use our hands in lots of different ways. The wrist must be extremely mobile to give our hands a full range of motion. At the same time, the wrist must provide the strength for heavy gripping. Wrist and forearm articulation play an important role in enhancing the usefulness of the hand by allowing it to take a variety of orientations with respect to the elbow [3].

2.3.1 The Structure of The Wrist Joint

The hand and wrist are complex structures with three types of bones and 27 bones altogether. These are: 8 carpal or wrist bones, 5 metacarpals or "palm" bones, and 14 phalanges or finger and thumb bones. The carpals are around and rotate in a ball-bearing type of motion at the end of the radius bone. This gives your wrist the flexibility to move in any direction.

There are also 35 muscles, tendons, and ligaments in the hand and wrist that support the broad range of joint movement. All of these structures – both the bones and the soft tissues — are subjected to stresses of varying types and degrees with every movement. For example, you create stress on the hand and wrist joints when you pick up heavy objects, accidentally cut your hand, or do certain motions repetitively, such as typing, assembly line work, or sewing. And when you fall, you may use your hand to brace or cushion your fall. With 27 bones and 35 soft tissue structures, a variety of problems can occur. The figure 2.4 show the structure of hands.

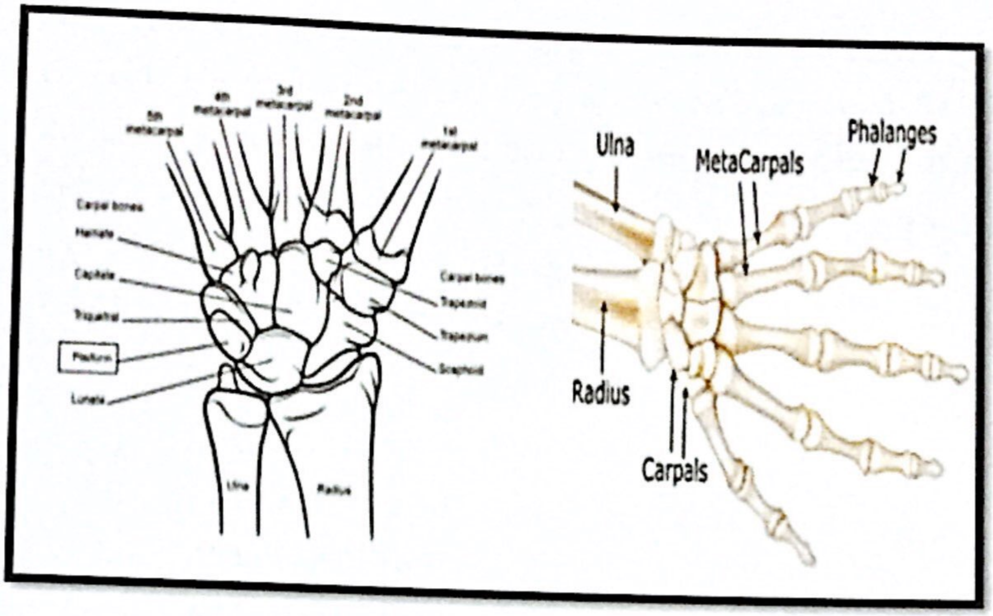


Figure 2.4: Structure of hands

2.3.2 Normal Range of Motion of the Wrist

The movements of the wrist are described with use of the four orthogonal and anatomically defined directions of flexion and extension in the sagittal plane and radial and ulnar deviation in the coronal plane [10].Wrist range of motion (ROM) is a combination of complex osseous articulations and intricate soft tissue constraints. It has been proposed that forearm rotation contributes significantly to carpal kinematics [11].

Forward bending of your wrist is called flexion. This motion is needed for daily activities such as styling your hair, writing, getting dressed, using a screwdriver and lifting heavy objects. Normal wrist flexion is approximately 70 to 90 degrees. Extension -- backward bending of your wrist -- is necessary for opening your car door, pushing a door closed, pressing up on the arms of a chair and driving.

The wrist joint deviates -- or tilts -- from side to side. Ulnar deviation tilts your wrist toward the pinkie side of your hand. Radial deviation tilts your wrist toward the thumb side of your hand. These movements are used frequently during the day as you type, write, get dressed and talk on the phone. This is normal range of motion of the wrist while figure 2.5 showed the normal of motion of wrist.

i. Flexion 0° To 90°
ii. Extension 0° To 90°
iii. Abduction 0° To 30
iv. Adduction 0° To 30°

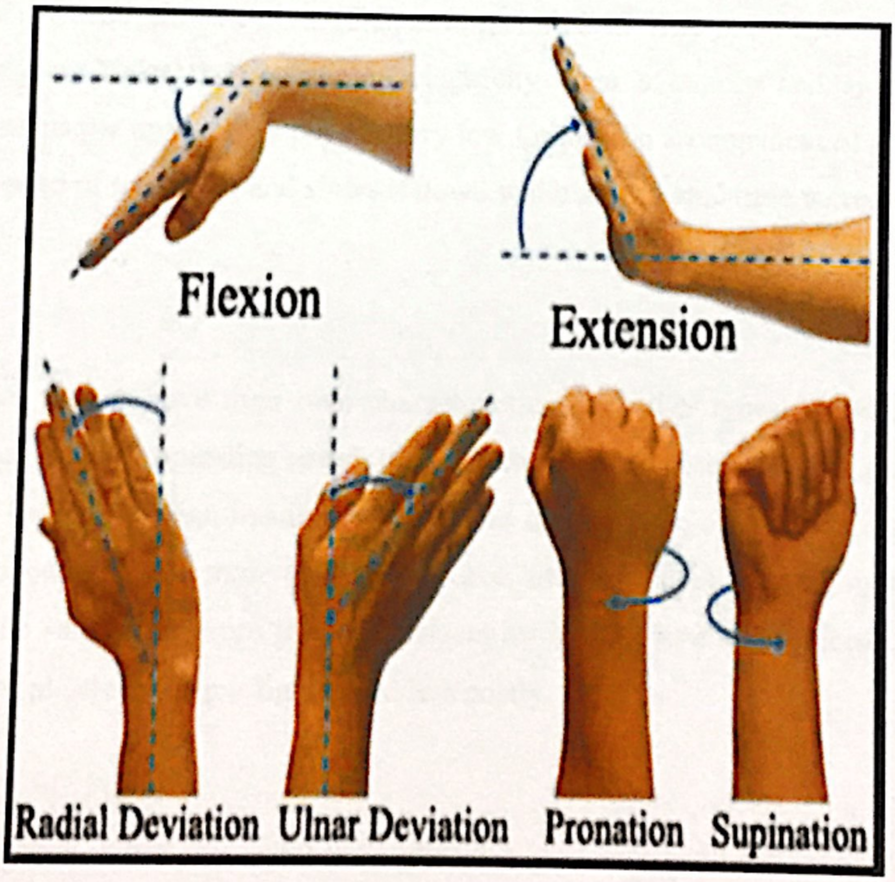


Figure 2.5: The normal range of motion of wrist

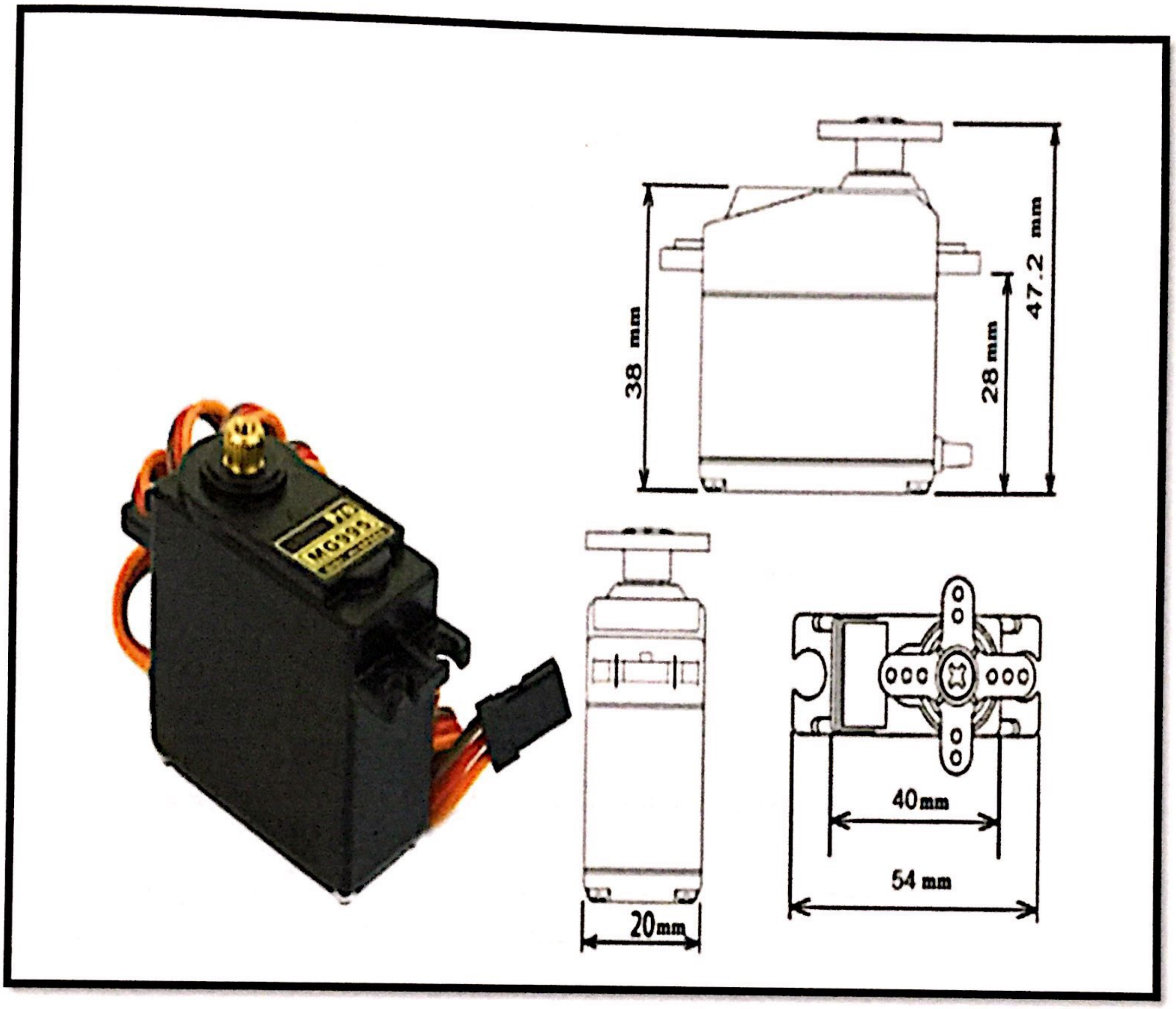
2.4 Servomotor

Servo motors (or servos) are self-contained electric devices that rotate or push parts of a machine with great precision. Servos are found in many places: from toys to home electronics to cars and airplanes. If you have a radio-controlled model car, airplane, or helicopter, you are using at least a few servos. In a model car or aircraft, servos move levers back and forth to control steering or adjust wing surfaces. By rotating a shaft connected to the engine throttle, a servo regulates the speed of a fuel-powered car or aircraft.

Servos also appear behind the scenes in devices we use every day. Electronic devices such as DVD and Blu-ray Disc players use servos to extend or retract the disc trays. The simplicity of a servo is among the features that make them so reliable. The heart of a servo is a small direct current (DC) motor, similar to what you might find in an inexpensive toy. These motors run on electricity from a battery and spin at high RPM (rotations per minute) but put out very low torque. An arrangement of gears takes the high speed of the motor and slows it down while at the same time increasing the torque.

The servo motors have their own characteristics like other types of motors, which are voltage, current, operating speed, torque, control pulse, resolution and pulse and weight.[12]The gear design inside the servo case converts the output to a much slower rotation speed but with more torque (big force, little distance). The amount of actual work is the same, just more useful. Gears in an inexpensive servo motor are generally made of plastic to keep it lighter and less costly.

The main point is that this servo is an ultra-low-cost servo and can be used in many situations. This servo motor was used for the movement of the robot head, neck and each arm. The figure 2.6 showed the structure of servomotors while the table 2.1 showed metal connection in servomotor and Table 2.2 is a specification of servomotor.



The figure 2.6: The Structure of Servomotor

Table 2.1: Metal Connection in Servo Motor

Wire colour	**Connection**
Yellow	PWM
Red	Supply
Brown	Ground

2.4.1 The Specifications of Servomotor

The table 2.2 showed the spefications of servomotor of MG-995

Table 2.2: specification of servomotor

General specifications	
Pulse Width	1000µs - 2000µs
Rotation/Support	Dual Bearing
Shaft Diameter	5.88mm
Speed	4.8V: 0.20 sec/60°
Torque	4.8V: 138.9 oz-in (10.00 kg-cm)
Gear Type	Metal
Modulation	Analog
Motor Type	Coreless Servo Motor
Range	180°
Weight	55 g
Temperature range°C	0 °C – 55 °C
Power supply	
Phase Voltage	4.8V - 7.2V

2.5 Arduino Uno

Arduino Uno is a specially designed circuit board used for programming and prototyping driven by Atmel based microcontroller, ATMega328P. Being one among the most widely used platforms in the world, Arduino has an open source design and unlike previous circuit boards, do not require additional hardware to burn programs onto the board [13].

This indicates that the codes written for the microcontroller can be loaded on to Arduino Uno using USB cables, which are easier to carry and deal with. As seen in the figure, the Arduino Uno is powered using ATmega328P microcontroller. The circuit board has a convenient power management which allows the input voltage up to 12V.

The built-in power regulatory mechanism then permits the regulation of this voltage into 5V and 3.3V. The power can be supplied by connecting an adapter to the external power supply or to computers (or other devices) using a USB cable. The figure clearly represents the existence of 14 digital I/O pins as well as 6 analog I/O pins. These pins are the circuit board's medium of communication to external devices. Apart from these features, Arduino Uno accommodates 32KB flash memory for the storage of programs.

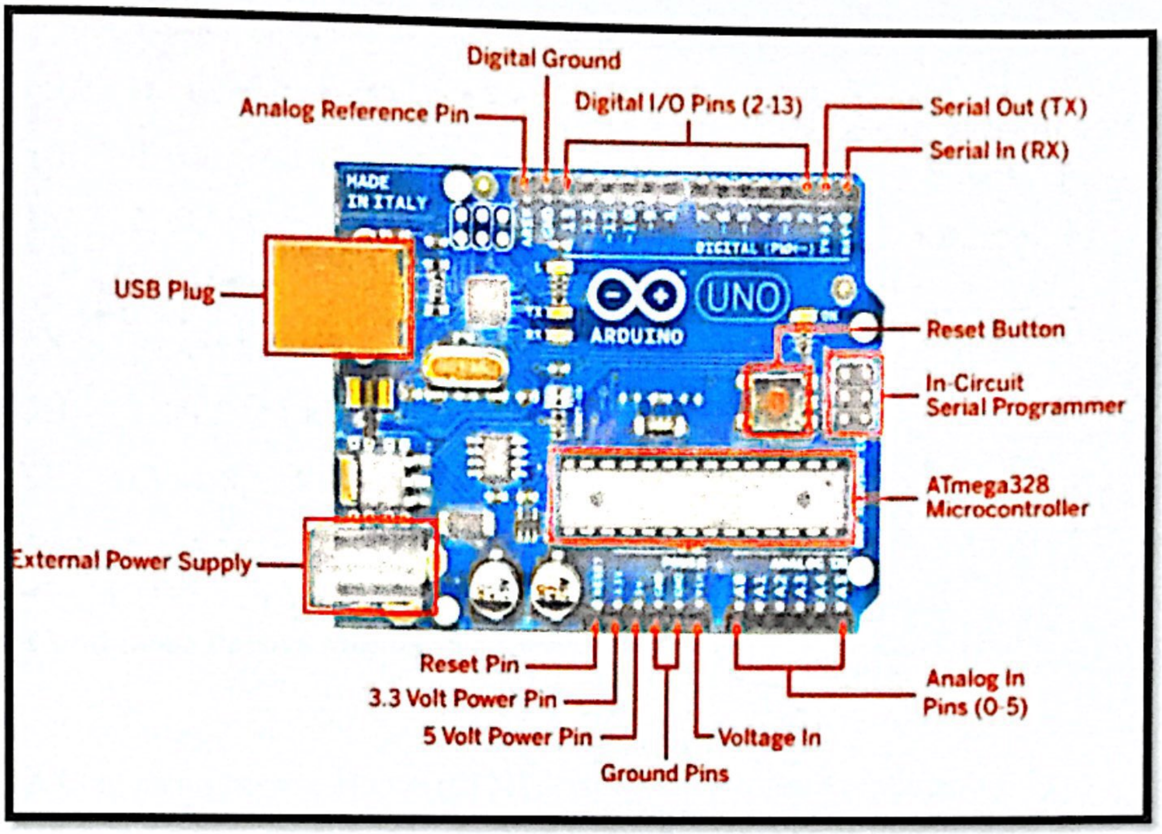


Figure 2.7: Arduino UNO

Arduino packages include circuit board as given in figure 2.7 as well as a piece of software, Arduino IDE (Integrated Development Environment). Since its introduction, many different versions of this software have been released and is basically used to code, compile as well as upload the programs onto the board. Arduino IDE uses a simplified version of C++, providing an open source platform as well as various examples of code, resulting in Arduino rising to the most popular programmable circuit board series. Due to its functionality and efficiency, it is used in the design [13].

Arduino UNO are used in this study. Below are the Arduino UNO Specifications and Features:

I. Microcontroller ATmega328

II. Operating Voltage 5V

III. Input Voltage (recommended) 7-12V

IV. Input Voltage (limits) 6-20V

V. Digital I/O Pins 14 (of which 6 provide PWM output)

VI. Analog Input Pins 6

VII. DC Current per I/O Pin 40 mA

VIII. DC Current for 3.3V Pin 50 mA

IX. Flash Memory 32 KB (ATmega328) of which 0.5 KB used by bootloader

X. SRAM 2 KB (ATmega328)

XI. EEPROM 1 KB (ATmega328)

XII. Clock Speed 16 MHz

2.6 Continuous Passive Motion

A Continuous Passive Motion (CPM) device is used to cause continuous passive motion of synovial joints following surgery of the hip, knee, ankle, shoulder, elbow, or wrist, traumatic injury or infection. CPM should be used as an adjunct to physical therapy with objectives to increase the duration and intensity of passive motion in order to achieve outcomes superior to that achieved by conventional physical therapy programs. CPM moves the joint continuously, allowing flexion and extension positions without patient effort.

An electrical power control unit is used to set the variable range of motion (ROM) and speed, which is determined by a physical therapist or other health care professionals' familiar with the device. The initial setting for ROM is based on a patient's level of comfort, joint stability and other factors that are assessed intra-operatively. The ROM is increased by 3-5 degrees as tolerated by the patient.

Continuous passive motion (CPM) devices are used during the first phase of rehabilitation following a soft tissue surgical procedure or trauma. The goals of phase 1 rehabilitation are, control post-operative pain, reduce inflammation, provide passive motion in a specific plane of movement, and protect the healing repair or tissue. CPM is carried out by a CPM device, which constantly moves the joint through a controlled range of motion; the exact range is dependent upon the joint, but in most cases the range of motion is increased over time.

CPM is used following various types of reconstructive joint surgery such as knee replacement and ACL reconstruction. Its mechanisms of action for aiding joint recovery are dependent upon what surgery is performed. One mechanism is the movement of synovial fluid to allow for better diffusion of nutrients into damaged cartilage, and diffusion of other materials out; such as blood and metabolic waste products. Another mechanism is the prevention of fibrous scar tissue formation in the joint, which tends to decrease the range of motion for a joint [14]. The concept was created by Robert B. Salter M.D in 1970 and, along with help from engineer John Saringer, a device was created in 1978.

2.6.1 CPM Following Strokes

There are limited occupational therapies that are fully supported across a spectrum of patients. The fundamental movements provided by the CPM units, potentially allows for a remedial and fast progressing therapy. This is according to the University of California. This is an untapped potential for these stroke victims that needs to be further explored, according to the same source.

CPM units are a rare form of therapy that directly correlates the amount of use to the amount of progress. It is easy to neglect at-home therapeutic exercises for various reasons, but CPMs can be used while watching television or doing anything stationary. This ability to multi-task therapy with recreational activities hold higher promise for patients completing the therapy at home. Completing the therapy at home is just as important as prescribing it. That is why some studies suggest physical and occupational therapy yield better results than CPM units.

CPM units should be used supplementary; also, these studies have fully compliant PT and OT patients whereas most patients do not fulfil they're at-home exercises as often or with proper form that is suggested in these studies.

2.7 Current Devices

This device is used to provides continuous passive motion(CPM) exercises to the patient who have problem at wrist joints of the impaired arm of stroke and injured patients. This machine is bigger and unmovable. So, every time the patients have to attend themselves to the hospitals for the treatment. This type of devices need AC power supply to operating.

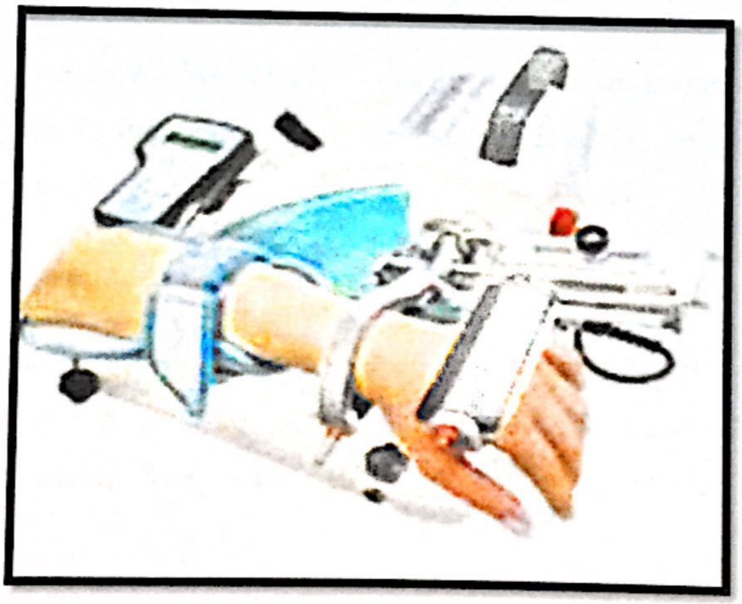


Figure 2.8: Current Technology

2.7.1 W2 Wrist CPM Device

Figure 2.9: W2 Wrist CPM Device

The portable W2 Wrist CPM is designed to deliver maximum mobility to the wrist joint in flexion/extension, ulnar/radial deviation, or a combination of both. Lightweight construction and comfortable soft goods allow the W2 to be worn for extended periods of time in both hospital and home settings.

For patient safety, a reverse-on-load safety feature ensures the W2 will reverse the direction of motion should the patient resist motion, or if motion should be obstructed. The specification of W2 Wrist CPM Devices is show below.

Specification

i. CE Certified
ii. Fully ambulatory and portable, battery operated
iii. Full range of motion
iv. Flexion/extension and ulnar/radial deviation, or a combination of both
v. Anatomical free-linkage design to prevent compression of radiocarpal joint
vi. Durable, compact and comfortable design
vii. Adjustable force settings for customization
viii. Rechargeable battery operation
ix. Reverse-on-load safety feature

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter is descripted and explained about the process and the method to implementing this study with successful. The detail explanations of the methodology are explained in this chapter such as the process of making the PCB board, Programming and so on

3.2 Flow Chart

Flow Chart below had showed that the whole process to implementing this study and it has been descripted with detail explanation for every step of the process.

3.3.1 Flow Chart of The Project

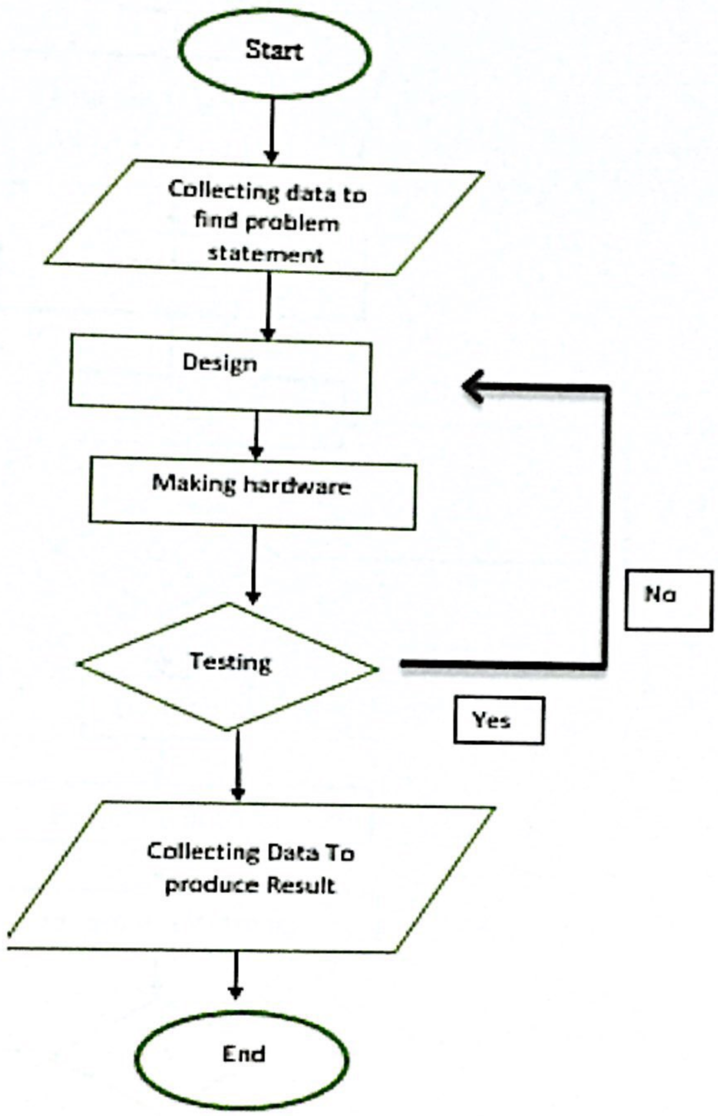


Figure 3.1: Flow Chart of The Project

3.3.2 Flow Chart of Implementation of Project Smart Wrist Exercise Tools

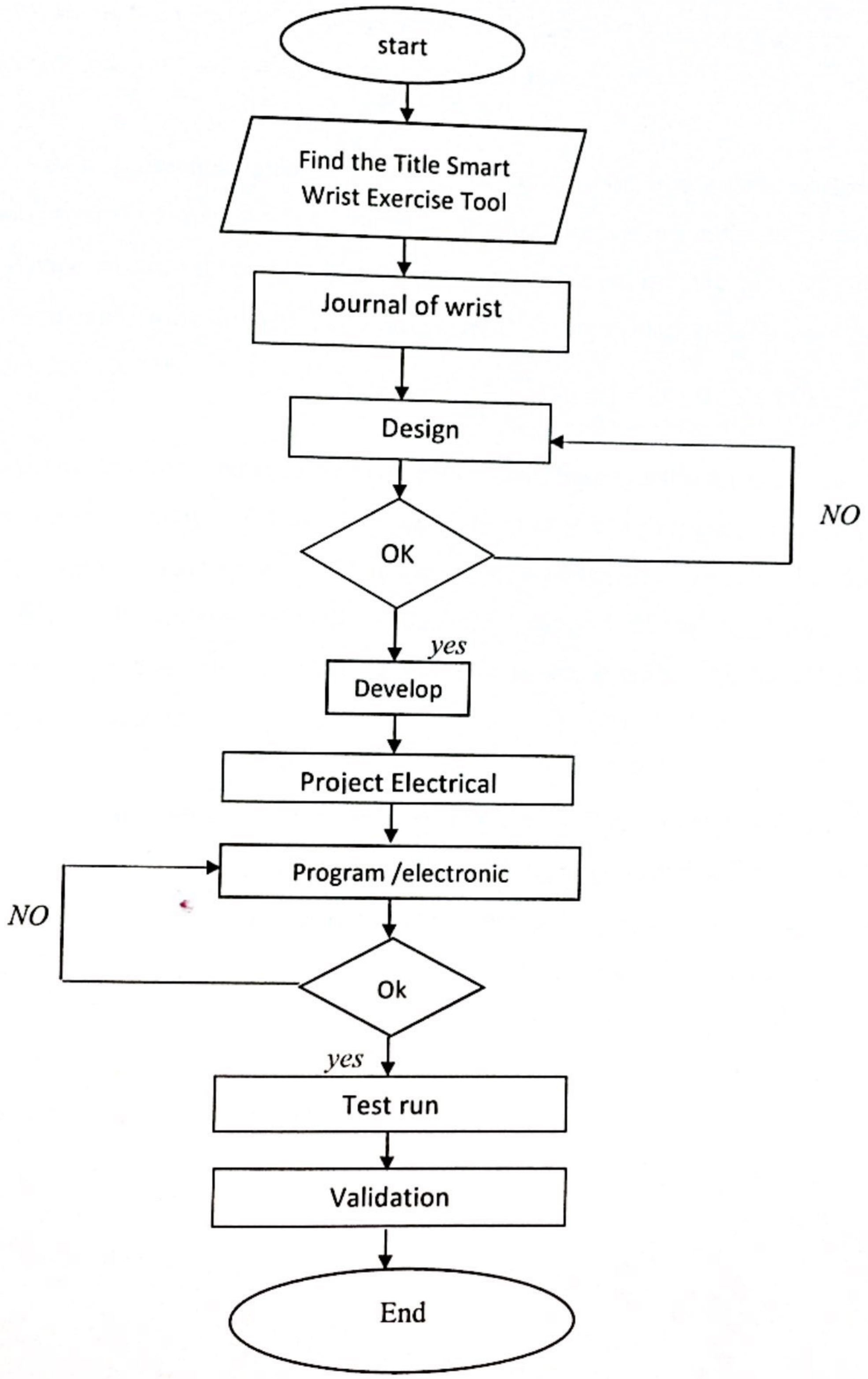


Figure 3.2: Flow Chart of Implementation of Project Smart Wrist Exercise Tool

To start this study, data collection was the first step of this study. To collect the data, the interview and distribute questionnaire (APPEDIX D AND E) to the physiotherapist, doctor and engineer were performed. After that, evaluate the data that collected, then find and create the problems statement.

After problems statement was created, design the shape and the device. Design the smart wrist exercise tools to overcome the problems. Design the suitable shape of the device according the problems statements. Determine the suitable materials, hardware or software that will be use. Planned the software that suitable used to control a motor such as Arduino UNO.

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an 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.

When the hardware is done, test The Smart Wrist Exercise Tools. Test the device, ensure the device is functioning and working in good and safe aspect. (If testing failed, return to the step before, redo the process, testing again the devices). Last step of the whole project process is testing and collect data. Test the device on 30 subjects (20 public and 10 physiotherapist) for usability testing. Then, collect the data from them by distribute questionnaire and analysis the data by using Microsoft excel. Discuss and conclude the result that had analyses

3.3 Data analysis/collection and testing

Distribute questionnaire to the rehabilitation unit at hospital to collecting data. Do some product testing on people to get data analysis. Data analysis and testing will be conduct 10 therapists and 20 public people to analyze about the usability and comfortably while using smart wrist exercise tools (SWET). (Refer Appendix E)

3.4 Block Diagram

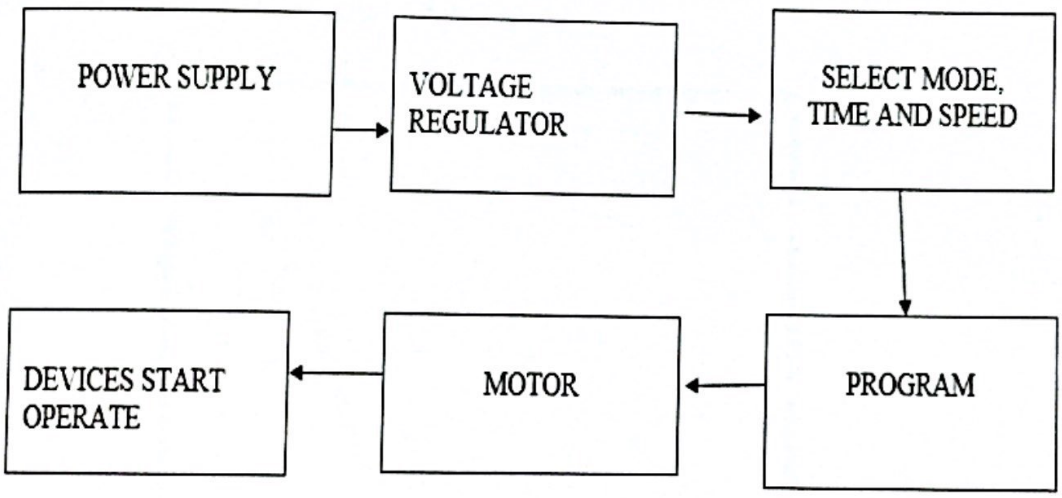


Figure 3.3: Block diagram of smart Wrist Exercise Tool

3.5 Requirement of Hardware And Software

For this project, I will have used Microsoft excel to make the data analysis and Arduino Uno to run the project. The software that are planned to be used are Proteus.

Figure 3.4 show the servomotor. A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

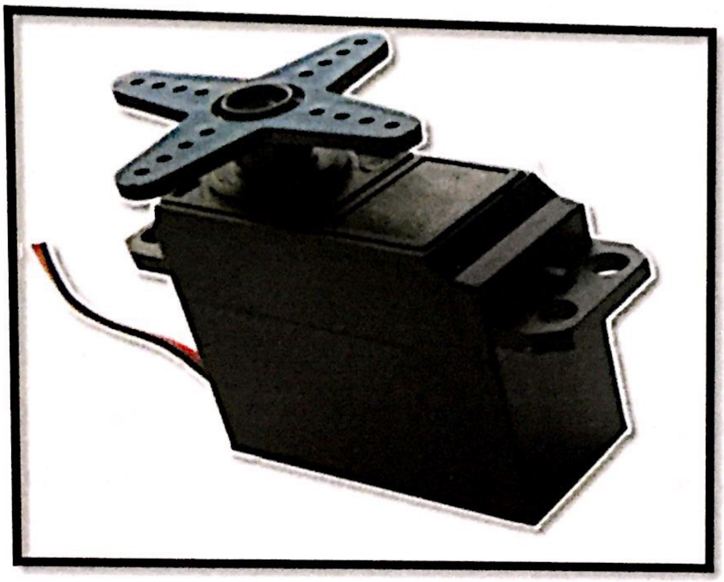


Figure 3.4 : Servomotor

Servomotor are controlled by sending an electrical pulse of variable width, or pulse width modulation (PWM), through the control wire. There is a minimum pulse, a maximum pulse, and a repetition rate. A servo motor can usually only turn 90 degrees in either direction for a total of 180-degree movement. The motor's neutral position is defined as the position where the servo has the same amount of potential rotation in the both the clockwise or counter-clockwise. It is requiring a high-speed control accuracy and good dynamic respond. In robotic applications, servo motors are used to move the robotic arm to a relevant position [15]. The figure 3.5 show the guts of the servo moto(L) and an assembled servo (R)

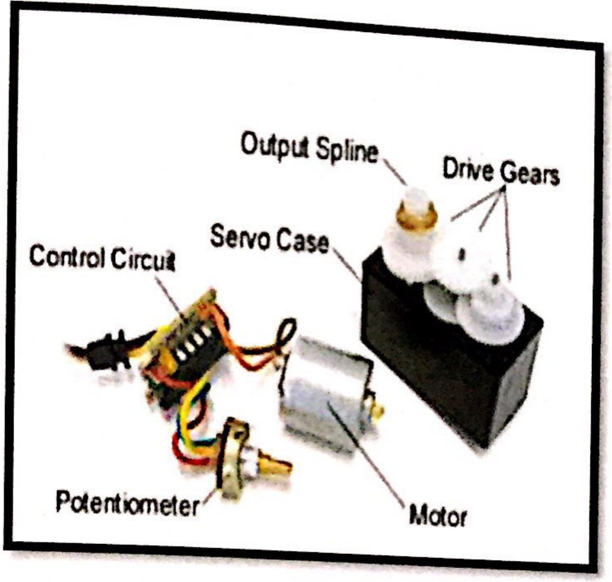


Figure 3.5: The guts of a servo motor (L) and an assembled servo (R)

3.7 Arduino Uno

Arduino is open-source hardware .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. It also can be powered via USB connection or with an external power supply (i.e., a 9-V battery) [16].The power source is selected automatically.

The Arduino board consists of a micro controller which enables to receive inputs from the sensors and thereby can be used to drive motors, LEDs, sensors and other components which Is known as physical computing [17].Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The Arduino UNO is read the setting from the user, and produces the output as the settings from the user. The user can select the speed that required, how many count needed and also the level of the angle, these are the settings that the user can decided themselves. Once the settings were done, the PIC will read the setting and produced the output depends on the requirement of the user. The figure 3.6 showed the Arduino UNO.

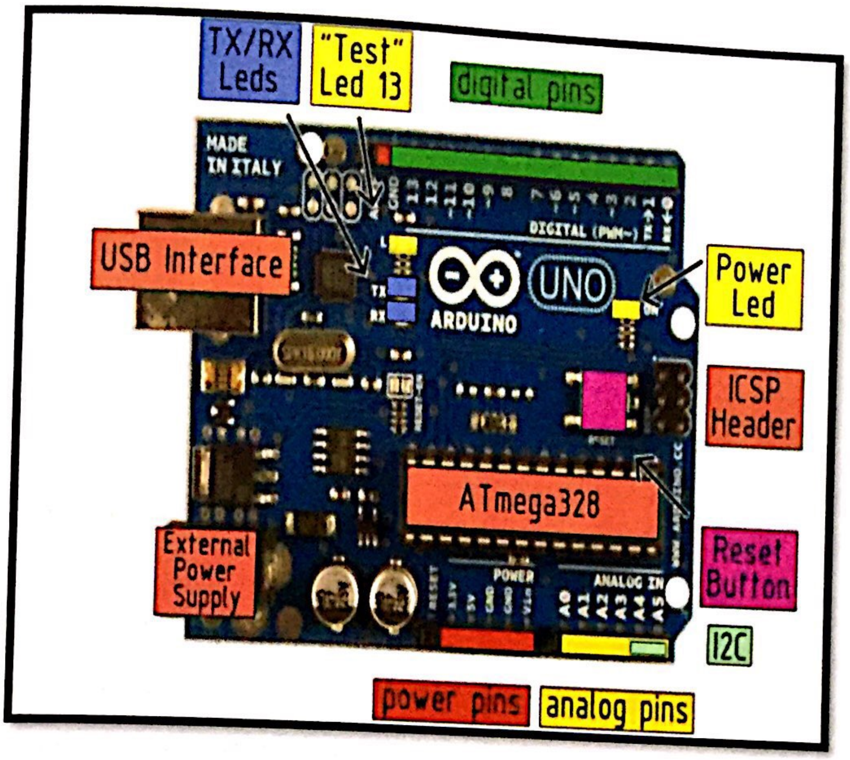


Figure 3.6: Arduino UNO

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter shown the result from our collected data such as questionnaire and the data is analyzed and generated graph by using Microsoft Excel. And then the result that analyzed is discussed in this chapter.

4.2 Smart Wrist Exercise Tools

The figure 4.1 below is the Smart Wrist Exercise Tools that has developed. This device has mode 1 or 2. Mode 1 for upward and downward. The angle can be selected on the patients There are provided 3 degree selections which are 20°, 40°and 60°. Initiation of treatment must be the smallest to the large angle. While mode 2 for right or left movement are fixed that provided degree 20.°. Besides that, Smart Wrist Exercise Tools also have setting to adjust to speed. The initiation speed must be slow on first day and increase faster on the second days.

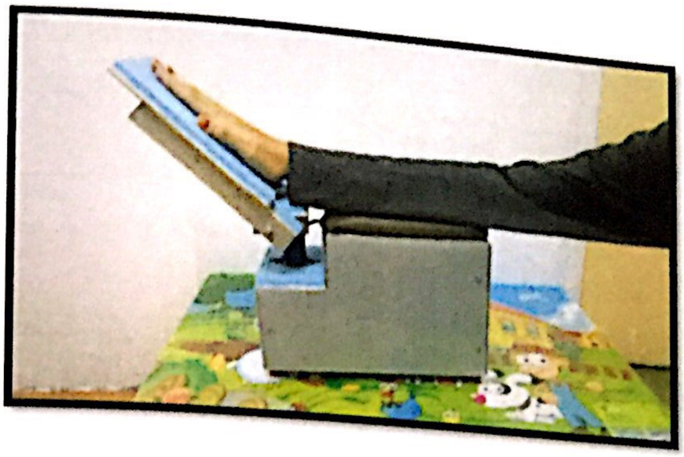


Figure 4.1: Wrist Joint Rehabilitation Device

This developed smart wrist exercise tools has main parts, which are control panel. The control panel contained reset button, increase button, decrease button, Enter button and LCD displays. This smart wrist exercise tools used two batteries to operate the device which are 9V batteries and 12V DC rechargeable batteries. The 12V DC batteries used to control the servomotor movement and the 9V batteries used to power up the control panel and provided the power to the LCD displays.

4.2.1 Structure of Smart wrist Exercise Tools

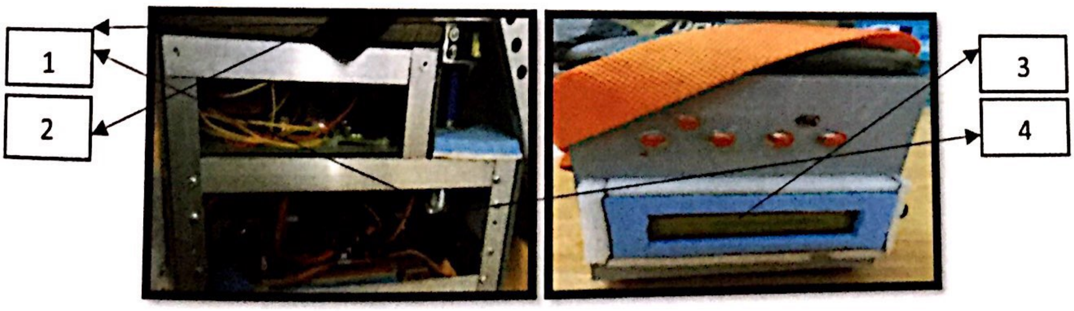


Figure 4.2: Smart Wrist Exercise Tools (Side View)

Figures 4.2 had shown the side view of the Smart Wrist Exercise, and the Table 4.1 shown the function of each part of the device.

Table 4.1: Function of the Parts of Device

No	Parts	Function
1	Servomotor	control of angular or linear position, velocity and acceleration
2	Arm & Forearm Straps	Tighten the Arm & Forearm
3	Control Panel	Setting and Control the Device
4	Arduino uno	It is read the setting from the user, and produces the output as the settings from the user.

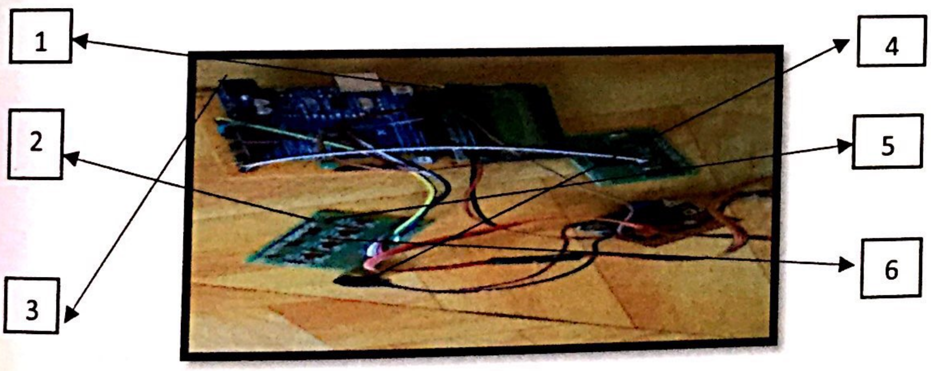


Figure 4.3: Control Panel (Top View)

Figure 4.3 had shown the top view of the control panel and table 4.2 had shown that the Function of the Parts of control panel.

Table 4.2: Function of control panel

No	Parts	Function
1	LCD Displays	Display the number of count
2	Reset	Reset the Device's settings
3	9V Batteries Connector	Connect with the 9V batteries
4	12V Batteries Connector	Connect with the 12V batteries
5	Decrease	Decrease the number of speed
6	Increase	Increase the number of speed

4.3 Usability test

During this usability testing, 30 normal subjects were tested, and questionnaires were distributed to them. Usability testing have consisted of 2 section A and B. The section A divided 4 main items which are Effectiveness, Comfortableness, Speed and Range and Design and Strength. Then section B are open questions. These 4 main items data were collected through the usability test, which the subject have tested the development of smart wrist exercise tools for stroke and injured patients, then answered questionnaire.

4.3.1 Effectiveness

The data of effectiveness about the developed devices was takes. 5 questions are consisted in this part, below is the table of the Effectiveness.

Table 4.3: Data of Effectiveness

No	Item & Elements	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	**Effectiveness**					
a)	Do you like to use this product frequently?	0	0	0	16	14
b)	Do you find some additional functions to integrate this product?	0	0	3	18	9
c)	Do you think the effectiveness of this product can enhance fast recovery?	0	0	0	19	11
d)	Most people can learn how to use this product quickly.	0	0	1	10	19
e)	SWET is suitable for the purpose of stroke's disease and injured patients for a better recovery.	0	0	1	12	17

From the table above, the graph is generated by the Microsoft Excel, and the graph is shown in the figure 4.4

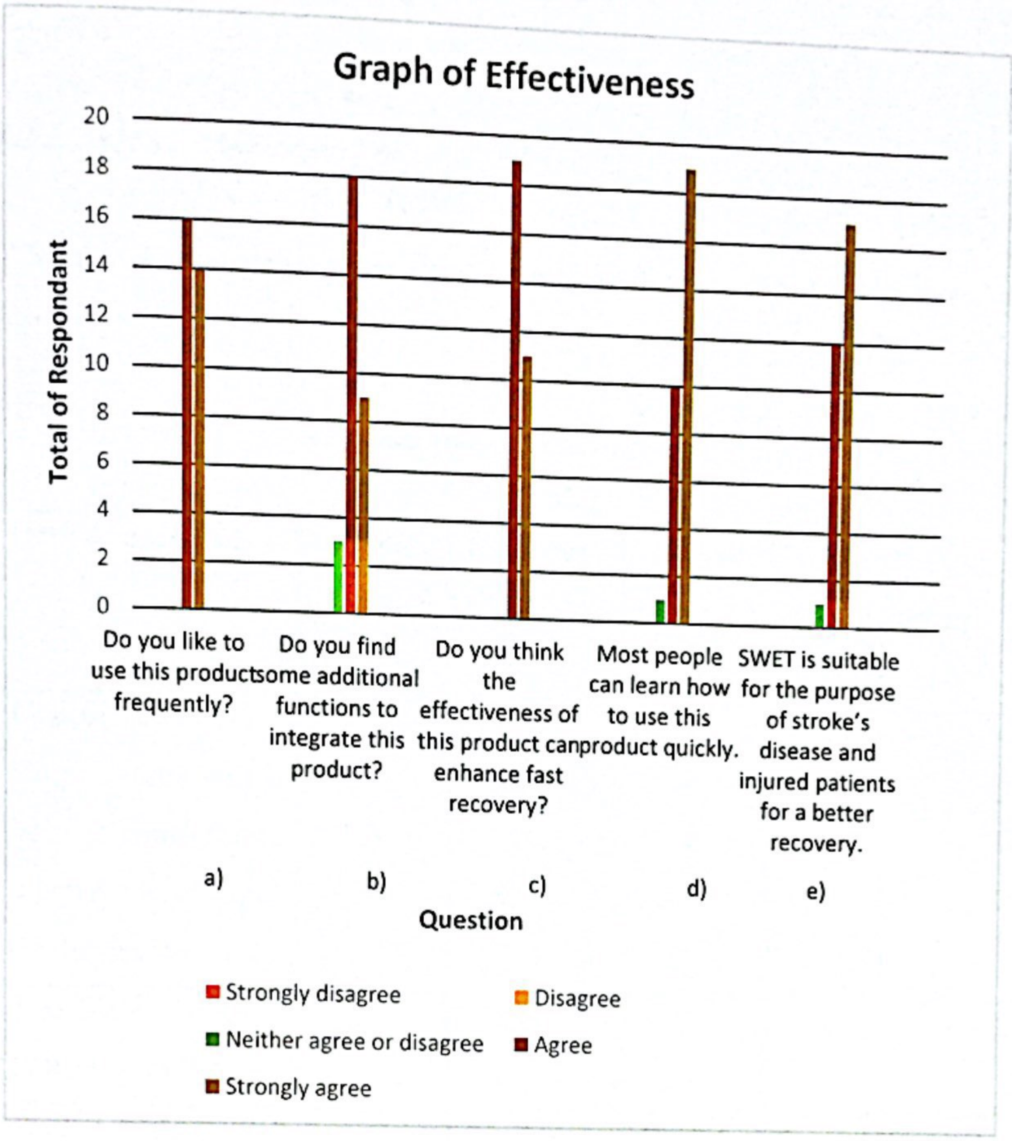


Figure 4.4: Graph of the Effectiveness Smart Wrist Exercise Tools

From the figure 4.4, 16 subjects are agreed that their like to use this product and 14 strongly agreed with that. After that, 18 subjects are agreed to find some additional functions to integrate this product, 9 subjects strongly agree with it. According the third question, 19 subjects were agreed that the effectiveness of this product can enhance fast recovery, 11 subjects were strongly agreed with it and none of them disagree with it.

Besides that,19 subjects were strongly agreed that people can learn how to use this product quickly, 10 subjects were agreed with that and 1 subject neither agree or disagree with that. Then, 17 subjects are strongly agreed the smart wrist exercise tools are suitable for the purpose of stroke's disease and injured patient for a better recovery,12 subject is agreed with that and 1 subject are neither agree or disagree.

4.3.2 Comfortableness

The table 4.4 have shown the data about the comfortableness of the smart wrist Exercise tools

Table 4.4: Data of comfortableness

No	Item & Elements	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	**Comfortableness**					
a)	Do you think will it be comfortable when the wrist is put on the devices?	0	1	0	16	13
b)	The SWET is easy to user friendly?	0	0	2	10	18
c)	Will it be convenience in using this product during exercise	0	1	0	17	12
d)	Do you think this product is stable while operating?	0	1	1	10	18
e)	The device is easy to be used or to be handled when operating?	0	0	1	13	16

The second main items are comfortableness, which consists of 5 questions which are about the comfortable when the wrist is put on the devices, user friendly, convenience in using this product during exercise, product is stable while operating and device is easy to be used or to be handled when operating. Figure 4.2 have shown the graph of the feedback about comfortableness.

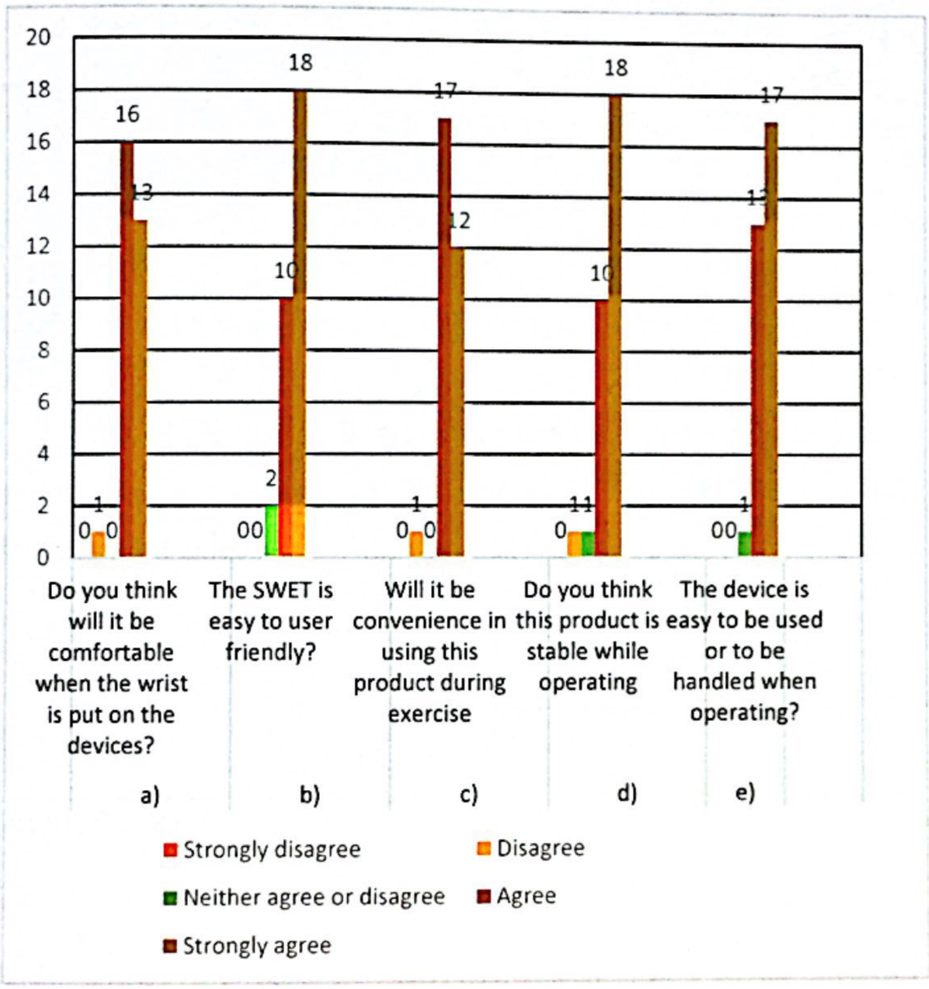


Figure 4.5: Graph of the comfortableness Smart Wrist Exercise Tools

From the figure 4.5, 16 subjects are agreed that comfortable when the wrist is put on the devices ,13 strongly agreed with that and 1 subject disagree. After that, 18 subjects are strongly agreed the smart wrist exercise tools is user friendly, 10 subjects are agreed with that and 2 subjects neither agree or disagree with it.

According the third question, 17 subjects were agreed that it will be convenience in using this product during exercise,12 strongly agreed and 1 subject is disagreed with that.

Besides that,18 subjects were strongly agreed this product is stable while operating,10 subject is agreed, 1subject is disagree and 1 subject are neither agree or disagree with that. Then 16 subjects is strongly agreed the device is easy to be used or to be handled when operating, 13 subject are agreed and 1subject neither agree or disagree with it

4.3.3 Speed and Range

Speed and Range is the third main item that was tested in the usability testing. This part consists of 5 questions. The table 4.3 below have shown the data of speed and Range

Table 4.5: Data of Speed and Range

No		Item & Elements	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1		**Speed and range**					
	a)	The speed and range can be selected easily?	0	0	1	10	19
	b)	Do you think the speed and range is adjustable to the patient and are they effective?	0	0	3	11	16

	c)	The speed can be selected easily	0	0	2	11	17
	d)	The high speed won't bring any wrist feels uncomfortable to the patients	1	0	2	12	15
	e)	The speed operation is suitable for stroke and injured patient?	0	0	1	10	19

According the table 4.5 above the data was generated a graph by using Microsoft Excel, and the graph has shown in the figure 4.6 below.

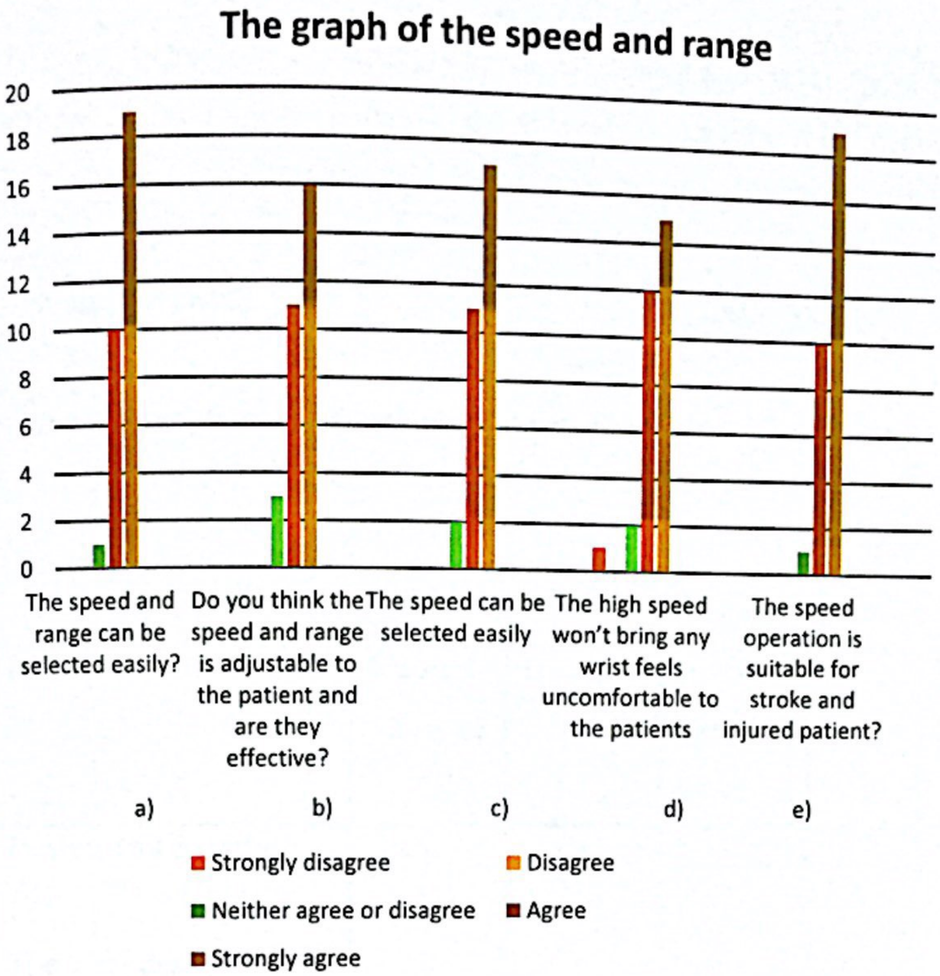


Figure 4.6: Graph of Speed and Range

From the figure 4.6 above, 19 subjects were strongly agreed that the speed and range can be selected easily. Besides that, 10 of the subjects also agreed with it, and 1 subjects were neither agreed nor disagreed.

The speed and range is adjustable to the patient and it is effective. There were 16 of the subjects strongly agreed with it. 11 of the subjects also agreed with that and 3 subjects neither agreed nor disagreed. Then the speed on the product can be selected easily where 17 subjects are strongly agreed,11 subject is agreed and 2 subjects were neither agreed nor disagreed.

Besides that, 15 subjects are strongly agreed the high speed won't bring any wrist feels uncomfortable to the patients ,12 are agree, 2 were neither agreed nor disagreed and 1 subject strongly disagree.

The last one, 19 subjects are strongly agree, 10 subject agreed the speed operation is suitable for stroke and injured patient and 1 subject neither agreed nor disagreed.

4.3.4 Design and Strength

Then Design and strength of the developed device. The table 4.6 below shows the data collected from 30 subjects.

Table 4.6: Data of Design and Strength

No		Item & Elements	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1		**Design and Strength**					
	a)	The design is comfortable?	0	0	0	10	20
	b)	The design is easily to be brought anywhere?	0	1	1	10	18
	c)	The product is suitable to be used everywhere?	0	1	0	9	20
	d)	The device is able to move the patient's wrist upward and downward/right and left?	0	0	1	8	21
	e)	The device is able to move the patient's wrist upward and downward/right and left?	0	0	1	13	16

From the table 4.6 above shows the data of design, the data was collected and generated or analysis by using Microsoft Excel. And the graph has shown in the figure 4.7 below.

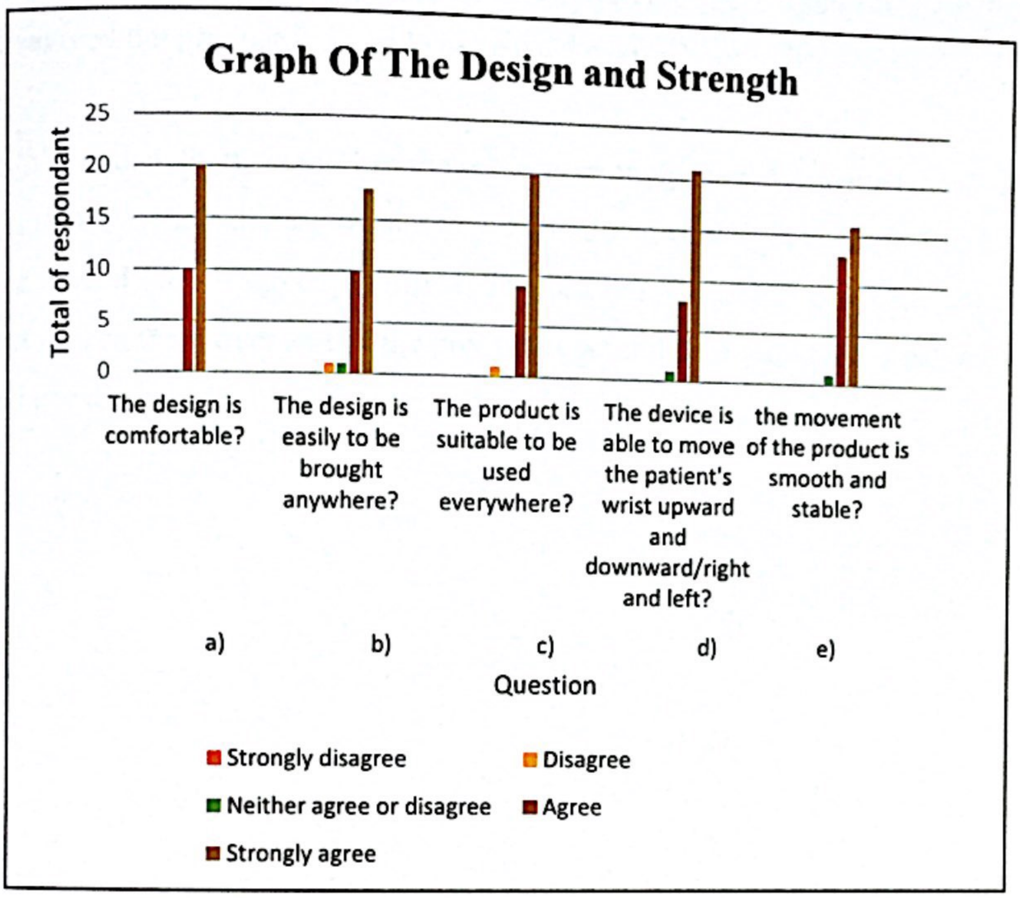


Figure 4.7: Graph of Design and Strength

The figure 4.7 has shown the data of design which it collected the data about the design of the developed device. From this design items, there consists of 5 questions. From the 30 subjects, there were 20 subjects strongly agreed and 10 subjects are agreed the design of the product are comfortable.

The design is easily to be brought anywhere, and there were also 18 subjects are strongly agreed,10 subject is agreed ,1 subject is neither agree or disagree and 1 subject is disagreed. The product is suitable to be used in everywhere, and there were also 20 subjects strongly agreed with it and 9 subjects are agreed and 1subjects neither agreed nor disagreed the product is suitable to be used everywhere.

After that, there were 21 of the subjects strongly agreed ,8 agreed that the device is able to move the patient's wrist upward and downward/right and left. But 1 subject neither agreed nor disagreed with that. The last one,16 subject is strongly agreed ,13 subject agreed the movement of the product is smooth and stable and 1 subject neither agreed nor disagreed with that.

4.3.5 Section B

Section B is the open question. The table 4.6 below shows the data collected from 30 subjects.

Table 4.7: Data of section b

No		Item & Elements	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	a)	Do you understand the operation of this device?	0	0	0	12	18
	b)	Is it easy to operate this device?	0	0	1	14	15
	c)	Is it safe to use this product?	0	0	2	8	20
	d)	I would like to recommend the device to other people who are needed?	0	0	1	13	16
	e)	SWET can help those in stroke and injured patients	0	0	0	13	17

From the table 4.7 above shows the data of section b, the data was collected and generated or analysis by using Microsoft Excel. And the graph has shown in the figure 4.8 below.

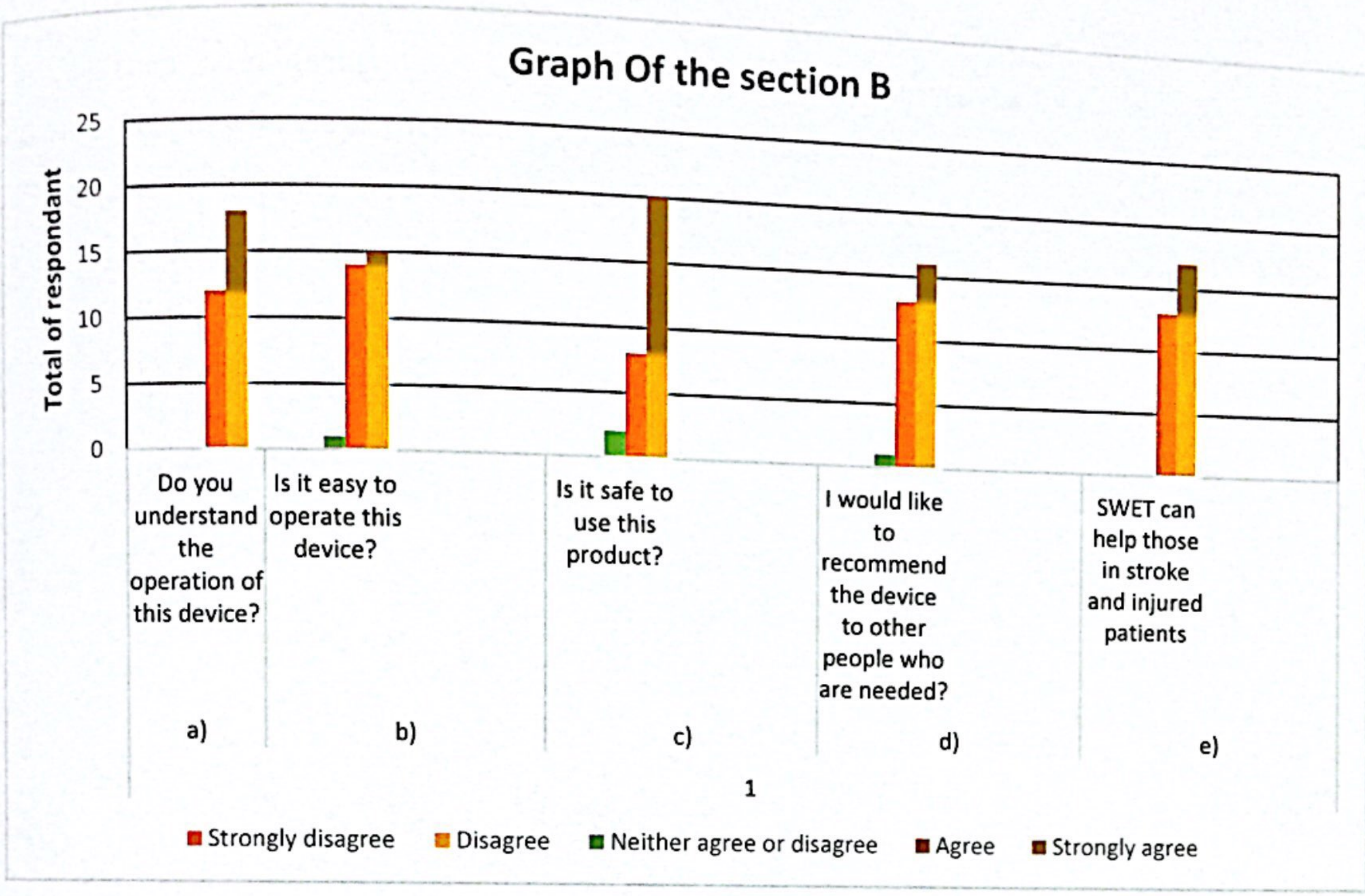


Figure 4.8: Graph of the section b

From the figure 4.8 above, 18 subjects were strongly agreed and 12 subjects are agreed that the understand the operation of this device. Besides that, 15 subjects are strongly agreed ,14 subject is agreed that the product is easy to operate and 1 subject neither agree or disagree.

According the third question, 20 subjects were strongly agreed that the device is safe to use this product, 8 subjects were agreed with it, 2 of the subjects were neither agree or disagree and none of them disagree with it.

Then ,16 subject strongly agreed, 13 are agreed to recommendation the device to other people who are needed and 1 subject neither agree or disagree with that. Then 17 subjects are strongly agreed ,13 subject is agreed the smart wrist exercise can help those in stroke and injured patients.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This chapter discusses the conclusions of the study, the results and analysis of the project. Suggestions for improvement projects in the future were also discussed to produce a project that is suitable for users.

5.1 Conclusion

As a conclusion, the smart wrist exercise tools for stroke and injured patients is develop, and it have achieved the objective, which the first objective is to develop smart wrist exercise tools to help stroke and injured patient can recovery fast.

The second objective is to design this product which is portable and easy to used. The product are lightweight compared others and able operating in a used battery powered to help for reduce the environment damage.

.

A usability test was done, 30 normal subjects was used to measure the effectiveness comfortableness, speed and Range and Design and of the device. During this test, the device was tested on the willingly of the 30 subjects, and the data was collected by distributed questionnaire. Once the testing was done, the data will be analysis by using Microsoft Excel. And the result finding that, the developed device is comfortable to be used. Furthermore, the developed device is operating in rechargeable batteries, and it was able to move the subject's wrist upward, downward, right and left.

5.2 Recommendation

Physiotherapist from Hospital for this Smart Wrist Exercise Tools have to looking for a method to maintain the position of hand. In addition, patient should able to stop devices anytime when feel uncomfortable.

Besides that, there is some recommendation from the panel which is the hand placement should be able to be removed and cleaned for hygiene purpose.

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APPENDIX A: - PROGRAMMING

```
#include <LiquidCrystal.h>



#define SW1  10
#define SW2  11
#define SW3  12
#define SW4  13

Servo myservo1;
Servo myservo2;

LiquidCrystal lcd(8, 9, 4, 5, 6, 7);
//-------------------------------------------


int MODE=0;
int pos =140;     // variable to store the servo position
float LEFTs=140.0;
float RIGHTs=180.0;
float UPs=120.0;
float DOWNs=180.0;
int spd=15;
float Sens1;
int Sens1Pin = 0;
float Sens2;
int Sens2Pin = 1;
int ROT=0;
```

```
void setup(void)
{
   pinMode(SW1,INPUT);
   pinMode(SW2,INPUT);
   pinMode(SW3,INPUT);
   pinMode(SW4,INPUT);

   myservo1.attach(2);
   myservo2.attach(3);

 Serial.begin(9600);
  lcd.begin(16, 2);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("  -- WELCOME --");
  delay(2000);



}

void loop(void)
{
  Sens1 = analogRead(Sens1Pin);            //read the value from the sensor
  Sens1 = (5.0 * Sens1 * 100.0)/1024.0;   //convert the analog data to SW1

  Sens2 = analogRead(Sens2Pin);            //read the value from the sensor
  Sens2 = (5.0 * Sens2 * 100.0)/1024.0;   //convert the analog data to SW2

  if (MODE==0){
```

```
    lcd.begin(16, 2);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("STATUS: STOP");
    if (Sens2 < 50){
      MODE=3;
      delay(1000);
    }

    if (Sens1 < 50){
      MODE=1;
      myservo1.write(140);
      delay(1000);
    }
    if (digitalRead(SW4)==0){
      MODE=5;
      myservo2.write(150);
      delay(1000);
    }
    Sens1 = analogRead(Sens1Pin);            //read the value from the sensor
Sens1 = (5.0 * Sens1 * 100.0)/1024.0;  //convert the analog data to SW1

Sens2 = analogRead(Sens2Pin);            //read the value from the sensor
Sens2 = (5.0 * Sens2 * 100.0)/1024.0;  //convert the analog data to SW2

}
if (MODE==1){
```

```
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("SPEED: ");
lcd.print(spd);
lcd.setCursor(0, 1);
lcd.print("L: ");
lcd.print(LEFTs,0);
lcd.print("  R:");
lcd.print(RIGHTs,0);
//------------------------------------------------------------------------
if (digitalRead(SW1)==0){
  if (spd <200){
  spd++;
  }


}
if (digitalRead(SW2)==0){
 if (spd > 1){
  spd=spd-1;
 }
}
//------------------------------------------------------------------------
if (ROT==0){
  if (pos < RIGHTs){
    lcd.setCursor(11, 0);
lcd.print("Right");
    pos++;
    myservo2.write(pos);              // tell servo to go to position in variable 'pos'
    delay(spd);                       // waits 15ms for the servo to reach the position
  }
  if (pos>=RIGHTs){
    ROT=1;
```

```
}
  if (ROT==1){
  if (pos > LEFTs){
    lcd.setCursor(12, 0);
lcd.print("Left");
    pos=pos-1;
    myservo2.write(pos);              // tell servo to go to position in variable 'pos'
    delay(spd);                       // waits 15ms for the servo to reach the position
  }
  if (pos<=LEFTs){
    ROT=0;
  }
}



//-----------------------------------------------------------------------------------


delay(50);
if (Sens1 < 50){
  MODE=0;
  myservo1.write(180);
  delay(1000);
}

 Sens1 = analogRead(Sens1Pin);            //read the value from the sensor
Sens1 = (5.0 * Sens1 * 100.0)/1024.0;   //convert the analog data to SW1

Sens2 = analogRead(Sens2Pin);            //read the value from the sensor
Sens2 = (5.0 * Sens2 * 100.0)/1024.0;   //convert the analog data to SW2
}
```

```
if (MODE==3){

    lcd.begin(16, 2);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Set Angle:");

    lcd.setCursor(0, 1);
    lcd.print("U: ");
    lcd.print(UPs,0);
    lcd.print(" D:");
    lcd.print(DOWNs,0);

    if (digitalRead(SW1)==0){
      UPs++;
      if (UPs > 180){
        UPs=120;
      }
    }
    if (digitalRead(SW2)==0){
      DOWNs++;
      if (DOWNs > 180){
        DOWNs=120;
      }
    }
    if (Sens2 < 50){
      MODE=4;
    }
   Sens1 = analogRead(Sens1Pin);              //read the value from the sensor
```

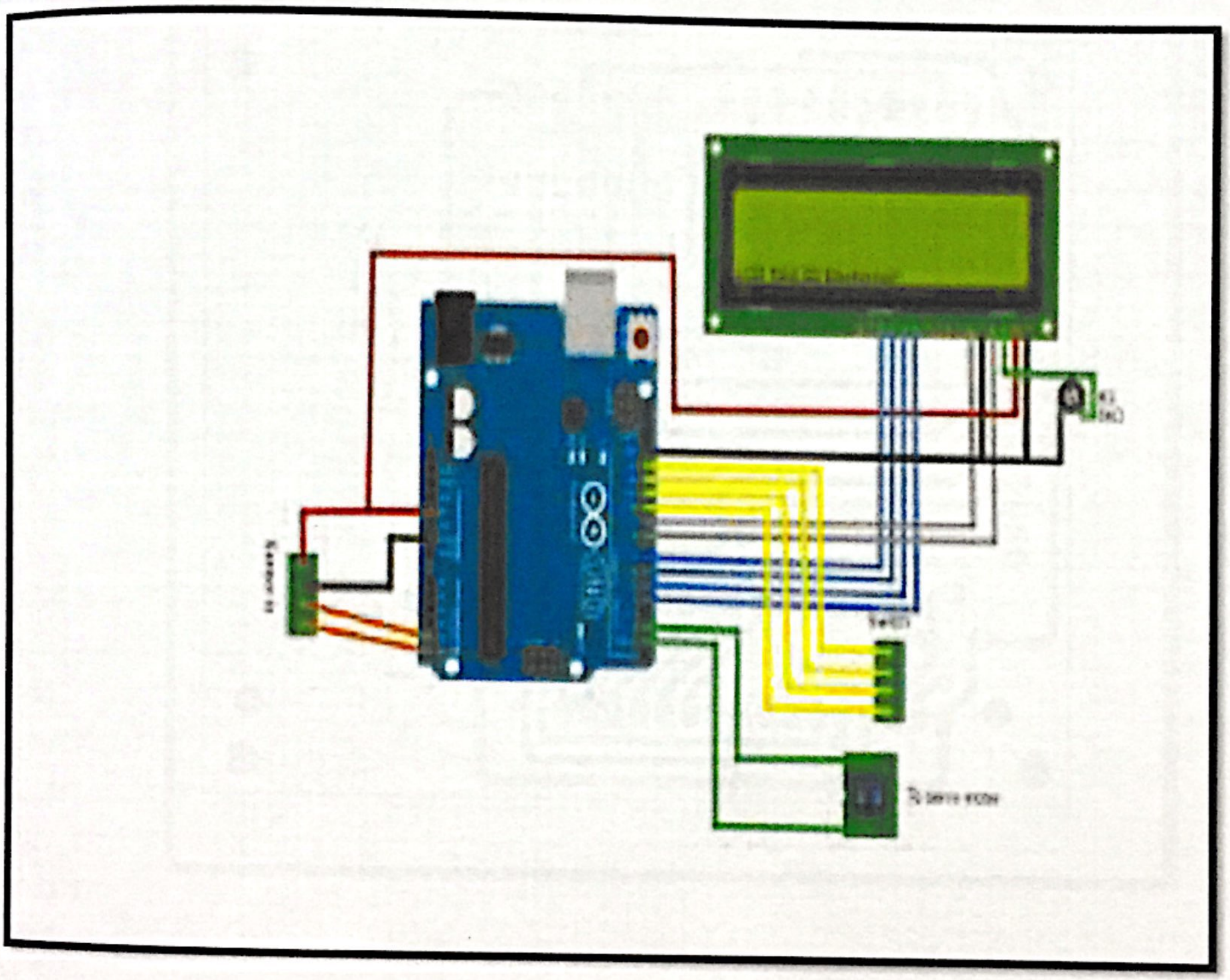
```
  }
  Sens1 = analogRead(Sens1Pin);            //read the value from the sensor
Sens1 = (5.0 * Sens1 * 100.0)/1024.0;  //convert the analog data to SW1

Sens2 = analogRead(Sens2Pin);             //read the value from the sensor
Sens2 = (5.0 * Sens2 * 100.0)/1024.0;  //convert the analog data to SW2
  // delay(10);
}
if (MODE==4){




    lcd.begin(16, 2);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Save setting...");
    delay(2000);
    MODE=0;
}

//%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
 if (MODE==5){




    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("SPEED: ");
    lcd.print(spd);
```

```
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("SPEED: ");
lcd.print(spd);
lcd.setCursor(0, 1);
lcd.print("U: ");
lcd.print(UPs,0);
lcd.print("  D:");
lcd.print(DOWNs,0);
//------------------------------------------------------------------------
if (digitalRead(SW1)==0){
  if (spd <200){
  spd++;
  }


}
if (digitalRead(SW2)==0){
 if (spd > 1){
  spd=spd-1;
 }
}
//------------------------------------------------------------------------
if (ROT==0){
  if (pos <DOWNs){
    lcd.setCursor(11, 0);
lcd.print("Down");
    pos++;
    myservo1.write(pos);              // tell servo to go to position in variable 'pos'
    delay(spd);                       // waits 15ms for the servo to reach the position
  }
  if (pos>=DOWNs){
```

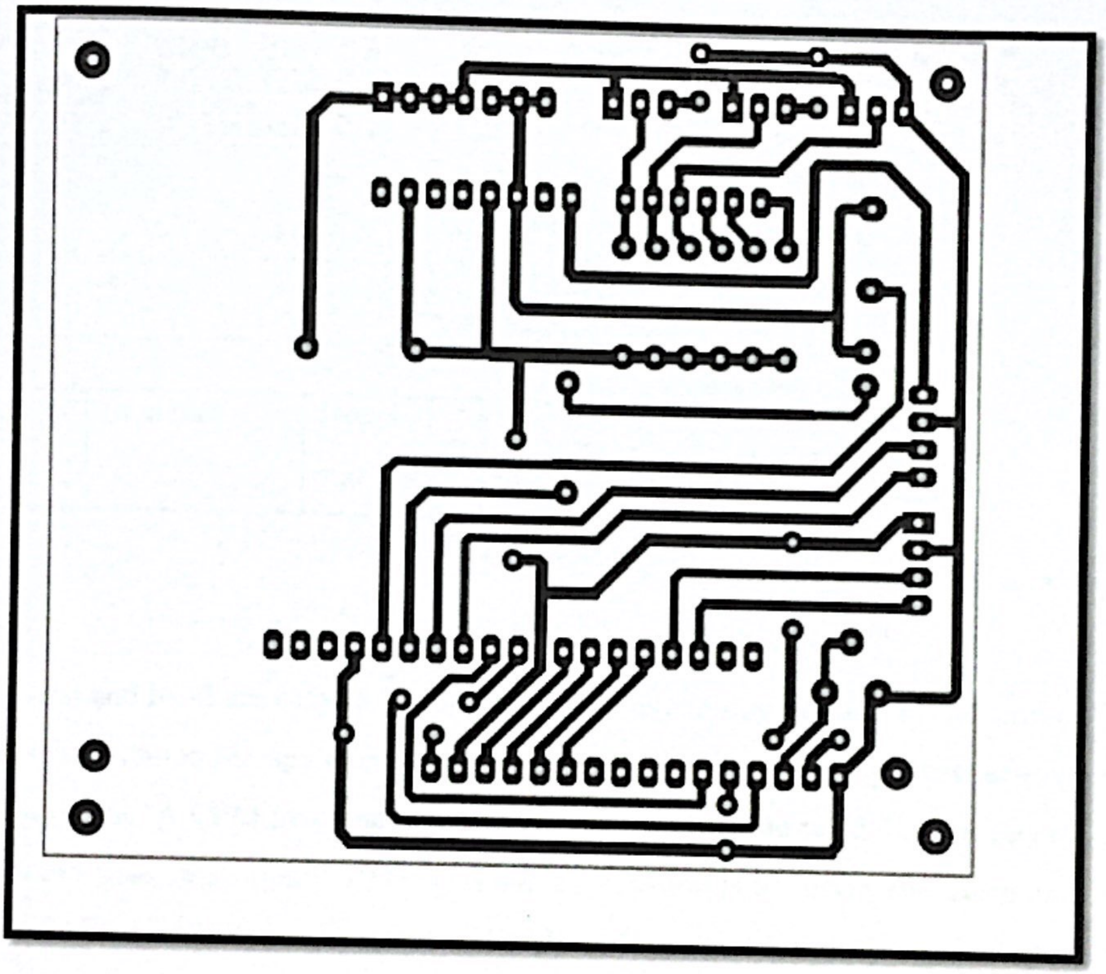
```
    pos++;
    myservo1.write(pos);              // tell servo to go to position in variable 'pos'
    delay(spd);                       // waits 15ms for the servo to reach the position
  }
  if (pos>=DOWNs){
    ROT=1;
  }
}
  if (ROT==1){
  if (pos > UPs){
    lcd.setCursor(12, 0);
lcd.print("Up");
    pos=pos-1;
    myservo1.write(pos);              // tell servo to go to position in variable 'pos'
    delay(spd);                       // waits 15ms for the servo to reach the position
  }
  if (pos<=UPs){
    ROT=0;
  }
}




//-----------------------------------------------------------------------------

delay(50);
if (digitalRead(SW4)==0){
  MODE=0;
  myservo1.write(180);
  delay(1000);
}
```

```
    MODE=0;
    myservo1.write(180);
    delay(1000);
  }

  Sens1 = analogRead(Sens1Pin);              //read the value from the sensor
Sens1 = (5.0 * Sens1 * 100.0)/1024.0;  //convert the analog data to SW1

Sens2 = analogRead(Sens2Pin);              //read the value from the sensor
Sens2 = (5.0 * Sens2 * 100.0)/1024.0;  //convert the analog data to SW2
}
```

APPENDIX B: - SCHEMATIC



APPENDIX C: - PCB LAYOUT



APPENDIX D: - QUESTIONNAIRE (PRE-SURVEY)

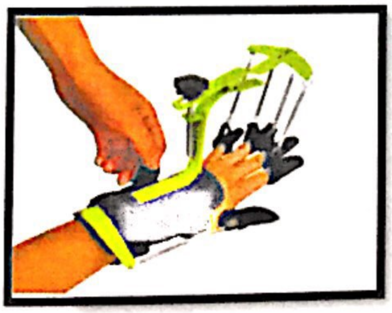
POLITEKNIK
Sultan Salahuddin Abdul Aziz Shah

Name: ....

Age: ....

Public	Student	Hospital staff

Human wrist and hand are easy to be injured or not functioning because of the stroke. Physical rehabilitation therapy after a wrist or hand operation or stroke patients always takes a long time. A CPM machine is a mechanism based on the rehabilitation theory of continuous passive motion (CPM). This survey question is to survey the usage and the needed of the utilization of smart wrist and hand exercise for stroke patients and injured patient. Rehabilitation device that used in the hospital. As I've planned, I want to develop the device which it can be functioning without help from caregiver.



1) Whether a stroke patient will be improved by physiotherapy?

a) Yes

b) No________________________________

2) Does wrist joint rehabilitation device only used for the patient who have wrist injury and stroke patients?

a) Yes

b) No

3) Do you think this project will help patient?

a) Yes

b) No

4)If the wrist joint rehabilitation device can work without AC power supply, which it can be working on batteries, do you think it is more convenience?

a) Yes, agree.

b) No

5)Are you agree if I design new technology for help stroke patient or injury?

a) Yes

b) No

6)The wrist joint rehabilitation device has problems and need to be improved??

a) Yes

b) No

7)The needed of the utilization of smart wrist and hand exercise for stroke patients and injured patient are needed in treatments? If no, please state the reason is why?

a) Yes

b) No, ______________________________

8) Is suitable for the elderly stroke patients?

a) Yes

b) No, If no, why?

____

9). Do the current wrist joint rehabilitation device convenience while using it? If no, why it is not convenience while using?

a) Yes

b) No, ______________________________________

10). Give your comment/ suggestion to the project.

____

____

____

THANK YOU FOR YOUR COOPERATION

APPENDIX E: - QUESTIONNAIRE (POST SURVEY)

POLITEKNIK
Sultan Salahuddin Abdul Aziz Shah

SURVEY QUESTIONNAIRE

THE DEVELOPMENT OF SMART WRIST EXERCISE TOOLS FOR STROKE AND INJURED PATIENTS

DISCLAIMER

The survey is made based on a final year Bachelor of Engineering Technology (Medical Electronic). The main purpose for the questionnaire is to get some opinion of information about the development of smart wrist exercise tools for stroke and injured patients and also to understand and evaluate the application of the device. This will be helpful in order to improve and to enhance the device in the future. Human wrist and hand are easy to get injured or not functioning well because of the stroke or due to injuries. Participants of this survey are completely voluntary and anonymous. Please fill in the following questions with (/)in the appropriate statement.

CONSENT

I have read and understand all the information mentioned above. My participation in this survey is voluntary and I am willing to share any necessary information needed for this survey.

Age	<18		18-40		41-60		>60	

Gender	Male		Female	
Occupation				

<u>**This survey divided into 2 sections. Section A and B**</u>

SECTION A

Please rate (/) on how strongly agree or disagree with each of these statements below

No		Item & Elements	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1		**Effectiveness**					
	a)	Do you like to use this product frequently?	1	2	3	4	5
	b)	Do you find some additional functions to integrate this product?	1	2	3	4	5
	c)	Do you think the effectiveness of this product can enhance fast recovery?	1	2	3	4	5
	d)	Most people can learn how to use this product quickly.	1	2	3	4	5
	e)	SWET is suitable for the purpose of stroke's disease	1	2	3	4	5

		and injured patients for a better recovery.					
2		**Comfortableness**					
	a)	Do you think will it be comfortable when the wrist is put on the devices?	1	2	3	4	5
	b)	The SWET is easy to user friendly?	1	2	3	4	5
	c)	Will it be convenience in using this product during exercise	1	2	3	4	5
	d)	Do you think this product is stable while operating?	1	2	3	4	5
	e)	The device is easy to be used or to be handled when operating?	1	2	3	4	5
3		**Speed and range**					
	a)	The speed and range can be selected easily?	1	2	3	4	5
	b)	Do you think the speed and range is adjustable to the patient and are they effective?	1	2	3	4	5

	c)	The speed can be selected easily	1	2	3	4	5
	d)	The high speed won't bring any wrist feels uncomfortable to the patients	1	2	3	4	5
	e)	The speed operation is suitable for stroke and injured patient?	1	2	3	4	5
4		**Design and Strength**					
	a)	The design is comfortable?	1	2	3	4	5
	b)	The design is easily to be brought anywhere?	1	2	3	4	5
	c)	The product is suitable to be used everywhere?	1	2	3	4	5
	d)	The device is able to move the patient's wrist upward and downward/right and left?	1	2	3	4	5
	e)	The movement of the product is smooth and stable?	1	2	3	4	5

Section B

Please rate (/) on how much you strongly agree or disagree with each of these statement below.

	Item & Elements	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
1	Do you understand the operation of this device?	1	2	3	4	5
2	Is it easy to operate this device?	1	2	3	4	5
3	Is it safe to use this product?	1	2	3	4	5
4	I would like to recommend the device to other people who are needed?	1	2	3	4	5
5	SWET can help those in stroke and injured patients	1	2	3	4	5

Recommendation/comments:

____
____
____
____

Signature,

____

Position:

Date:

Thank you for cooperation.

☺

APPENDIX F: - LETTER OF ACKNOWLEDGEMENT FROM RADICARE

Radicare

Radicare (M) Sdn. Bhd.

Date : 6th April 2017

TO WHOM IT MAY CONCERN

Letter of Acknowledgement for "The Development of Smart Wrist Exercise Tools for Stroke and Injured Patients

Hereby, with a sense of gratitude and appreciation for the innovations that has been made on the Smart Wrist ExerciseDevice. The innovator detail as below:

Name of innovator	**: Nabila Bt Mohd Gahni @ Mohd Ghani**
NRIC	**: 930119-11-5456**
Innovation's name	**: The Development of Smart Wrist Exercise Tools for Stroke and Injured Patients**

2. This innovation also demonstrated the ability to provide benefits to the consumer and society. Furthermore, this innovation is suitable to market for the use by Stroke and Wrist Injury patient. With the use of battery to operate machine, electrical safety risk to the consumer is eliminated.

3. We hope for more innovation to improve the quality of therapy in rehabilitation field.

Thank you

Sincerely,

06/04/17

NORAINI ISMAIL
Technical Manager, Eastern Zone
Biomedical Engineering Maintenance Services

FROST & SULLIVAN 2007
Head Office: Level 13, Wisma UOA Damansara II, No. 6 Jalan Changkat Semantan, Damansara Heights, 50490 Kuala Lumpur, Malaysia.
Branch: d/a Hospital Sultanah Nur Zahirah, Jalan Sultan Mahmud, 20400 Kuala Terengganu, Terengganu

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17/03/2017 2/2

Applicant :

[x] Owner [ ] Author [ ] Licensee

Title of work (Original language) : THE DEVELOPMENT OF SMART WRIST EXERCISE TOOLS FOR STROKE AND INJURED PATIENTS

Translation :

Transliteration :

Name of the Language ("Language that been used in the work) : ENGLISH

If published in a periodical or serial (Literary Work) : (Volume / Number) (Issue Date) (On Pages)

Section A : Type of Works

[x] Literary [ ] Musical [ ] Artistic [ ] Film [ ] Sound Recording

Date of Fixation / First Published / Erected / Incorporated : 1 / 3 / 2017

Section B : Publication

The Work is : [x] Published [ ] Unpublished

If published : 2017 (Year of Compilation) 1 / 3 / 2017 (Date of first publication) MALAYSIA (Country)

Section C : Author (If author is "same as owner" go to Part D - if more than one author, please attach a list of names and addresses of all the author)

Name : REFER ATTACHMENT

National Identification No / Passport No :

Address 1 :

Address 2

RECEIVED