DEVELOPMENT OF HAND SUPPORT AND THERAPY DEVICE

KHAIRUL ASYRAF BIN ABU TALIB

POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

DR. HJ. ZUNUWANAS BIN MOHAMAD
PENSYARAH KANAN DH48
IJAZAH SARJANA MUDA TEKNOLOGI KEJURUTERAAN ELEKTRONIK
(ELEKTRONIK PERUBATAN)
POLITEKNIK SULTAN SALAHUDDIN
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DECLARATION

I hereby declare that the work in this thesis is my own except for quotation and summaries which have been duly acknowledged.

Signature : .....

Name : **KHAIRUL ASYRAF BIN ABU TALIB**

Registration No: 08BEU16F3030

Date : **5 JULY 2018**

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ABSTRACT

Hand support devices are very helpful for embraced patients for daily living, for example, paraplegic patients, accidental effects and so on that cause limited movement. It is vital for patients with major and minor injuries to undergo rehabilitation process to improve their condition effects from the injuries. It is found that, there are wide range of existing support tools nowadays however, the support device only has one function only, as a support system. Therefore, this study aims to design a compatible hand support device, to develop a hand support and therapy in one device, and to analyze the usage of hand support and therapy device in daily life at home. This study applied a quantitative method with a survey distributed to 50 polytechnic students that have a knowledge about hand support and therapy device and understand about the terms used in biomechanical. Results shown that this device is comfortable, suitable and portable for daily used. Hand support provides various benefits to the patients which improve their quality of life and fasten the recovery time. It also has the potential in providing a supplemental home-therapy device for certain patients and acts as a daily used device for minor injury patients. Through this device it will help the patients in enhancing their recovery time and improvement of hand function in a short time.

Keywords: hand support, therapy device, limitation movement, recovery

ABSTRAK

Alat sokongan tangan sangat membantu para pesakit untuk menjalani kehidupan seharian, contohnya, pesakit paraplegic, kemalangan kecil dan sebagainya yang menyebabkan pergerakan menjadi terhad. Adalah penting bagi pesakit yang mengalami kecederaan besar dan kecil menjalani proses pemulihan untuk memulihkan keadaan mereka dari kecederaan. Didapati bahawa terdapat pelbagai alat sokongan yang ada pada masa kini, namun alat sokongan tersebut hanya mempunyai satu fungsi sahaja iaitu sebagai sistem sokongan. Oleh itu, kajian ini bertujuan untuk mereka alat sokongan tangan yang serasi, mencipta alat sokongan tangan dan terapi dalam satu alat, dan menganalisis penggunaan alat sokongan tangan dan terapi dalam kehidupan seharian di rumah. Kajian ini menggunakan kaedah kuantitatif dengan kajian yang diedarkan kepada 50 pelajar politeknik yang mempunyai pengetahuan mengenai alat sokongan tangan dan terapi dan memahami terma-terma yang digunakan di dalam biomechanical. Keputusan menunjukkan bahawa alat ini adalah selesa, sesuai dan mudah alih untuk kegunaan harian. Alat sokongan tangan ini menyediakan pelbagai manfaat kepada pesakit seperti meningkatkan kualiti hidup mereka dan meningkatkan masa pemulihan. Ia juga berpotensi untuk menyediakan alat terapi rumah tambahan untuk pesakit tertentu dan bertindak sebagai alat yang digunakan setiap hari untuk pesakit kecederaan kecil. Melalui alat ini, ia akan membantu pesakit dalam meningkatkan masa pemulihan dan fungsi tangan dalam masa yang singkat.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The development of rehabilitation robotic systems are increasing due to current needs and demands from the globalization. Many researcher started to develop new devices to assists along the rehabilitation process especially patients with home based rehabilitation. Hand injuries will impact both the physical function, daily living activities, social, psychological and financial life. Patients with hand injuries experience pain and stiffness up to four years after the injury [1]. They experienced limited movements of hands and depends on other people to perform day to day activities.

This is associated with the psychological burden such as stress, frustration, loss of confidence, discouragement and fear of re-injury. Given the impacts of hand injury, a relevant and consistent hand rehabilitation is important in restoring the function of injured hand to enables patients return to day to day activities without least restrictions. Any injury that involved nerve system will resulted a problem with the muscle or sensation. Nerves connect the brain and spinal cord to the muscles and skin which giving the movement and feeling. If there is an injury to the nerve, there will be an interruption in the information being conveyed to the skin or muscles to and from the brain.

The larger nerves in your arm and leg, which are about the size of a pencil are made up of tens of thousands of nerve fibers, similar to the telephone cable and the nerve fibers are grouped together in fascicles. Some nerves like the median and ulnar nerve in your arm have motor and sensory fascicles giving you movement and feeling

to your hand. In nerve injury, the nerve will try to repair itself by sprouting regenerating nerve units. These regenerating units will then try to grow down the nerve to re-innervate muscle or skin. If they make a correct connection, motor nerve to muscle or sensory nerve to skin, then recovery of muscle function and skin sensation will occur.

If however, the regenerating nerve fibers do not make a correct connection then no recovery will occur. Nerves will regenerate at the rate of 1 inch per month. While sensation can be regained even after long periods of denervation, muscle reintegration will not occur after long periods of time without nerve innervation. Therefore, it is necessary to get nerve to muscle as quickly as possible if it is not going to recover on its own. This project proposes a technical feasibility study of an electro diagnostic tests, including electromyography (EMG) and nerve conduction studies that use to see if the muscle is recovering.

1.2 PROBLEM STATEMENT

Hand injuries are difficult to repair because of the complexity of the hand. After a hand injury, the hand may not be functioning well as it did before the injury due to loss of motion, dexterity and grip. It is found that, patient only undergo physiotherapy exercise at hospital rather than at home. This means that they did not practice the therapy exercise at home. This is due to the issue of no equipment that can help the patient to perform home-based physiotherapy. The existing equipment is usually only available at the hospital and most of the support devices work only one method, which is therapy or daily support.

If the patients have a hand support device which compatible and user-friendly and can be use at home, they could enhance their improvement and get recover in a short time. They also will less depended with physiotherapy center at the hospital.

Moreover, in Malaysia, current method used by the rehabilitation center is less relevance with the current demands and needs. According to [2] Malaysia physiotherapists used conventional method to conduct the rehabilitation process. This is time consuming and led to loss focus and interest to undergo the rehabilitation exercise. Not to mention, commitment in terms of attendance to rehab appointment can

also cause the patients' improvement decrease due to logistic and domestic problems. Through this hand therapy device, patient can carry out the exercise at home and improve the current physiotherapist method which is more comfortable, compatible and portable.

1.3 OBJECTIVE

The objectives of this project are:

i. To design a hand support and therapy device that more portable, comfortable and suitable for the hands of different people.

ii. To develop a hand support and therapy in one device which applicable for daily use.

iii. To analyze the usage of hand support and therapy device in daily life at home.

1.4 SCOPE OF PROJECT

This project will focus only on designing a device that user-friendly and suitable for daily use. Different people will have different size of wrist and hand therefore, this project will create a comfortable device that adjustable for any size of wrist and hand. The device also is portable for daily use. Patients can apply this hand support and device everyday as long as they are required to use, as a way to improve the recovering process.

1.5 SIGNIFICANT OF PROJECT

The detail and careful design of hand support and therapy device is conducted to achieve the requirement of minimum cost of production with optimum functionality. The current device used have limited movements which less significant for the current needs and demands. A device should have a compatibility usage and flexible movement that will progressively improve the recovering process of the patient. In addition, the device will allow the therapist and patient not to depend much on the physiotherapists at the hospital and can conduct the rehabilitation activities at home. Figure 1.1 simplify the significant of this project.

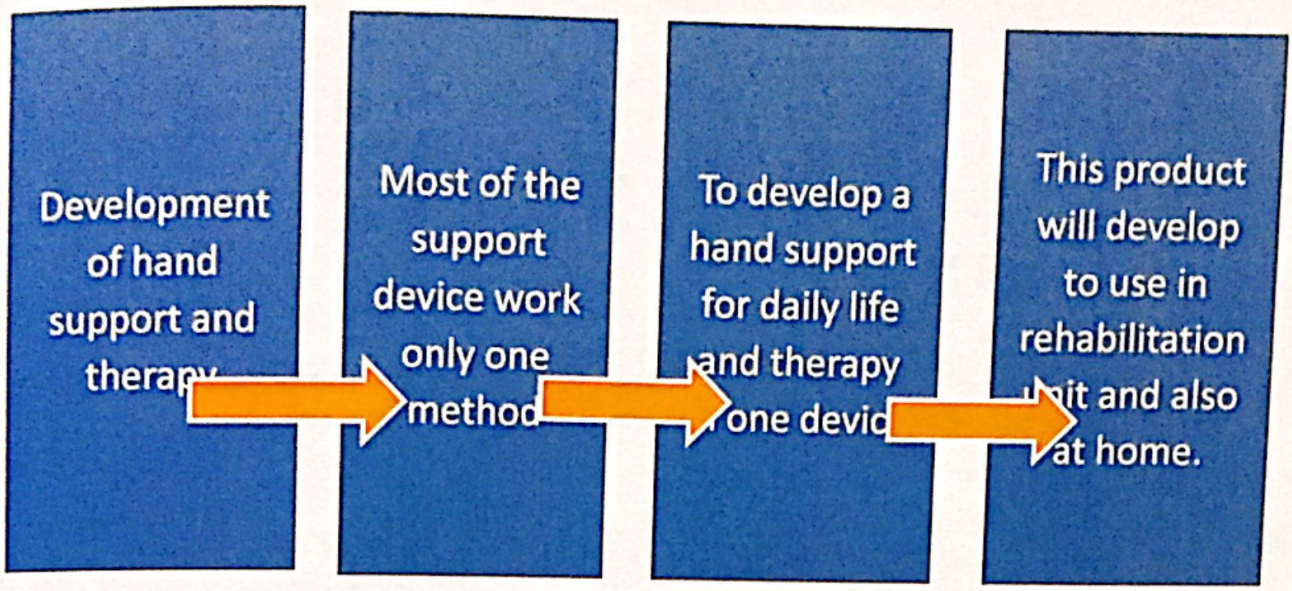


Figure 1.1: Significant of the project

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Hand is necessary for a human to become independence and working in a daily life. The loss of hand function resulted various negative causes including inability to care for oneself, feeding and limitation in participate in work, social and family life. Moreover, it also could affect the emotion and psychology of a person to recover. When a person feel devastated with the degenerate recover, the speed of recovery will declined. Therefore, this person may need a support that can help them recover fast so that they can living a life without depending with other people.

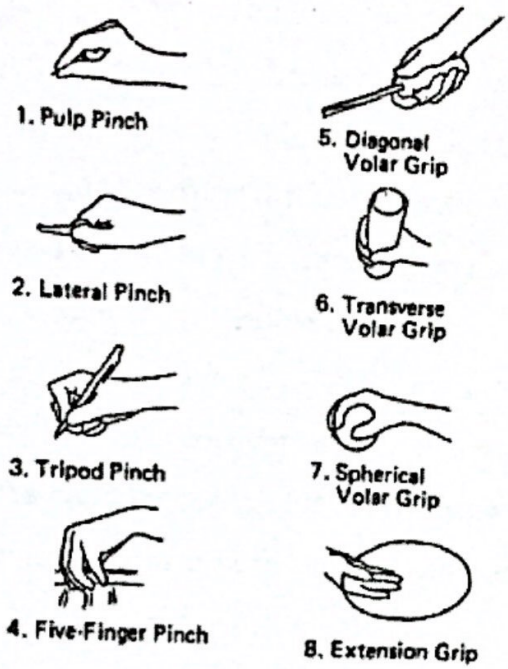
2.2 HAND FUNCTION

According to [3], hand function is described as the ability to use the hand in daily life to perform everyday activities. Hands and fingers play vital role in human life especially in almost all human activities such as to feeding, to pick up things, to perform certain work, to write and others. The limitation of hand function is due to the injuries and diseases that happened to experience by a person.

A study in Denmark indicates that the rate of injuries to the hand and wrist was 28.6% of all injuries and this comprises a 34% of the domestic accidents, 35% were leisure accidents, 26% were occupational and 5% were traffic accidents. And the most frequent causes for admission were fractures (42%), tendon lesions (29%) and wounds (12%) [4]. Besides of the injuries, hand function also affected by a disease including osteoarthritis where 90% of women and little less than 80% percent of men has been confirmed to have this diseases in a group of 70-74 years and a group of more than 80 years, is recognize to have 99% for women and over 95% for men [4].

The statistics of the above showed that hands and fingers are easily fractured and when a person loss the ability to use the hand function, it is likely to affect the persons to depend solely on other people to complete daily activities. The degree of independence is vary as it depends on the individual activity to coordinated hand movement and function [3]. The main purpose of rehabilitation is to help reduce the impairments and restore functional performance by hand. There are many techniques and tools introduced to help facilitate and speed up the recovery of the hands [3]. This includes range of motion exercises, strengthening exercises, and aerobic or endurance exercises.

A range of motion exercise purpose to enhance the flexibility of joints and relieve stiffness from hands and fingers, while strengthening exercise involved certain weight to increase the muscle strength to support and protect the joints, and aerobic endurance exercise performed to decrease joints swelling in some cases [4]. Besides of this exercise, a sensory devices has been also introduced to increase the functionalities of hands such as grip force measurement devices, finger pinch force sensors, virtual reality gloves and exoskeleton system. The assessment of hand discover that the function of hand has focused on grip or pinch strength and range of hand motion subject to evaluation of the activities. Figure 2.1 showed eight main types of functional grasp played by normal hands in daily activities. This functional grasp is vital in increased the hand function especially if the person performed during the rehabilitation practice.



Source: Sollerman C. and Ejeskar A. (1994)

Figure 2.1: Eight types of grasp.

It is to note that when a person experienced an injury to a nerved, they most likely have problem with the muscle and loss in sensation [5]. There are few types of nerve injury that affect the hand sensation. A first degree injury (neurapraxia) will recover fast from certain days to 3 months, second degree injury (axonotmesis) slower than first one as the nerve need to grow to reinnervate the muscle or skin and the nerve grow an inch per month, third injury experienced a partial recovery and it depends on several factors, fourth and fifth degree injury require surgery for recovery as a tissue has blocking any recovery and lastly the sixth degree injury is a combination the other types of nerve injury and recovery and treatment will vary.

In some cases, if a person experiences an extreme injury a surgery is required to improve the nerve recovery. Some of the recommended surgery are nerve repair, nerve graft, nerve transfer or neurolysis [5]. After the surgery, the person is required to do rehabilitation practice to get back sensation and improve hand functionality. However, currently not all rehabilitation process are adequate for all types of injuries. This is agreed by [4] as most of the systems are inadequate for usage in severe cases of hand disabilities such as for patients in the last stages of rheumatoid arthritis and

osteoarthritis. Different patients may require different types of rehab or the recovery would not be worked. Besides of rehab, in this high technology era various robotic tools can be used by patients to help in rehabilitation. Some of the advantage using robots are it able to provide therapy for a long time periods in a consistent and precise manner without fatigue, can be programmed to perform different functional modes, can measure and record a range of behaviors and able to perform as a remote to human control [6]. However, robotic is a very expensive and inflexible tools.

Therefore, this study will identify adequate device that will help patients speed up the recovery and increase the hand function. This study also will create and develop a device that is flexible where patients can use at any time without feeling uncomfortable and cheaper.

2.3 ANATOMY OF THE HAND

The human hand is considered as the most complicated part of human body which consists of 27 bones, 27 joints, 34 muscles, 100 ligaments and tendons and numerous blood vessels, nerves and soft tissue [6]. All of these elements have different functions which connected with each other to ensure the hand movement. There are three main parts of human hand; wrist (carpus); palm (metacarpus); and fingers (manus) [7]. The wrist is compasses of 8 bones (carpal bones) that connect with 5 metacarpal bones which connects to fingers (phalanges) at a joint called metacarpophalangeal joint (MCP joint) or knuckle joint [6]. The hand and wrist bones are supported by numerous soft tissue includes; cartilage (allows smooth movement when two bones connect with each other); tendons (provide support from the connection of muscle and bones); ligaments (holds tendons in place and provide stability to the joints); and muscles (responsible for thumb and little finger movement when holding or grabbing items) [6].

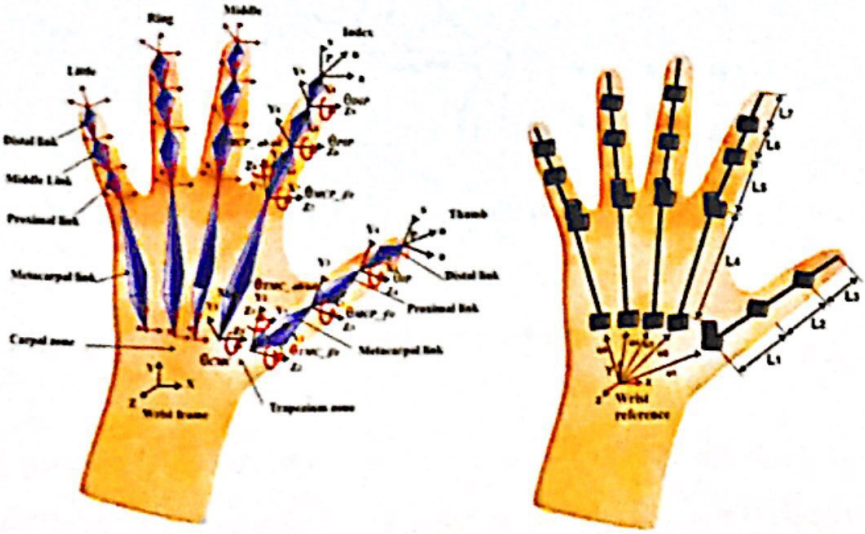
Besides that, there are also several joints in human hand. Starting from the wrist is the radiocarpal joint (between the carpal bones and radius bone), midcarpal and intercarpal joints (enable movement of flexion/extension – towards the palm or back of the hand and radial / ulnar flexion – towards the thumb or little finger), five carpometacarpal (CMC) joints (helps the movements of flexion and extension,

abduction and adduction, circumduction and opposition), metacarpophalangeal joint, (MCP) and interphalangeal joints (the proximal and distal phalanx) [7].

2.4 BIOMECHANICS OF HUMAN HAND

Hand is referring to an open kinematic chain that starts from the wrist joint and ending in finger joints which enable human to do a rotation motions [7]. It also enable human to perform certain activities and task through grasp and pinch. While biomechanics is a term to define the movement of the body, where a stable wrist with two digits, at the minimum, is capable of grasping motion [8]. [7] Differently define the biomechanism hand that comprises of individual bones (movable parts) and joints (kinematic parts).

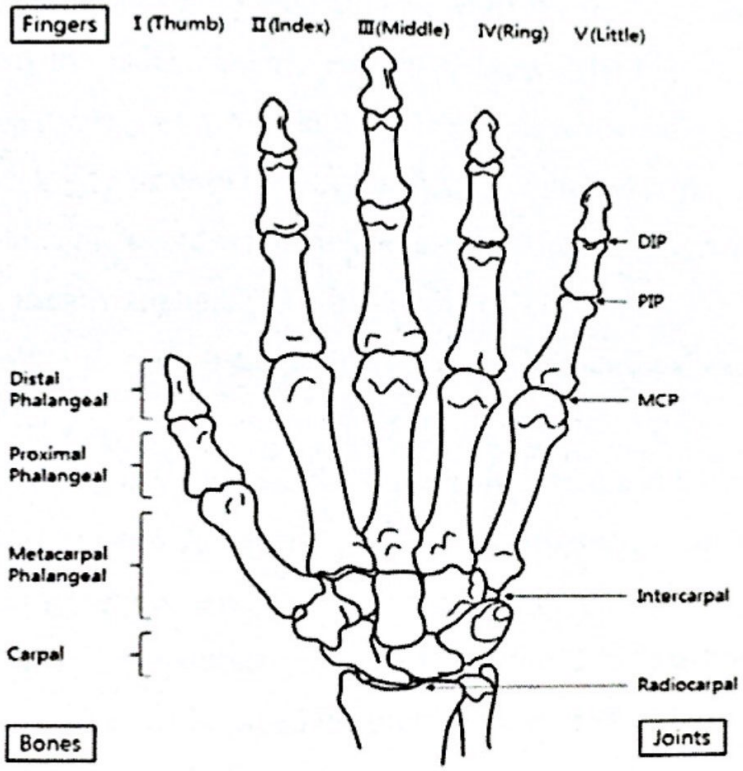
Figure 2.3 presents the model of human fingers by [9] that depicting the human fingers which comprises of 19 links corresponding with human bones and 24 degrees of freedom representing the joints of hands. These models is used as the reference in conducting the flexion/extension and abduction/adduction movement of the fingers in all metacarpophalangeal joints [7].



Sources: S. Cobos et al. (2008), Efficient Human Hand Kinematics for Manipulation Tasks

Figure 2.2: The kinematic chains of the human fingers.

Besides of the above model, [10] presented an overview of the biomechanics human hand with 19 bones and 14 joints distal to carpals. Each finger with metacarpal bone and proximal phalanx are liked at MCP joints enable two degrees of freedom of flexion, extension, abduction and adduction movements. [10] indicates that different shapes of finger joints resulted in varying DOF which provide a large range of motion and greater flexibility of the digits. This will shows the overall motion used in a hand movements.



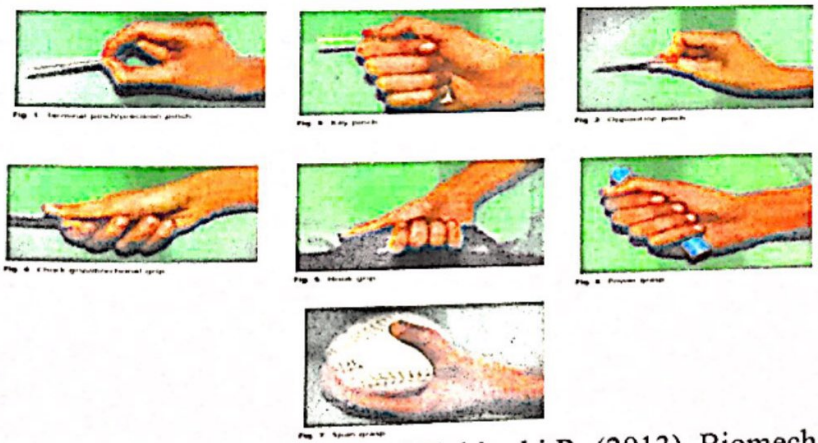
Sources: Abdallah I.B., Bouteraa Y. and Rekik C. (2017), Design and Development of 3D Printed Myoelectric Robotic Exoskeleton for Hand Rehabilitation.

Figure 2.3: Bones and joints of a human hand.

This project is focusing on the hand support from the wrist until fingers, therefore, to develop an ergonomically comprehensive design, researcher is required to obey the natural movements and limitation of a human wrist [2]. The human wrist is the combination of forearm adds up to the three-degree of freedom (DoFs) where the forearm is capable in performing the radial/ulnar deviation, flexion/extension and

pronation/supination movements. Besides of these three movements [2] listed seven maneuvers that covers most of hand functions for a biomechanics motion;

i. The precision pinch or terminal pinch, involves flexion of the interphalangeal (IP) joint of the thumb and the distal IP (DIP) joint of the index finger.
ii. The oppositional pinch or subterminal pinch. This pinch is where the pulp of the thumb and index finger are brought together with the IP and DIP joints in extension, which allows for increased forces to be generated through thumb opposition.
iii. Key pinch maneuvering. Functioning when the thumb is addicted to the radial aspect of the index finger's middle phalanx. The key pinch maneuver does require a stable post, which in this situation is really the index finger.
iv. The chuck grip or directional grip. It allows the index finger, long finger, and thumb to come together to envelop a cylindrical object. A rotational and axial force is usually applied.
v. The hook grip requires finger flexion at the IP joints and extension at the MCP joints. This grip is used, for example, when one picks up a suitcase or a briefcase.
vi. In the power grasp position, the fingers are flexed and the thumb is flexed and opposed relative to the other digits such as gripping a club or bat.
vii. The span grasp maneuver is when the DIP joints with the proximal IP (PIP) joints flex to approximately 30 and the thumb is palmarly abducted such that forces are generated between the thumb and fingers.



Sources: Duncan S.F.M., Saracevic C.E. and Kakinoki R. (2013), Biomechanics of the Hand.

Figure 2.4: Seven maneuvers of hand functions.

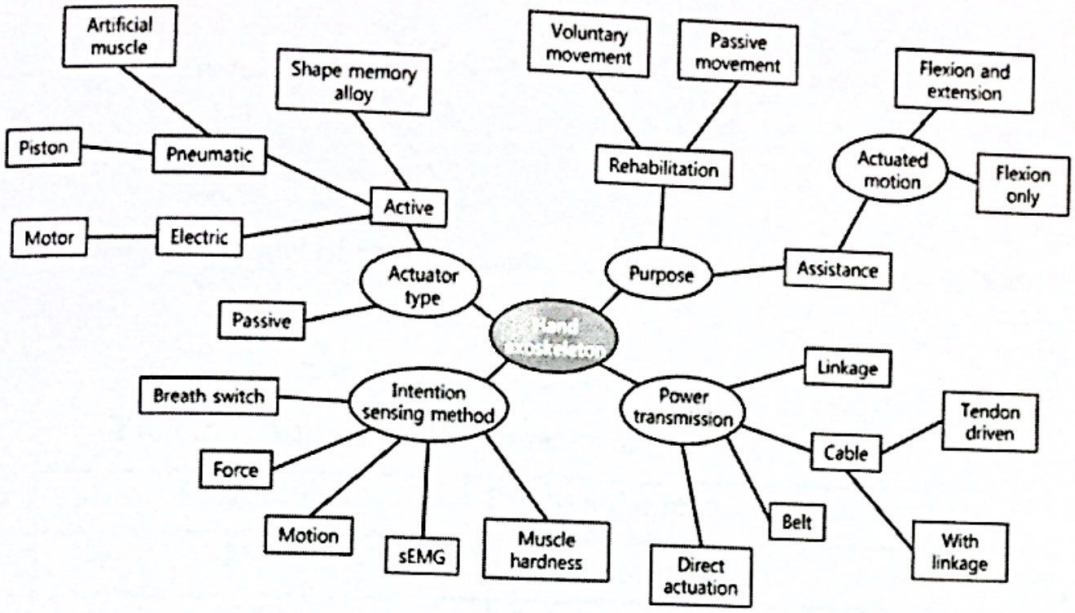


Figure 2.5: Elements in hand exoskeleton.

In designing and creating a hand support and therapy device, there are certain requirements should be taken account to ensure the safety of the device especially when it involves a physical human-device interaction. [10] indicates that a physical interaction device should ensure the hazardous and unexpected movements that may occurred because any malfunction of the device can be seriously harmful to the users. Besides that, figure 2.5 represents the elements that need to be taken into account in developing a hand exoskeleton device. Therefore, table 1 is used as a guideline in limiting the range of motion when the device want to force the hand to move in an excessive range of motion. As shown in Figure 2.5, the mechanical configuration design need to ensure the possibility of the center of rotation because an issues arise between the centers of rotation of the user's hand, the device can damage both the device and user's hand. Therefore, a detail and careful design of hand device is vital in avoiding any negative circumstances.

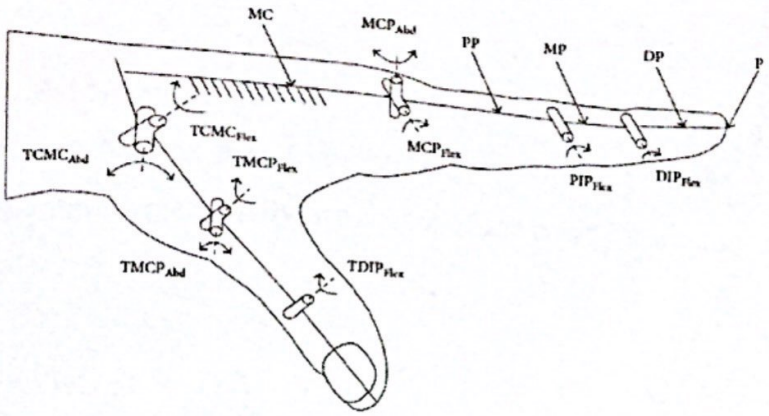


Figure 2.6: Kinematic model of hand: exception of thumb, the remaining digits are a fixed metacarpal.

Table 2.1: Normal values for range of motion of joints

Finger joint	Angular motion range (°)
MCP	[-90, 30]
PIP	[-120, 0]
DIP	[-80, 0]

2.5 THE HAND SUPPORT AND THERAPY DEVICE

Nowadays, we can see most of rehabilitation center implement robotic platform as one of the initiative in providing intensive therapy that us more accurate, repetitive and controllable manner [2]. There are various robot assisted devices found in the markets that assist and improve the rehabilitation process. Not to mention, wrist injury also used robotic platform to fasten the recovery process. However, this process might be harmful to the users as it may not compatible and hardly to manage.

The common exercise for wrist injury primarily focusing in enhancing the patients' range of motion of the wrist and movements, and strengthening wrist stretches, but sometimes it is quite boring and sometimes patients find it difficult to perform the exercise which lead to delaying the recovering process. According to [2], the conventional therapy required specific occupational therapist and medical instruments which is less convenient, relevant and a huge burden for patients, while the robot assisted device only focus on sensitive training and strength training but neglect the neurological rehabilitation. Neurological rehabilitation is vital in ensuring the wrist and

hand have the ability and strength to do certain movements for a long time. Therefore, a compatible, portable and user-friendly device should be developed to ensure that patients can use the device as daily use as one of the ways for training and fastening the recovering process.

2.6 THE SERVO-MOTOR

In choosing a servo motor, researcher should have a good understanding of the system controlled. There are two classes of servo control; the command tracking; and the disturbance rejection. The first class indicates how well the actual motion follows the velocity, acceleration, position and the torque commends while the second class encompasses anything from the torque disturbance [12]. A servo motor is a rotary/linear actuator which may be on permit exact that control about angular/linear position. It may be comprised of a DC engine coupled for a diminishment gear.

There are two types of servo motors, which are the AC and DC. AC servo mostly used in industrial machinery as it is used with a higher current surges. While for DC servos, it is not designed for high current surges and used for a smaller applications. Moreover, DC motors are less expensive than AC counterparts. In this study, researcher used servo motors with continuous rotation, this will make the device easy way to move. They feature two ball bearings on the output shaft for reduced friction and easy access to the rest-point adjustment potentiometer.

There are advantages and disadvantages in using servo motor. Servo motor used to increase the current to the motor coil, when using the load should not be too heavy or may cause an error. This type of motor also possible for a high-speed operation. However, servo motor is not suitable for precision control of rotation as it tries to rotate according to the command pulse. The cost also higher as it is expensive to buy.

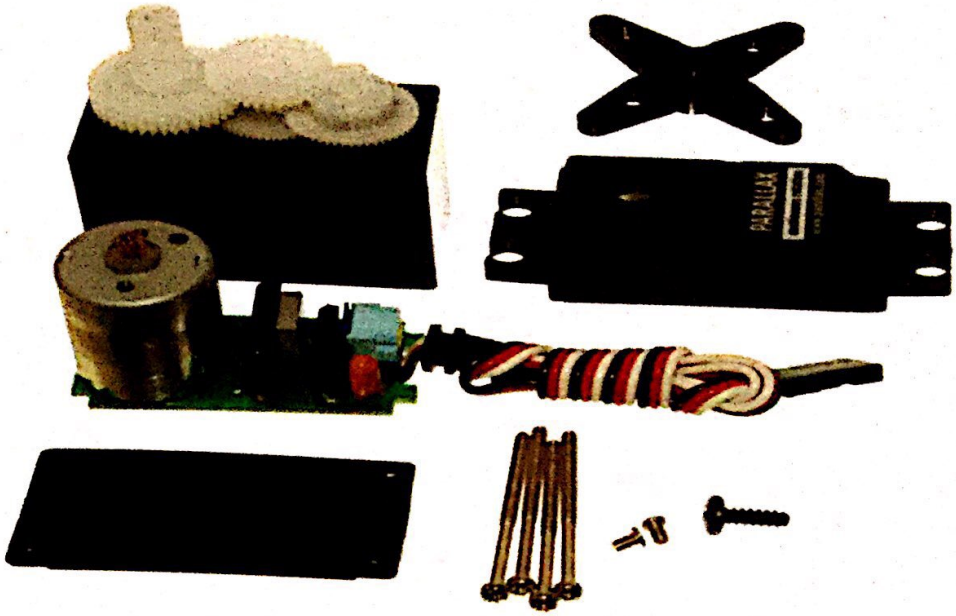


Figure 2.7: RC Servo disassembled showing its main elements.

2.7 ARDUINO UNO

Arduino is a source of programming electronics that used a lot in microcontroller or any circuit board that can be programmed to perform certain or numerous task by sending information from the computer programme [13]. User can simply use a USB cable to upload and use simplified version of C++ software. Arduino functioning to help the user read information from the input devices and send information to output devices.

This framework gives an arrangement of advanced and simple I/O sticks that can be interfaced to different extension sheets (shields) and other circuits. It highlights SCI (Serial Correspondence Interface) for stacking programs from PCs. For programming it, an IDE (Incorporated Improvement Condition) is given which incorporates bolster for the C and C++ programming dialects. It comprises of a chip IC ATMEGA 328P-PU. It gets information from all the information modules and procedures it as indicated by the program. Subsequent to handling, it sends flag to the yield module.

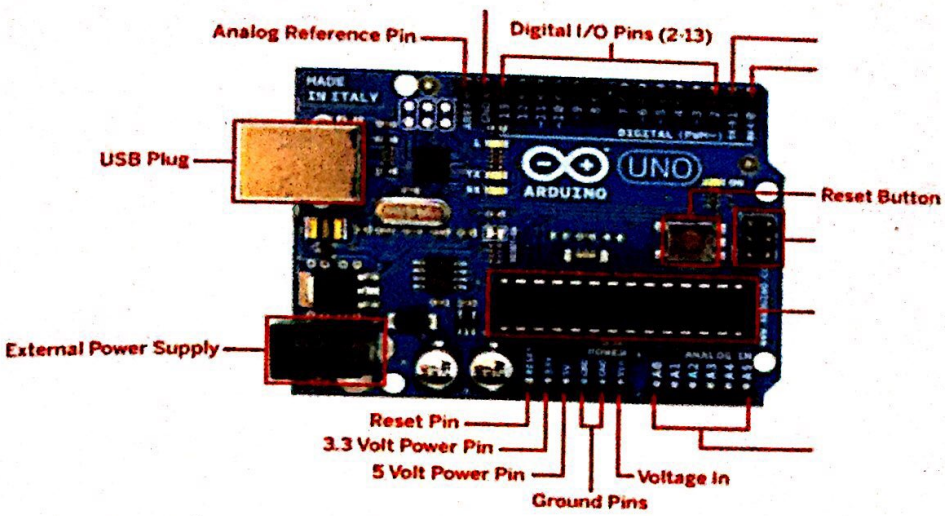


Figure 2.8: Labelled Arduino Board

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This section describes the investigative focus, research methodology and specific methods used in this study. The methodology used was a mixed methods research framework encompassing both quantitative and qualitative methods and measures. In this part, planning must be in a proper manner in the way of identifying an information and requirement, such as hardware and software. Planning is also sometime can be the way for investigator to identify the problem statement as a reason to proceed with the study. For this project planning phase are done by data collection and requirement of hardware and software. Usually for this early stage, the method of planning was by primary collection, which is more to interview and meeting with outsider to get information. The questionnaires of data collection are distributed to the staff of physiotherapy unit, staff nurse, and neurology specialist doctor. By data collection, requirement for hardware and software can be plan as well. At this stage, project resources and requirements, literature studies and schedule to get more information in this study are planned.

3.2 SAMPLE POPULATION

The sample population for this study is students at Polytechnic Premier Sultan Salahuddin Abdul Aziz Shah, Shah Alam which focusing in Electrical Engineering Department. This student is chosen as they has knowledge in rehabilitation and therapy subject. This project have own inclusion and exclusion criteria in choosing sample population. For inclusion criteria, the project is focusing on the individual or students that understand about therapy and biomedical terms. They also should have knowledge about biomedical and rehabilitation.

3.2.1 SAMPLE SIZE AND SAMPLING TECHNIQUE

Krejcie and Morgan theory has been used to determine the sample size. The population of limitation for this study is 50 respondents, therefore the sample size will be 44 respondents which consists of degree students in PSAS.

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	1000000	384

Note: N is Population Size; S is Sample Size *Source: Krejcie & Morgan, 1970*

Figure 3.1: Krejcie and Morgan table to determine sample size

3.3 DATA COLLECTION

In collecting the data, the survey are distributed to the degree students in Polytechnic Premier Sultan Salahuddin Abdul Aziz Shah (PSAS). When collecting the data, requirement for hardware and software can be plan as well. At this stage, project resources and requirements, literature studies and designing the device are planned. All materials are collected from journal, internet, research paper, and text books. Refer appendix B for questionnaire form

3.3.1 SURVEY QUESTIONNAIRE DEVELOPMENT

This survey questionnaire was developed based on existing validated measurement from previous literature which related with this topic. The selected measurement were then tailored slightly to accommodate the objective of this study. This study develop questionnaire based on the existing validated measurement in literature review. Researcher selected the most appropriate validated measurement and tailored slightly to accommodate with this research study. The advantage of using existing validated measurement is it has been assessed for reliability and validity thus, they are good indicator to be used in this study [14]. Moreover, this minimize the time burden and money invested to develop new questionnaire [14].

In developing questionnaire, researcher need to give careful attention including keeping the vocabulary simple and the question short, avoid hypothetical questions, avoid overlapping response categories and do not overtax the respondent's memory. The language used is appropriate enough for people at the minimum level of administration. Questions also neatly organized in few categories, to make it easy to answer and read the question accordingly. There are two questionnaire developed for this project, first is for the respondents where researcher asked about the device and second is

3.3.2 BLOCK DIAGRAM

In designing and developing a new hand support and therapy device based on the existing one, researcher has illustrated the system through the block diagram in figure 3.2.

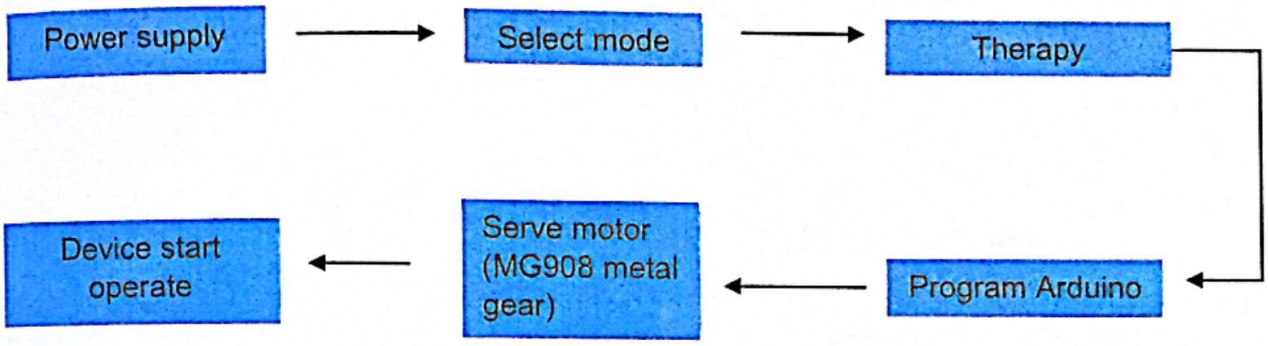


Figure 3.2: Block diagram of hand support and therapy device.

3.3.3 MATERIAL

In the process of designing and making the device, researcher used circuit board with component, servo motor (MG908 metal gear), DC motor, programming Arduino and battery lipo with 11V.

Material list

Circuit board with component	**DC motor**
Servo motor (MG908 metal gear)	**Programming Arduino**
Battery	

3.3.4 PROJECT COSTING

Here is the costing for this project, where the process of designing and building the device takes place. Approximately, RM870 total costing of building the hand support and therapy device. Researcher bought all materials at electric and electronic store where most of items can be found.

Items	Price	Unit	Total
Servo motor (180°)	RM 40.00	5	RM 200.00
Battery lipor (11.1 volt)	RM 50.00	1	RM 50.00
Circuit board and component	RM 150.00	-	RM150.00
Programming Arduino	RM 400.00	-	RM 400.00
Other materials	RM 400.00	-	RM 200.00
	Total		**RM 1,200.00**

Table 3.1: Project costing

3.3.5 FLOWCHART OF DESIGNING THE DEVICE

The flow chart in figure 3.3 shows the sequence of steps and decisions needed to perform the process of designing the hand support and therapy device.

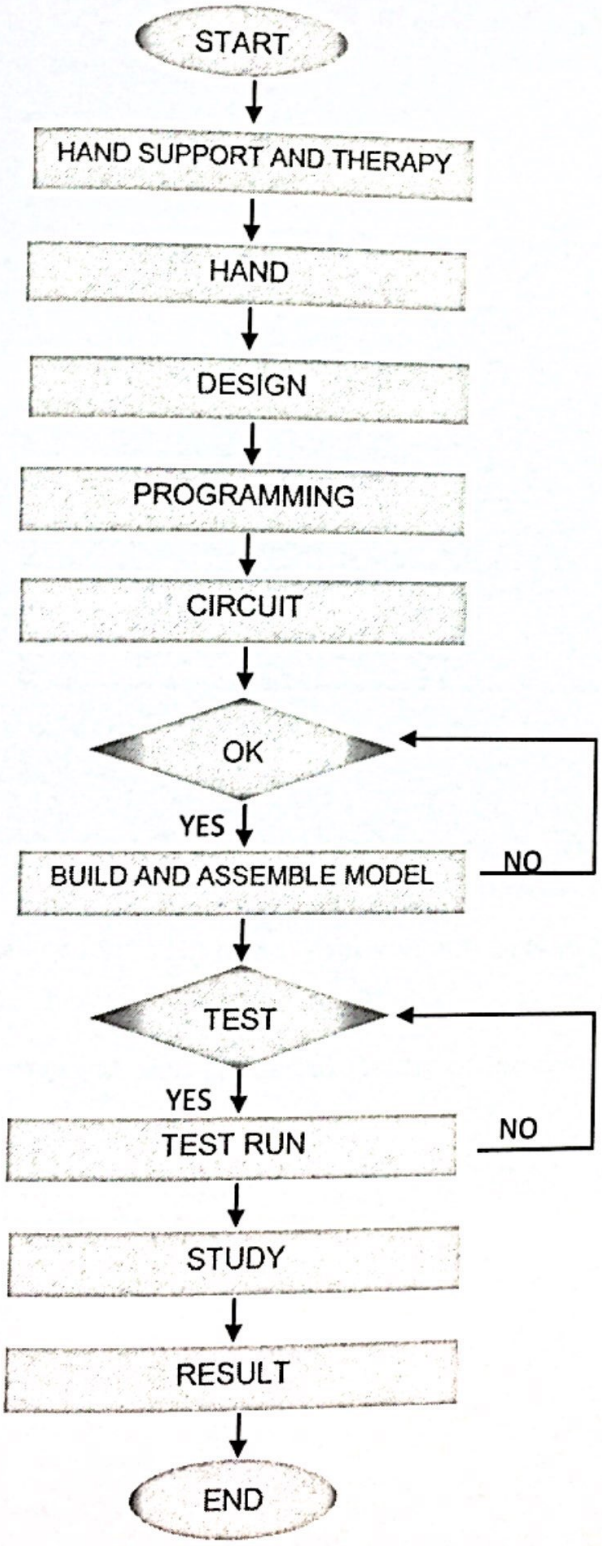


Figure 3.3: Flow chart of hand support and therapy device.

3.3.5.1 IMPLEMENTING THE HAND SUPPORT AND THERAPY DEVICE

In this phase, researcher has started the process of designing the hand support and therapy device. This is where the programming and built and assemble process takes place. After the device is finish develop, researcher will test the device with a patient and ask experts opinion.

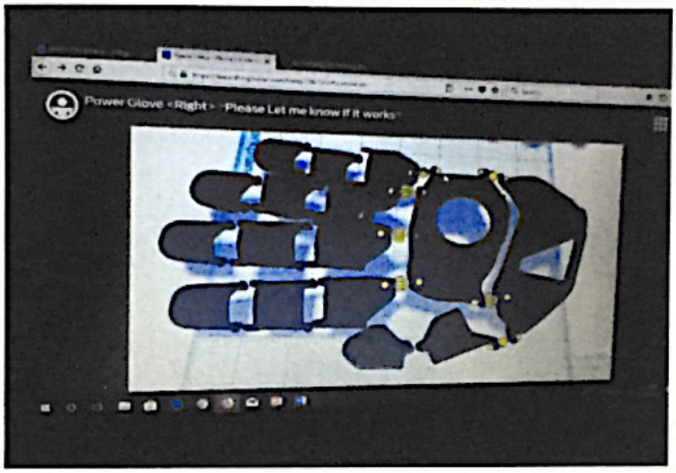


Figure 3.4: The design of hand

Researcher search suitable design that is not complicated and have a lot of spaces between fingers or joints for an easy movement. Spaces between joint will help fingers move smooth. After choose the design, researcher sent the design for a 3D printing. From this, researcher will get actual feature of the design.

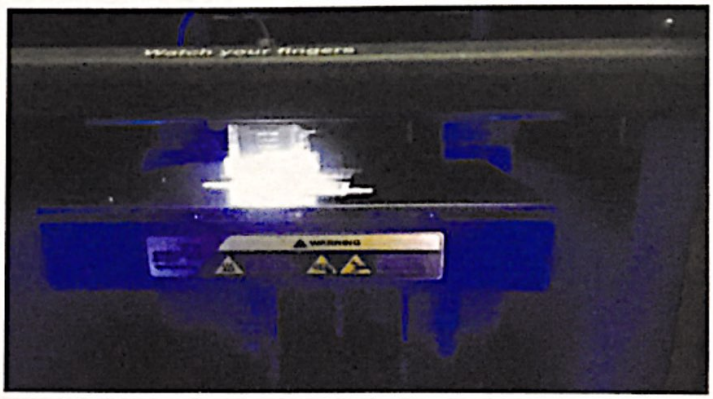


Figure 3.5: 3D printing for the design

Figure 3.6: The result of the design after 3D printing.

Figure 3.5 shown the process of 3D printing while figure 3.6 shown the result of the printing. There are six parts in assembly the hand design. After clearing all the unnecessary part, researcher start to combine all the parts to become the hand shape. Before printing the hand design, researcher has chosen a proper type of material which is Acrylonitrile Butadiene Styrene (ABS) filament. ABS filament is an eco-friendly material, a versatile petroleum-based material same material as thermoplastic polymers.

It does not have high chemical effects to the user and the environment, more over this type of material suitable for a heavy duty use. ABS filament have strong, affordable and easy to modify parts after printing. In achieving the objectives of using the device as daily used, researcher need to ensure the material used for the device is suitable for heavy duty activities. Moreover, this type of material can stand 200C heat.

Figure 3.6 also shown the results of 3D printing, the size is same as in the design. This to ensure the finger part is suitable and have the same size as the human hand. Moreover, the small sprint shown is used to replace the joint between the fingers. This will make the finger easier to move.

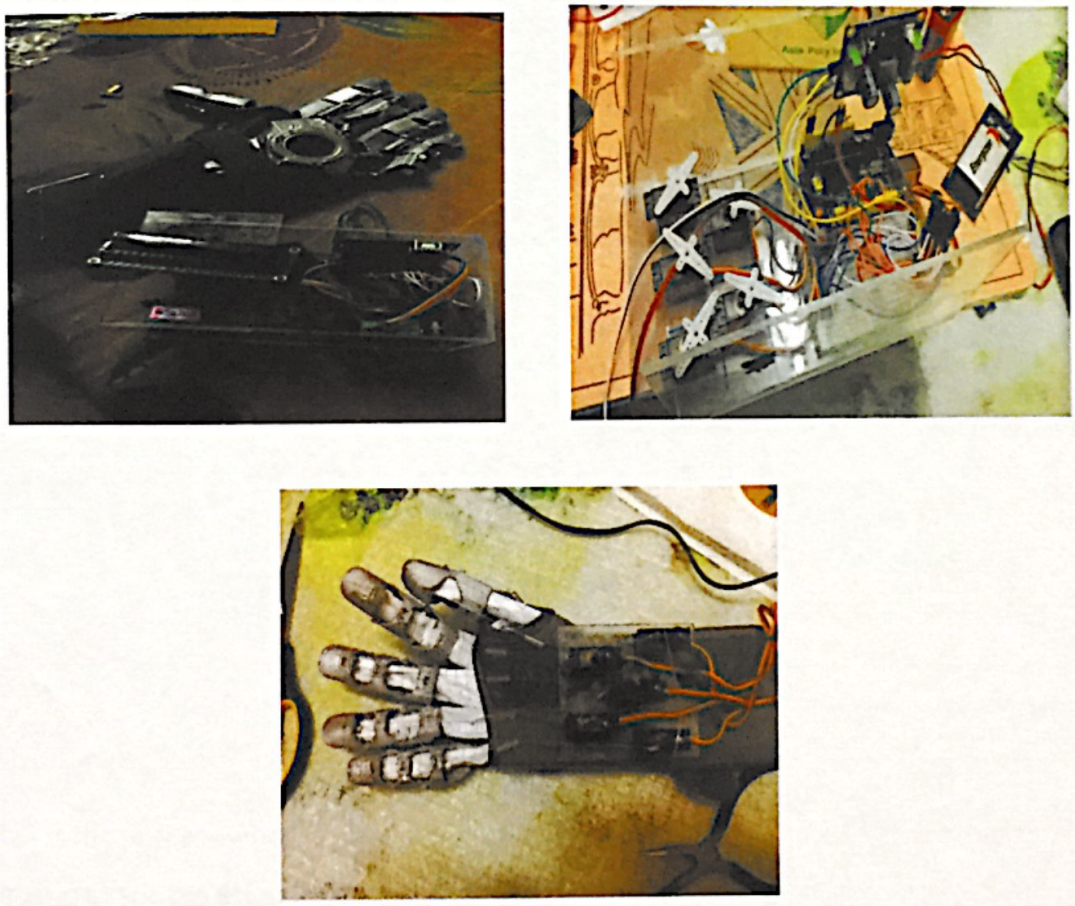


Figure 3.7: Programming process.

The next process in designing the hand support and therapy device is the programming. Researcher applied Arduino Uno programming in this project. There are

3 method of hand function implement by researcher. These 3 method is the most basic exercise in hand therapy. This will help increase the recovery time for the patient and improve their hand motion. Each method have been programmed to perform the motion in 5 minutes and total time for all methods is 15 minutes. The 3 methods included in this device is first, all motor move together from 0 degree to 180 degree and reverse to 180 degree to 0 degree. Second method is motors are moving one by one from 0 degree to 180 degree and reverse to 180 degree to 0 degree. And third method is, two motors are moving from 0 degree to 180 degree and reverse to 180 degree to 0 degree.

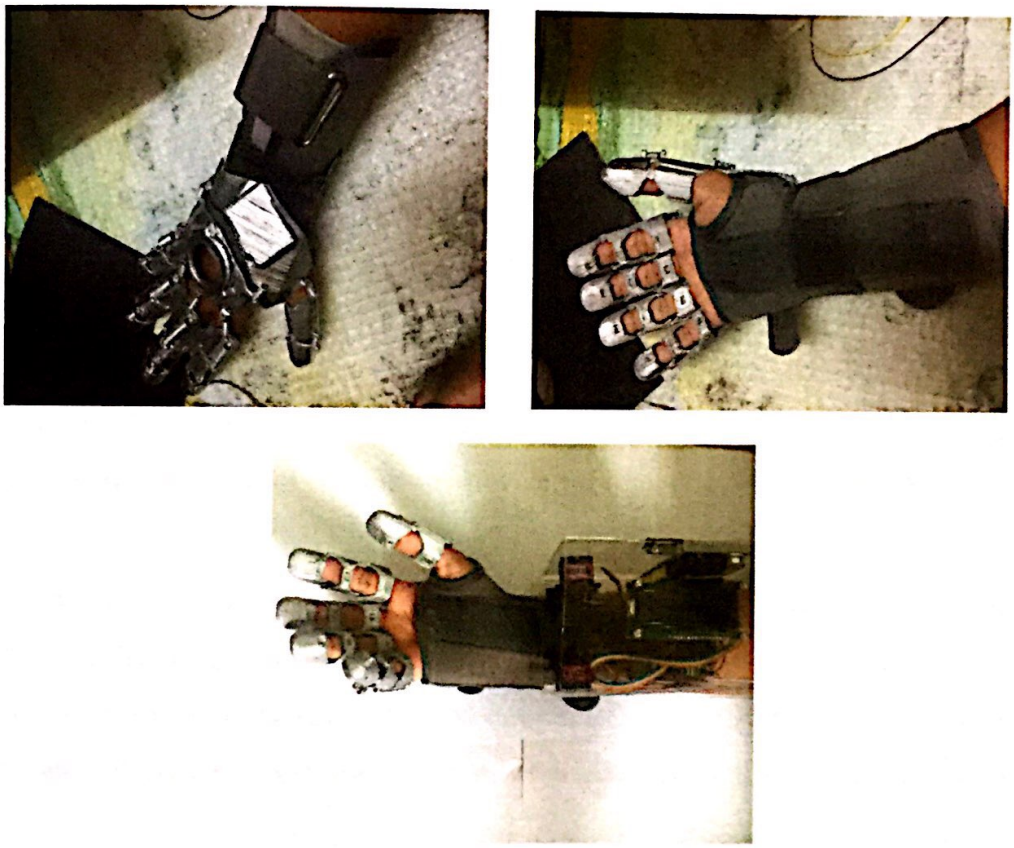


Figure 3.8: Design of the hand.

This is the process where researcher start to test on a patient. With this prototype, researcher able to see the effectiveness and the movement of the device. This is the final touch of the device.

3.4 DATA ANALYSIS

After collecting the data of survey and designing the device, researcher will analyse the data. Researcher used Statistical Package for Social Science (SPSS) version 22 to analyse the survey questionnaire. SPSS helps researcher knew the importance elements in designing the survey. Analysis divided into two parts, which are the survey questionnaire analysis and the technical test of the device. Technical test are included the relationship between the importance of device, types and design of the device.

3.4.1 SPSS

Data analysis is done by using the Statistical Package for Social Science (SPSS) version 22. There are 50 surveys collected and the data are used to identify the appropriate characteristics of hand support and therapy device. SPSS is one of the method in qualitative that can perform highly complex data manipulation and analysis with simple instruction. It is function to help producing statistic for evaluation test by the subjects. Through SPSS also, researcher able to identify the effectiveness and the importance of hand support and therapy device for minor hand injury patients.

In survey questionnaire, there are three measurement used by the researcher which are the hand support and therapy device, types of hand support and therapy device and the design of hand support ad therapy device. All these measurement will assist the researcher to design and develop a compatible and appropriate device for the patients.

3.4.2 FLOWCHART OF METHODOLOGY

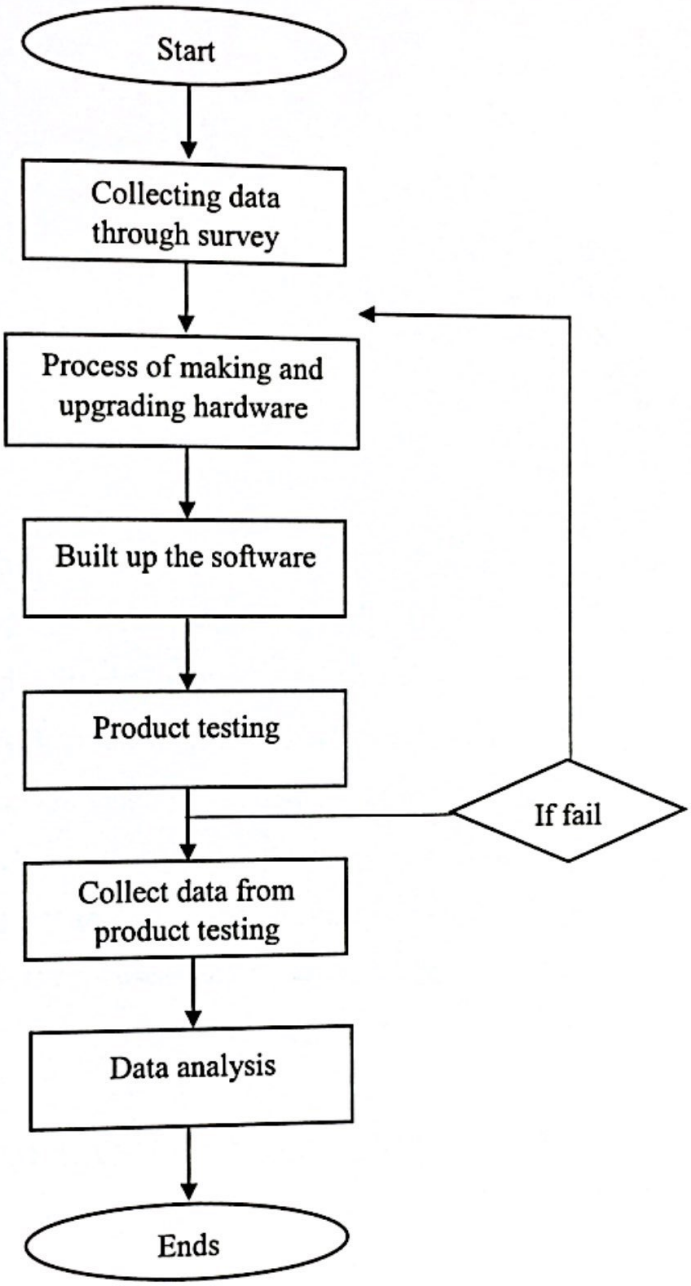


Figure 3.9: Flowchart of methodology

CHAPTER 4

DATA ANALYSIS

4.1 INTRODUCTION

This chapter shows the results and analysis of data collected from the respondents. This study attempted to design a hand support and therapy device that more portable, comfortable and suitable for the hands of different people, develop a hand support and therapy in one device which applicable for daily use and analyze the usage of hand support and therapy device in daily life at home. This study made use of a quantitative research approach which includes descriptive analysis and cronbach's alpha. There are two types of survey used in this study, first is used to collect data among students while for the second survey, researcher aims to get opinions from the doctor about the device.

4.2 THE DESIGN OF HAND SUPPORT AND THERAPY DEVICE

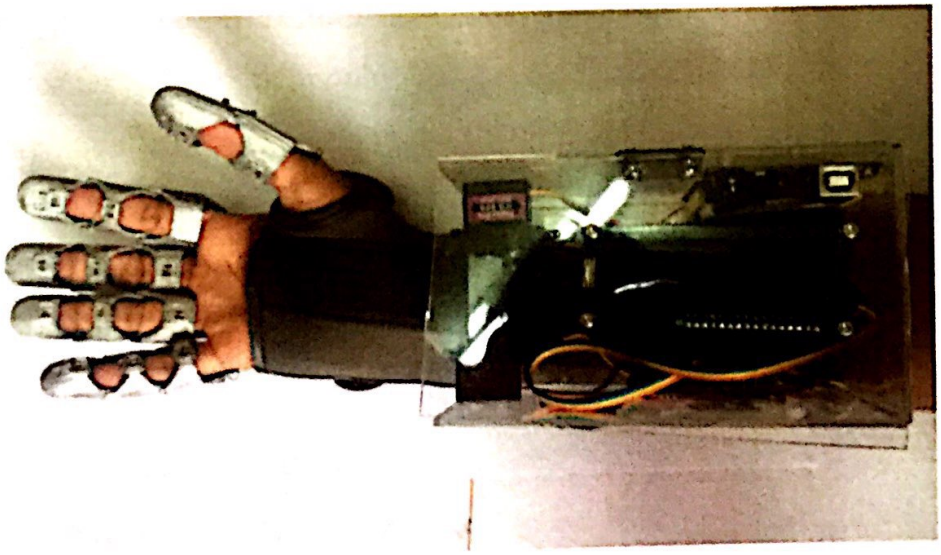


Figure 4.1: Final design of the hand support and therapy device

Before designing and building the hand support and therapy device, researcher has reviewed previous projects and analysis about the hand support and therapy device. From that process, researcher collected important notes on how to design and built portable, compatible and comfortable for daily used. It is found, there are some weakness in current device which need some improvements, but it does not mean it is not suitable for the patient to use. The usage and function of hand support and therapy device is depends on the situation and condition of the patient. It is also depends on the objective or aims of recovery.

After collecting data from the literature review, researcher started to design and develop the hand support and therapy device that is portable, compatible and comfortable for daily use. Researcher is focuses on daily use of the device because researcher believe by applying the device or conducting the therapy everyday as daily use, the recovery time for the patients will increase. Moreover, it help the patient perform their daily life activities. Some patients with hand injury have limited movement or motion as their hand have difficulties to make certain move. Therefore, through this device, researcher believe it will help the patient live life better.

4.3 THE ANALYSIS RESULT OF THE SURVEY OF THE DEVELOPMENT OF HAND SUPPORT AND THERAPY WITH STUDENTS

In first process of collecting data, this study has chosen degree students in Polytechnic Premier Sultan Salahuddin Abdul Aziz Shah (PSAS) as the respondents by using the purposive sampling technique. Criteria that taken into account is have knowledge in biomedical and rehabilitation area and understand the term used in biomedical and rehabilitation especially in the survey. The total population of Degree students in Polytechnic Premier Sultan Salahuddin Abdul Aziz Shah is 51 students.

The surveys are distributed to 50 students within a day and 50 surveys are completed and returned to the researcher, yielding 100% response rate. The respondents are all degree students at Polytechnic Premier Sultan Salahuddin Abdul Aizz Shah (PSAS). Table 4.2 showed the results of respondent's education crosstabs with age of

respondents. There are 48 students between ages 20 to 30 years answered the survey and two students between ages 31 to 40 years. While table 4.1 indicates the number of respondents based on their gender. The highest number of respondents is among female respondents with 60% and male respondents with 40%.

Table 4.1: Number of respondents based on gender

	Frequency	Percent
Male	20	40.0
Female	30	60.0

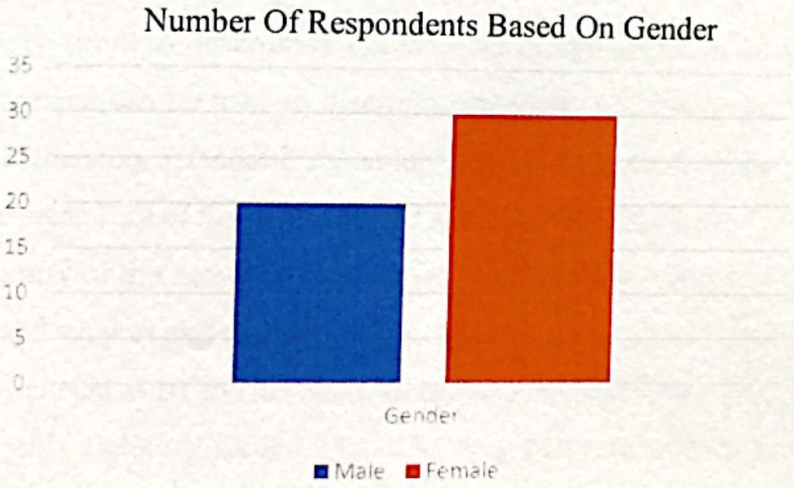


Figure 4.2: Graph of number of respondent based on gender

Table 4.2: Number of respondents based on age

	Frequency	Percent
20 – 30 years	48	96.0
31 – 40 years	2	4.0

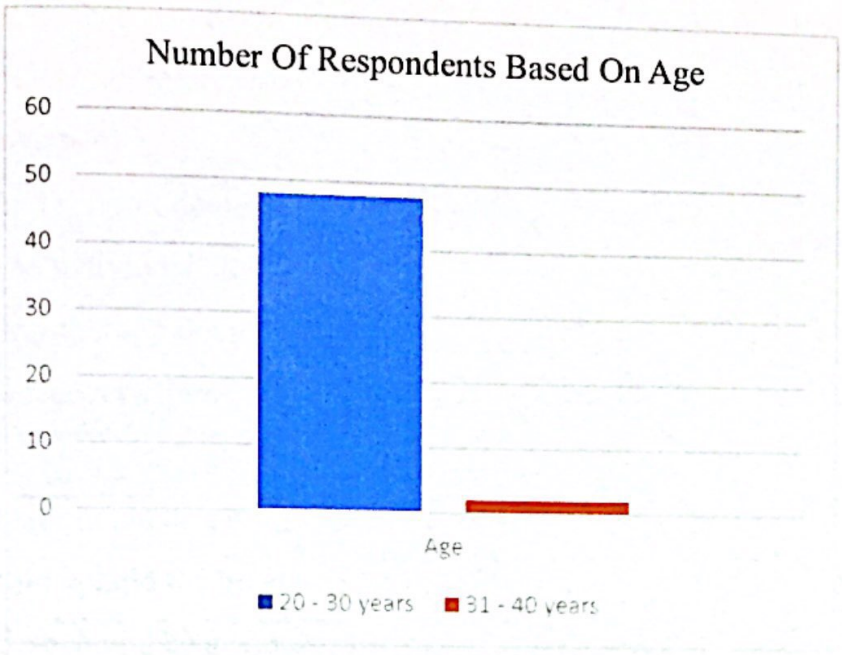


Figure 4.2: Graph of number of respondent based on age

This is the result of descriptive statistics for the three groups of variables. The descriptive command can be used to determine measures of central tendency (mean), measures of dispersion (standard deviation) and Cronbach's alpha of the four constructs. The mean sore of the responses for all items was vary from 3.96 to 4.40, this shows that majority of the respondents satisfied with the items stated in survey which represent the hand support and therapy device (labeled as A), types of hand support and therapy device (labeled as B) and design of hand support and therapy device (labeled as C). The Cronbach's alpha values are 0.88, 0.89 and 0.86 respectively as illustrated in table 4.3.

Table 4.1: Descriptive statistics of three factors of variables

Labels	**Items**	***M***	***SD***	***a***
				.88
A1	Hand support device is very important for a person whom need additional support	4.30	0.65	
A2	Hand therapy device is very important for a person whom injured	4.24	0.66	
A3	Hand support device should be used every day to support the hand movement	4.08	0.67	

A4	Hand therapy device rehabilitation should be conducted every day to increase the hand movement	4.36	0.69	
A5	Hand support device improve the recovery process of an individual	4.34	0.69	
A6	Hand therapy device helps an individual to fasten the recovery time	4.26	0.72	
				.89
B1	There should be a portable hand support device that could uphold the hand movement	4.32	0.65	
B2	There should be a portable hand therapy device that could uphold the hand movement	4.38	0.64	
B3	There should be a comfortable hand support device for a long time use	4.40	0.61	
B4	There should be a comfortable hand therapy device for a long time use	4.32	0.68	
B5	There should be a suitable hand support device that could be used anywhere and for every activities	4.26	0.69	
B6	There should be a suitable hand therapy device that could be used anywhere and for every activities	4.28	0.70	
				.86
C1	Hand support device should be developed with hand therapy device	4.24	0.59	
C2	Hand support device should not be developed with hand therapy device	3.96	0.75	
C3	Combining hand support and therapy device could stimulate the hand movement	4.26	0.66	
C4	Combining hand support and therapy device could improve the hand movement	4.30	0.65	
C5	Combining hand support and therapy device could fasten the rehabilitation process	4.32	0.62	

4.4 THE ANALYSIS RESULT OF THE SURVEY OF THE DEVELOPMENT OF HAND SUPPORT AND THERAPY WITH A DOCTOR

In analyse the hand support and therapy device, researcher conducted second survey with expert for the clinical part. Expert from the medical area is important because the doctors or engineers are knowledgeable about the device and they understand the requirements required for a device. Moreover, this expert may see issues or problems researcher not see, this will help improving the device function to be better than before.

One expert or doctor is involve in this survey. He has 5 years experiences in medical and rehabilitation field. He did projects about rehabilitation, therefore, he understand the terms and function of the device. He also understand the patient situation when using this device. Therefore, he is suitable for this project survey.

In this survey there are two section the respondent should answer, first section is the demographic part and the second section is the usage of hand support and therapy instrument. In second section, there are four instruments use to analyse the usage of the device; comfortableness; strength; function; and effectiveness.

The first instrument that is the comfortableness, the result of the survey shows that the device is at the medium condition. When the doctor applied and use the device, he slightly agree that the device is easy to use and friendly, the motor applied is well-functioned and the design is suitable and comfortable for daily use, and during the therapy session, the position of finger with the device is consistence.

For the second instrument, which is the strength of the device. The doctor uncertain about the strength of motor, where it found to be not much vary as mentioned. However, this device is suitable for therapy where it increase the time of recovery. He also mentioned that, this device help the patient discipline themselves to conduct the therapy by own and not depend much with other people.

In third instrument, researcher asked about the function of the device. The doctor slightly agree with the statement of the device safety, the motor moving automatically and the device is easy to handle for beginners. He felt that this device is compatible and user-friendly, so there will be no problem for the patient to use this device. However, the doctor uncertain about the device motion. The motion is not too smooth for a patient as patients injury need a device that have smooth and slow motion and have vary speed to control the motion. From this, the device will help improving the speed and weightage of the exercise.

Last instrument asked about the effectiveness of the device. The doctor slightly agree with the statement of the using this device daily and most of people will learn to use this product very quickly. Due to his feature of user-friendly, this device is designed to have the simplest function differ from other device. Patient will need less support of guidance from the technical people as they can learn to use it by them self. However, the doctor uncertain about the function of the device, whether it is well integrated or not. Overall results of this survey found that this device is suitable for a home based therapy as it is portable and not much heavy. However, it should have a very friendly design which is more suitable for hand injury patients, furthermore this device may have to include a choice of speed so that the patients can control the speed or weightage of motors motion. Figure 3.9 shows the process of collecting data with the doctor.

Figure 4.4: Process of collecting data with the doctor

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This study was intended to design and develop hand support and therapy device that suitable for daily used. Although we can find various hand support and therapy device in the market but they have limited functions for a patient. Therefore, this study aims to design and develop hand support and therapy device in one device which user-friendly and compatible for any patient with minor hand injury to used it daily. It is found that 90% of research objectives was achieved

This study recommend that this device can include a choice of speed for the motors. With this patient can choose the suitable speed for the therapy. Speed of motors will help patients improve time of recovery. Moreover, this device also may choose other suitable design that is more user friendly. Patient will use this device every day to perform a daily activities therefore, it should have a friendly user design that have adjustable fingers.

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APPENDIX A

GANTT CHART

tack	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mac-18	April-18	June-18
Project title agreed by supervisor									
Complete project questionnaire									
Identify the material and cost									
Collect article and journal about project									
Present initial presentation									
Submit initial report									
Design layout product									
Design PCB board circuit									
Design product (software and hardware)									
Writing proposal									
Submit proposal									
Defend proposal									
Survey									
Collecting data									
Test product									
Writing thesis									
Analyze data and result									
Submit thesis									
Present viva									

APPENDIX B

POLITEKNIK MALAYSIA
SULTAN SALAHUDDIN ABDUL AZIZ SHAH

SURVEY OF DEVELOPMENT OF HAND SUPPORT AND THERAPY

In the questionnaire we ask you about hand support and therapy device. The questionnaire itself has two parts. In the first one consists demographic questions and second is the hand support and therapy device. We assure complete anonymity of the gathered data. Please provide answers on all questions even though you feel that they repeat themselves occasionally. This is the only way we can assure statistical validity of the questionnaire.

SECTION A: DEMOGRAPHIC

This section relates with your background in brief. Please tick your answer (√) and your answer will be kept strictly confidential.

1. Age

- ☐ 20 - 30 years
- ☐ 31 - 40 years
- ☐ 41 - 50 years
- ☐ > 51 years

2. Gender

- ☐ Male
- ☐ Female

3. Education

- ☐ Student
- ☐ Worker
- ☐ Unemployed

SECTION B: DEVELOPMENT OF HAND SUPPORT AND THERAPY

Please read carefully and based on linked scale given, please tick (√) based on your understanding and evaluate.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

	Hand Support and Therapy Device	1	2	3	4	5
1	Hand support device is very important for a person whom need additional support					
2	Hand therapy device is very important for a person whom injured					
3	Hand support device should be used every day to support the hand movement					
4	Hand therapy device rehabilitation should be conducted every day to increase the hand movement					
5	Hand support device improve the recovery process of an individual					
6	Hand therapy device helps an individual to fasten the recovery time					

	Types of Hand Support and Therapy Device	1	2	3	4	5
1	There should be a portable hand support device that could uphold the hand movement					
2	There should be a portable hand therapy device that could uphold the hand movement					
3	There should be a comfortable hand support device for a long time use					
4	There should be a comfortable hand therapy device for a long time use					
5	There should be a suitable hand support device that could be used anywhere and for every activities					
6	There should be a suitable hand therapy device that could be used anywhere and for every activities					

	Design of Hand Support and Therapy Device	1	2	3	4	5
1	Hand support device should be developed with hand therapy device					
2	Hand support device should not be developed with hand therapy device					
3	Combining hand support and therapy device could stimulate the hand movement					
4	Combining hand support and therapy device could improve the hand movement					
5	Combining hand support and therapy device could fasten the rehabilitation process					

Your cooperation and participation is greatly appreciated. If you need further information regarding to the questionnaire, please do not hesitate to contact me. Million thanks!

Contact:
Khairul Asyraf Bin Abu Talib
Jabatan Kejuruteraan Elektrik
Politeknik Sultan Salahuddin Abdul Aziz Shah
013-3295043

QUESTIONAIRE: THE DEVELOPMENT OF HAND SUPPORT AND THERAPY

Thank you for taking time to fill in this questionnaire. The goal of this questionnaire is to develop understanding on the range of instrument usability of hand support and therapy. The questionnaire itself has two parts; includes demographic questions and usage of hand support and therapy instrument.

We would like to ask you to be realistic and objective in assessing your organization. We assure complete anonymity of the gathered data. Please provide answers on all questions even though you feel that they repeat themselves occasionally. This is the only way we can assure statistical validity of the questionnaire.

SECTION A: DEMOGRAPHIC

This section relates with your background in brief. Please tick your answer (√) or fill in the blanks and your answer will be kept strictly confidential.

1. Gender
   ( ) Male
   ( ) Female

2. Age
   ( ) 20 – 30 years
   ( ) 31 – 40 years
   ( ) 41 – 50 years
   ( ) > 51 years

3. Occupation
   ( ) Public Sector
   ( ) Private Sector
   ( ) Students
   ( ) Housewife
   ( ) Others
   (Please mentioned .....)

4. Do you have problems in
   ( ) Hand equipment
   ( ) Independent therapy
   ( ) Portable device
   ( ) Others
   (Please mentioned .....)

5. What kind of the treatment used
   ( ) Hospital
   ( ) Treatment

6. How many times that therapy used in a month?
   ( ) 1 - 5
   ( ) 6 - 10
   ( ) 11 -15
   ( ) > 15

If you have someone facing this condition, what is the cause?

.....

SECTION B: USAGE OF HAND SUPPORT AND THERAPY INSTRUMENT

Please read carefully and based on Likert scale below, please circle based on your understanding and evaluate.

1	2	3	4	5
Strongly Disagree	Slightly Disagree	Uncertain	Slightly Agree	Strongly Agree

	COMFORTABLENESS					
1	I found this hand and therapy is easy to use and friendly.	1	2	3	4	5
2	The modified hand support and therapy was added with motor to help it functioned automatically and the design is suitable for me.	1	2	3	4	5
3	The modified hand support and therapy was added with motor to help it functioned automatically and the design is comfortable for daily used.	1	2	3	4	5
4	During therapy session, the position of comatose is consistence while rotate.	1	2	3	4	5
	STRENGTH					
1	Strength of motor can be vary depend on weight of finger.	1	2	3	4	5
2	Hand support and therapy is suitable for the therapy.	1	2	3	4	5
3	Hand support and therapy is suitable for the purpose of reduce pressure and sore.	1	2	3	4	5
4	Hand support and therapy is suitable for the purpose of increasing time of recovery.	1	2	3	4	5
	FUNCTION					
1	I feel safe when I used the hand support and therapy.	1	2	3	4	5
2	Motor was used in hand support and therapy to move it automatically.	1	2	3	4	5
3	The hand support and therapy has smooth motion.	1	2	3	4	5
4	The hand support and therapy was easy to handle for beginners.	1	2	3	4	5
	EFFECTIVENESS					
1	I would use this product daily.	1	2	3	4	5
2	I would need support from a technical person to use this product.	1	2	3	4	5
3	I found that some additional functions in the product were well integrated.	1	2	3	4	5
4	I imagined that most people would learn to use this product very quickly.	1	2	3	4	5

Your cooperation and participation is greatly appreciated. If you need further information regarding to the questionnaire, please do not hesitate to contact me. Million thanks!

Contact:

Khairul Asyraf Bin Abu Talib
013-3295043
Jabatan Kejuruteraan Elektrik
Politeknik Sultan Salahuddin Abdul Aziz Shah
asyraf1723@gmail.com