DEVELOPMENT OF HAND ORIENTATION MEASUREMENT FOR A HAND MUSCLE

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2019

DECLARATION

I declare that this thesis entitled "DEVELOPMENT OF HAND ORIENTATION MEASUREMENT FOR A HAND MUSCLE is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

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I hereby declare that I have checked this report entitled " **Development of hand orientation measurement for a hand muscle**" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature :

Supervisor Name :

Date :

DEDICATIONS

To my beloved mother, father and sisters.

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ABSTRACT

In today's era human machine interaction is becoming widespread. So, with the introduction of new technologies the gap between the machine and human is being reduced to ease the standard of living. Rehabilitation is probably one of the most significant phases of recovery for stroke survivors. Its goals are to build strength, capacity and self-care skills by which the survivors can continue their daily activities despite the effect of effect of stroke. The main purpose of this project is to develop a rehabilitation device for stroke patients which integrated 2-dimensional board game that motivates hand muscles movement.This thesis, describes the hand motion orientation measurement, where an accelerometer ADXL335 are used to measure the angle of the human hand motion.The project design a 2 degree of freedom accelerometer hand orientation measure device for hand gesture detection. Furthermore, the Arduino Nano is used as a controller to calculate the angle and transmit the data to receiver. Besides that, there is some mathematical calculation to measure the angle of hand motion. The main purpose of this project is to measure the performance in terms of orientation accuracy and precision. The Arduino Nano is a microcontroller that controls the overall performance of the system and it converts the angles in analog voltage given by the accelerometer ADXL 335 to the digital output. Moreover, there are three analysis to acheive the objective which are analysis on the real hand capture of maximum sampling data, filtering the unwanted signal, and the vibration identify the type of patients. The data was calculated and collected through the arctangent 2 argument algorithm of the ADXL335 accelerometer. This project acheived 10 sampling sata in 1 sec it captures real hand motion. Moreover, the infinite impulse filter k=0.1is used to reduces the unwanted signal from the hand vibration. In conclusion, there are some minor challenges faced to complete this project, all the objective were acheived successfully in this project. For the future work, there will be clinical test conduct to measure the effectiveness of the project and may want to include integration with the board game, example stewart platform.

ABSTRAK

Dalam era hari ini interaksi mesin manusia semakin meluas. Oleh itu, dengan pengenalan teknologi baru, jurang antara mesin dan manusia dikurangkan untuk meringankan taraf hidup. Pemulihan mungkin salah satu daripada fasa pemulihan yang paling penting untuk mangsa strok. Matlamatnya adalah untuk membina kekuatan, keupayaan dan kemahiran penjagaan diri yang membolehkan para penyelamat meneruskan aktiviti harian mereka walaupun kesan kesan strok. Tujuan utama adalah untuk membangunkan alat pemulihan untuk pesakit strok dengan permainan papan dimensi 2 dimensi yang memotivasi pergerakan otot tangan, dan bukannya mengelakkan kebosanan terhadap pesakit dengan mengulangi pergerakan yang sama. Dalam kajian ini, ia menerangkan tentang pengukuran orientasi gerakan tangan, accelerometer ADXL335 digunakan untuk mengukur sudut gerakan tangan manusia. Reka bentuk projek merancang peranti pengukur orientasi tangan 2 dimensi berasaskan accelerometer untuk mengesan isyarat tangan. Selain itu, Arduino Nano digunakan sebagai pengawal untuk mengira sudut dan menghantar data kepada penerima. Selain itu, terdapat beberapa pengiraan matematik untuk mengukur sudut gerakan tangan. Tujuan utama projek ini adalah untuk mengukur prestasi dari segi orientasi ketepatan, ketepatan masa dan tindak balas. Arduino Nano adalah mikrokontroler yang mengawal keseluruhan sistem dan ia menukarkan sudut dalam voltan analog yang diberikan oleh pecutan ADXL 335 ke dalam output digital. Selain itu, terdapat tiga analisis untuk menyelaraskan objektif yang menganalisis penangkapan tangan sebenar bagi data pensampelan maksimum, penapisan isyarat yang tidak diingini, dan getaran mengenal pasti jenis pesakit. Dalam aplikasi sebenar, dalam 1 data per detik gerakan menangkap lambat terlalu perlahan, projek ini adalah dapat 10 data dalam 1 saat ia kelihatan seperti menangkap gerakan tangan sebenar kerana setiap 0.1 alogrithm yang dikumpul data. Lebih-lebih lagi, dari getaran tangan, projek ini menghasilkan beberapa penganalisis isyarat yang tidak diingini penapisan membuat isyarat kepada pengurangan untuk menilai ketepatan. Sebagai kesimpulan, accelerometer ADXL335 ini menggunakan algoritma arctangent, algoritma mengira dan mengumpul data, terdapat beberapa cabaran kecil yang dihadapi untuk menyelesaikan projek ini, untuk kerja masa depan akan ada uji klinik untuk mengukur keberkesanan projek. kerja masa depan, akan ada kelakuan ujian klinikal untuk mengukur keberkesanan projek dan mungkin ingin memasukkan integrasi dengan permainan papan, contoh platform stewart.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

The motivation behind rehabilitation is to re-establish a few or the majority of the patient's physical, tangible, and mental abilities that were lost because of damage, ailment, or disease. Rehabilitation includes assisting the patient to compensate for shortfalls that cannot be turned around therapeutically. Hand deterioration is a common action that contributes considerably to ailment in the U.S. and around the world. In the circumstance of stroke, it is predicted that relatively 80% of the 700,000 individuals who survive stroke each year needed hand therapy. Other conditions that have a high incidence of hand deterioration are hand, multiple sclerosis wrist trauma, and high-level spinal cord injury.[1] Half year after stroke, around 65 percent of patients cannot incorporate the influenced hand into their typical exercises. Poor upper-extremity outcomes are plausible after a hemispheric dead tissue when the leg cannot move for fourteen days and the hand has no development or just slight finger flexion with no opening for a month, steady with significant harm to the corticospinal tract.[2]

Stroke patients might be delegated being in an acute, chronic stage after stroke. Although few remedial ways can happen together in various stages after stroke it can be said that impulsive recovery through compensation.[3] People who experience the ill effects of utilitarian disability after stroke frequently have not achieved their maximum capacity for recuperation when they are released from healing centers, where they receive initial rehabilitation. Few devices can be used at home but the devices are very costly. Such as, the

HandMentor and HandTutor cost several thousand dollars, and the Amadeo (TyroMotion) is of high cost.[1] A foremost obstacle for recovery after healing facility release is geological distance among patients as well as narrow obtainability of personnel. These prompt elevated amounts of patient disappointment for not getting satisfactory and adequate preparation for the potential outcomes after release from healing facility. Four years after stroke, just 6% of stroke patients are satisfied with the functionality of their disabled arm.[3]

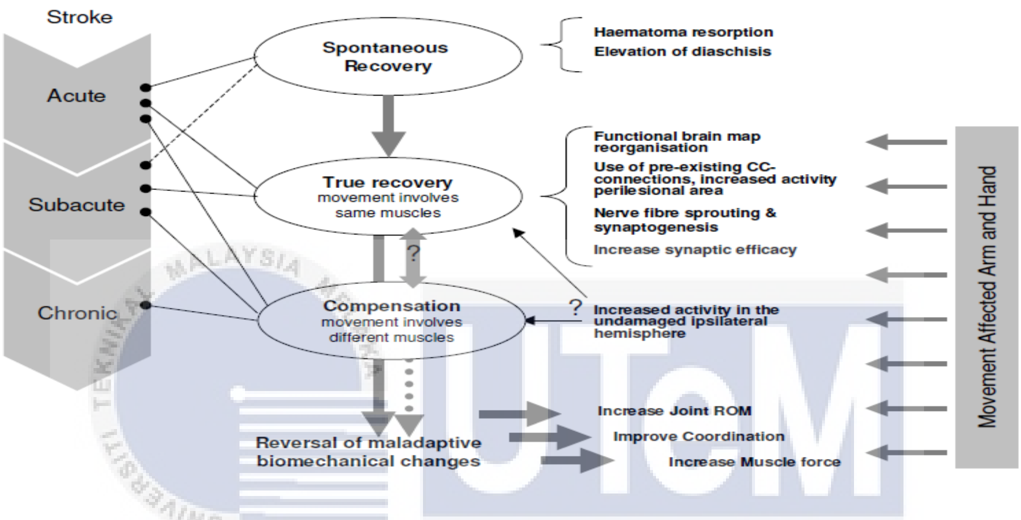


Figure 1.1 Declarative model recovery after stroke

For stroke patients with physical and mental challenges, robots may offer a chance for interaction and therapy. Robots provide a possible therapeutic role for using a mechanical device to improve social connections physical test because the personification of a robot provides unique chances not obtainable in other forms of technology. For example, researchers are working on designing robots that provide support for physical therapy. Endeavors incorporate giving recommended force and to help rebuild flexibility, strength, modify adaptability and quality that could incorporate identifying inspirational state and adjusting therapy to maximum benefits. Therefore, effective methods to encourage stroke patients who have survived stroke to make exercises at home by using the orientation tracking with the machine vision system attached to the entertainment box which enables them to be more independent. The entertainment box motion based input by the orientation of hand movement can provide a helpful way to help people therapeutic exercises at home.

1.2 Problem statement

Stroke is a “brain attack". It can transpire at any time; a stroke happens when the blood supply to part of your cerebrum is reduced, denying brain tissue of oxygen and supplements. When the brain cells die during the stroke, abilities controlled by that zone of the cerebrum, for example, memory and muscle control are lost. There are two major kinds of stroke, ischemic and hemorrhagic. In an ischemic stroke a blood vessel becomes blocked, usually by a blood clot and a portion of the brain becomes deprived of oxygen and will stop functioning. Therapy is restricted in light of the fact that on-going restoration practice conveyed one-on-one with a rehabilitation advisor is expensive. Gyms do not have suitable equipment to ease practice to improve hand skills. Stroke rehabilitation games can possibly help stroke patients to improve from a stroke. By lessening boredom of hundreds of frequent motions and providing show feedback, the games will increase the quality and quantity of patients’ home treatments.[4]

The aim of this project is to make an integrated 2-dimensional marble maze game that motivates hand muscles movement for the stroke patients as a part of their therapy session. There are several ways to measure the orientation of hand movement, for example the application practices the images from web camera located work area, where the predictable gestures act as input for the next step that transfer the gesture data to the game. The players, must change their hand gestures that can be found it by the game.[5]

In this project, the accelerometer and the hand gesture concept will be used as a tool for measuring the hand orientation tracking and also as an input for the any 2-dimensional entertainment box game. A hand orientation controlled is constrained by utilizing hand instead of some other techniques like catches or joystick. One just needs to move hand to measure the orientation angle for role and pitch. A transmitting device is attached with the Arduino Uno which contains RF Transmitter and ADXL335 accelerometer. This will transmit order to goal that it can do the required undertaking several angle from the hand orientation and the detection list will measure the performance in terms of orientation accuracy, precision and reaction time.

1.3 Objective

The objectives of this project are:

1) To develop a hand orientation rehabilitation device that motivates hand muscles movement

2) To design an accelerometer based on 2-dimensional hand for hand gesture detection

3) To measure the performance in terms of orientation accuracy and precision.

1.4 Scope

The scope of this research includes:

1) Clinical test are systematic studies shown to discovery the better methods to avoid disease but in this project the device is not tested clinically and no integration to any games.

2) Limitation of this project is two degree-of-freedom that is roll and pitch, the yaw is out of the scope.

3) A transmitting device is attached with the Arduino Nano which contains ADXL335 accelerometer. This will transmit the angle of hand orientation measurement in the range of 0 degree to 360 degrees in the roll and pitch orientation only.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In 21st century, researchers have focused on a few perspectives inside robot-assisted therapy, for instance, appearance of the robot, and empowering clinicians to program robots in this part of the report, details and information collected from reading journals, books, papers, articles and other sources that written by the other researchers. The idea of this is to have a clear understanding of the key elements involved in this project. The ideas are originally taken from the authors, however it is all written in own words by synthesizing and paraphrasing.

Moral thoughts include whether robot-assisted rehabilitation delivers long-standing benefits and does not root cause expressive or cognitive. The motivation for allowing clinicians to program robots stalks from clinician's defective is to avoid defense of sameness, that is, repetitive robot performance. Robot-assisted treatment suggestions a hopeful methodology to neurorehabilitation, particularly for harshly to moderately reduced stroke patients.[6][7]

2.2 K-Chart

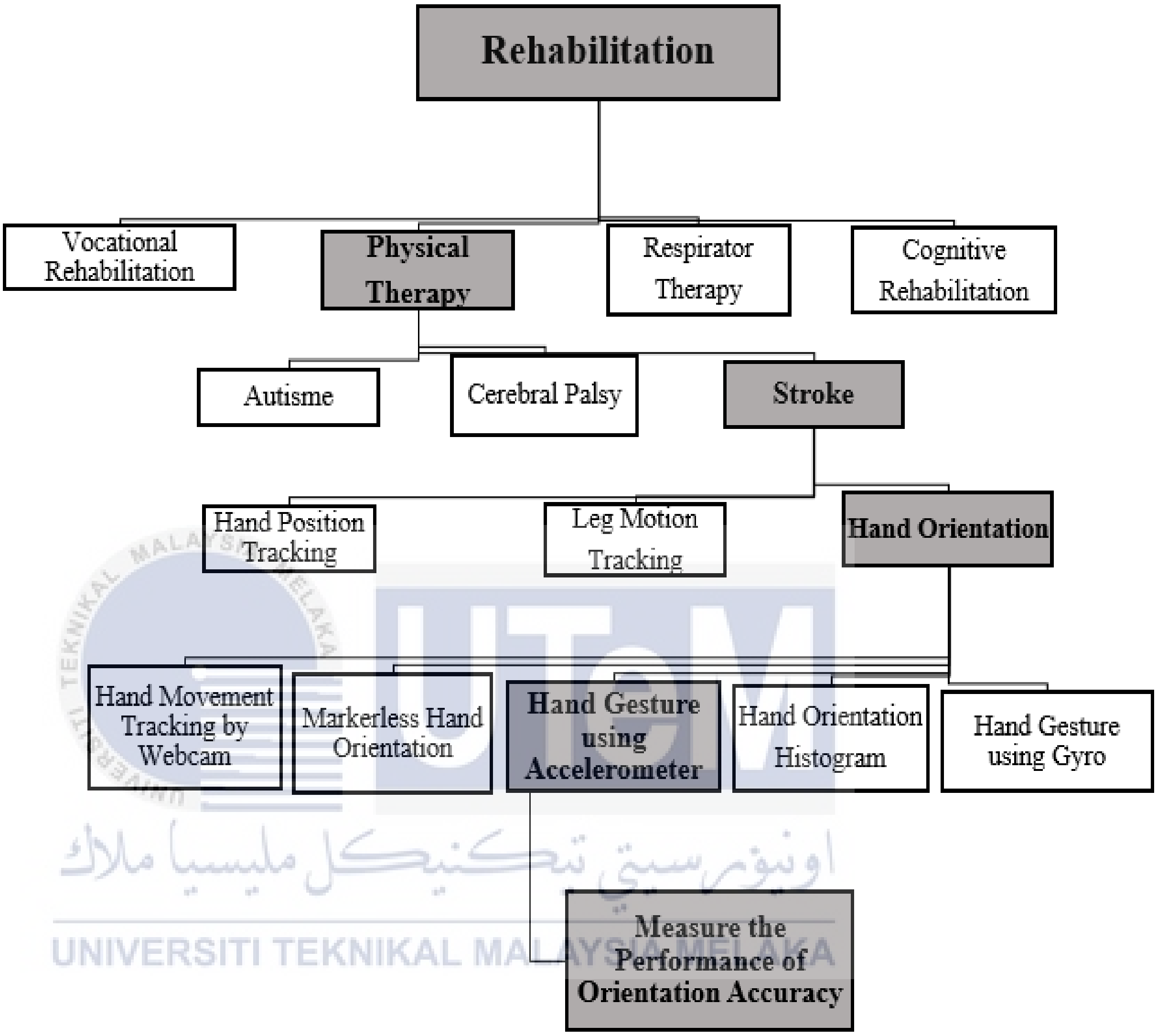


Figure 2.1 K-Chart

Rehabilitation is the way towards helping an individual who has endured a disease or damage to re-establish lost abilities thus recapture most extreme independence. The general objective of rehabilitation is to enable you to recover your capacities and recapture freedom. Be that as it may, the particular objectives are distinctive for every individual. They rely upon what caused the issue, regardless of whether the reason is progressing or brief, which capacities you lost, and how serious the issue is. For instance, individual who has stroke may require restoration to have the capacity to dress or wash without assistance. Rehabilitation has various type of therapy in this project focusing more to the physical therapy. Physical therapy is a kind of recovery treatment that attempts to improve development brokenness. Advisors work with patients to re-establish development, quality, soundness as well as practical capacity and decrease torment through focused exercise and a scope of other treatment strategies. Physical therapy focusing mainly on body parts and more precisely for this project it focuses more to the hand stroke peoples stroke is a "brain attack". It happens when blood stream to a region of mind is cut off. At the point when this occurs, mind cells are denied of oxygen and start to pass on. At the point when mind cells kick the bucket amid a stroke, capacities constrained by that zone of the cerebrum as in example, memory and muscle control are lost. In this project that is focusing on the hand orientation measurement, motion acknowledgment is a developing region of intrigue since it gives a characteristic, 3D interface for people to convey with PCs. In this paper, we state the possible strategies to perceive hand motions utilizing a 3-axis accelerometer, the accelerometer equation will be main important data to the input part. There are two different parts, namely input and output in their input the data which is taken from the hand orientation. The data received by the RF receiver for the output part, and the stewart platform used for main tool hence marble maze will be attached instead of decrease the boredom the entertainment box will be useful for the patients.

2.3 Review on existing rehabilitation device with game

2.3.1 Rehabilitation

The purpose of rehabilitation is to recover someone or the entire patient's physical and mental skills that were lost due to injury or disease. Exercise treatment has for some time been recommended to patients as a component of their rehabilitation following orthopedic medical surgery. However, poor exercise system can frequently result in poor results for these patients and delay their return to full capacity.

Exercise biofeedback offers a potential arrangement. Biofeedback has been utilized for over fifty years in rehabilitation to encourage typical development designs after injury.[7] Increasing the walking skills or speed and quality after ailment or injury shows various difficulties, not slightest of which is keeping patients drew in with treatment which they may find boring. The quickly creating zone of virtual generated reality offers innovation which can track users movements and utilize them to drive connections in virtual universes.[8]

The accentuation of the exploration has turned to supporting the procedure of rehabilitation and reducing the influence of neuromotor purpose on quality of life. The robots are created for few purposes. Existing continuous passive motion (CPM) machines can be utilized for moving additions tediously, automating one feature of physical therapy but lack of structures such as flexibility to single patients and to generalize to additional one mission or task.[9] The accompanying rehabilitation intercessions were assessed for their relationship with practical result after stroke.[10]

1) Functional deficiencies at rehabilitation affirmation

2) Control or time takes for rehabilitation

3) Type of non-inpatient rehabilitation: home health therapy

4) Specificity of rehabilitation facilities

5) Strength of rehabilitation facilities

2.3.2 Stroke

A stroke happens when the supply of blood to the cerebrum is either hindered or decreased. At the point when this occurs, the brain does not get enough oxygen or supplements, and blood vessel is block. The objective of stroke restoration is to enable you to relearn abilities you lost when a stroke influences some portion of your brain. Stroke restoration can enable you to recapture autonomy and improve the quality of lifestyle. The seriousness of stroke confusions and every individual's ability to recuperate differ broadly.

Figure 2.2 Showing a blockage in a blood vessel at brain

Consequences of stroke are immediately needed in additional populations of the world, particularly in developed countries where the hazard of stroke is higher, life routines are altering rapidly, and population restructuring is happening. Stroke is a non-transmittable disease of expanding financial significance in maturing populations. Stroke is also a main cause of long-term disability and has theoretically huge expressive and socioeconomic consequences for patients, their relatives, and health facilities.[11] The stroke patients lose their ability level day-by-day. Such activities like bathing, cleaning house, take the thing from one place to another place and eating.[12]

Stroke is a non-transmittable disease of expanding financial significance in aging populations. The extent of the problem is unclear however it could be vital to consider the sorts of problems that happen in deciding if a stroke has happened or not. Without cautious examination of the stroke patients, strokes not related with hemiparesis or hemiplegia might be missed. In the broad World Health Organization overview (just 70 percent of occurrence stroke cases had hemiplegia. The size of the potential mistake if just motor signs are noted might be significant[13].

There is strong proof that, when contrasted with regular consideration, interdisciplinary stroke rehabilitation does not decrease generally speaking rates of humanity. There is moderate proof that for more serious stroke patients interdisciplinary stroke recovery diminishes mortality when contrasted with normal consideration. There is solid prove that interdisciplinary stroke rehabilitation does not reduce the quantity of patients in the end requiring institutionalization. Be that as it may, there is solid prove that particular stroke rehabilitation diminishes the length of the hospitalization time frame. There is likewise moderate proof that for moderate-to-extreme strokes interdisciplinary stroke recovery enhances the consolidated outcome.[14]

2.3.3 Type of rehabilitation devices with game

Rehabilitation with the game is a procedure of by means of common game consoles and practice to goal and recovers physical and psychological weaknesses through healing developments. Rehabilitation device with the attached games are attractive and an important part of work-related therapy exercise in rehabilitation. By decreasing boredom of repeat motions and showing the feedback toward the therapist, the entertainment games will be a stimulator in the growth the quality of patients' improvement by the home treatments. There are many types of rehabilitation devices, such as;

2.3.3.1 Tangible robot with the sheet of printed paper game

This paper shows that using tangible items that the aging is used and as long as a simple tangible interface with basic elements may decrease the knowledge of curve. Tangible handlers interface also cares for the post-stroke exercise over the addition of physical and mental illustrations with digital demonstrations by permitting the exercise quality and development of the patient. Proven the tangible interface on the rehabilitation; the researcher recommends the usage of Cellulo, less-sized graspable and haptic permitted robots. The robots can work on the sheets of the printed papers can be utilized as an interface for communicating with much virtual point like object that exist on a plane. Our structure objective is to give down for the practical, ease to handle instinctive upper-arm rehabilitation by utilizing these novel substantial robots the game operators and items Figure 2.2.By increasing tangible objects usually utilized for recover with robot automated advances, for example, exact restriction and movement we estimate that different parts of rehabilitation can be made increase.[15]

Figure 2.3 Tangible robots[15]

Figure 2.4 The designed paper with visual game elements.[15]

2.3.3.2 Joint based hand griper robot

The researcher stated that this rehabilitation robot-assisted hand to recovery examines include patients rehearsing single joint or multi joint activities, hand opening/getting a handle on developments, individual finger exercises. Joint-based activities are typically polished as a major aspect of a computer games, though utilitarian developments, for example, getting a better handle on re practiced on the real situations or visual based. [16]

Figure 2.5 Hand grip rehabilitation robot[16]

2.3.3.3 Hand motion-controlled with video game

Movement controlled computer games, including the Nintendo Wii and Xbox Kinect, have turned into an inexorably normal assistant to physical therapy and show potential as compelling and doable post-stroke treatment choices. Even though the potential utility of buyer computer game frameworks for stroke rehabilitation, various constraints have been featured. The researcher designs the games for the overall stroke patients can be challenge for patients to develop the physical or mental. There are four games that the researcher suggests for the post-stroke patients, for rehabilitation clinicians and a game growth center, Current Circus (Melbourne, Australia). The games are selected by the rehabilitation clinician for the physical development for patients.[17]

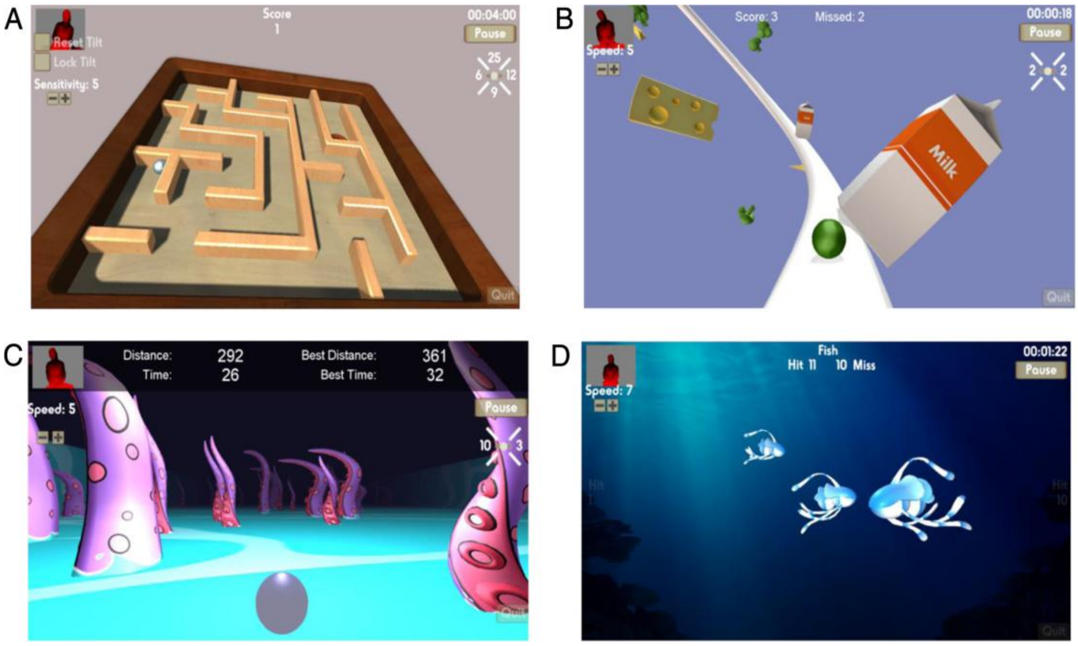


Figure 2.6 Four type of games for the stroke patients [17]

2.3.3.4 Rehabilitation device with VR Game

Patients are regularly required to make a travel to particular units for supervised outpatient treatment. The home-based, maybe with visiting experts, enable the individual to create aptitudes in their home environment. Rehabilitation software engineers are normally concocted by an expert working intimately with the stroke survivors.

Patients are regularly required to make a travel to particular units for supervised outpatient treatment. The home-based, maybe with visiting experts, enable the individual to create aptitudes in their home environment. Rehabilitation software engineers are normally concocted by an expert working intimately with the stroke survivors. [12]

Figure 2.7: Fruit catcher game for hand rehabilitation [12]

2.3.3.5 Rehabilitation device approach for gamified

The utilization of an instrumented gadget for preparing and getting to hand grip constrain control of a patient empowers both the use to increasing progress, other than permitting the joining of recreations in the rehabilitation sessions. The usage of the game in hand rehabilitation like growing the physical of patients, as they have been appeared to build commitment and treatment efficient. There are various gadgets a work in progress that give a portion of these feature for the best of the authors information there are no monetarily accessible gadgets that give grip control training. The researcher aims to making a system that empowers remote or self-sufficient hand rehabilitation, a gadget with various transducers and a going with virtual condition were produced.

The instrumented device was considered in a way that permits simple substitution of the outward shell, with the goal to reproduce several of objects sensors that empower estimation of the connected hold constrain, spatial introduction and location of regardless of whether it is set on a surface. This data is transmitted using the wireless system, either through MiWi or Bluetooth Low Energy to a PC.[18]

Figure 2.8 Hand grip instrument[18]

2.3.4 Review on hand orientation measurement

Motion recognition, at that point, comprises of the tracking of human development, as well as the translation of that development as semantically significant directions.[19][20] The hand orientation tracker is important for many tools, such as:

1) Games look at movements for computer games tracked a player's hand orientation or movements of communicating game objects.

2) Virtual Reality Motions for virtual and enlarged reality applications have encountered one of the best levels of take-up in computing. Virtual reality connections utilize motions to empower practical controls of virtual items utilizing one hand, for 3D display connections

2.3.5 Type of the orientation measurement

The objective of movement recognition explore is to make a framework which can distinguish particular human motions and utilize them to pass on data or for gadget control. A motion might be characterized as a physical development of the hands, arms, face, and body with the plan to pass on data or significance. In the current technology there are several methods to measure the hand orientations, such as:

2.3.5.1 Hand gesture position tracking

The location and orientation of the display are followed by the framework with the end goal that the PC created display seems to possess real space. At least two members can have a similar PC display model as though it were genuine. This situation appears to be like shared virtual situations, but there are key contrasts between shared computers generated simulation and shared augmented reality approaches. By taking the enlarged reality strategy, at least two clients can see each other with no difficult. Since the arrangement of every member is indistinguishable, activities, for example, guiding signal are important toward all members. The researcher said, the hand orientated was also actual. The user must use a finger to pointing move the object, the hand orientation measurement must be very effective for the next step. However, to overcome the error , the patient will point at the virtual.[21]

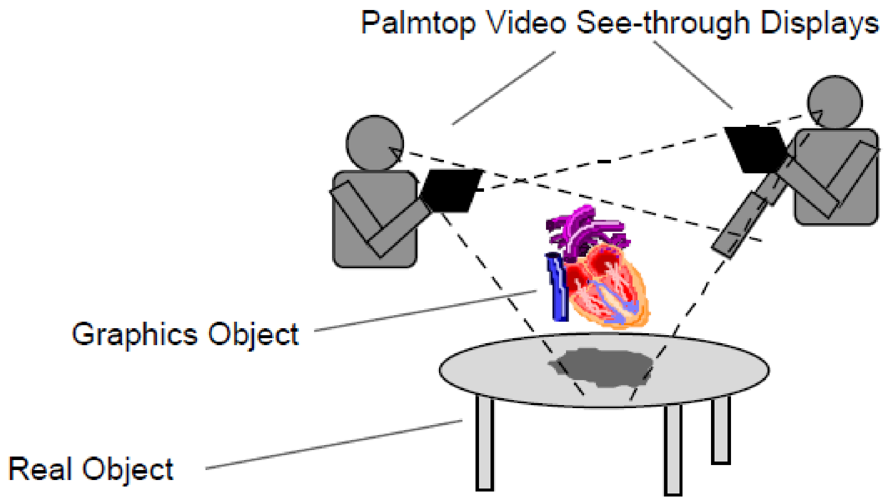


Figure 2.9 The measurement of finger printing[21]

2.3.5.2 Hand movement tracking by webcam

The aim of the researcher is to control the game bad on the hand motion recognition the hand must be put in the picture and sectioned from the background before recognition. Color is the chosen signal as a result of its computational simplicity, its invariant properties with respect to the hand shape setups and the human skin-shading trademark value. Additionally, the suspicion that color can be utilized as a sign to recognize hands has been demonstrated valuable in a few distributions for our application, the hand segmentation has been done utilizing a low computational cost strategy that performs well continuously. Applying an associated segments calculation to the probability picture, bunches pixels into a similar. The system is strong as a foundation for changes and low light conditions.[5]

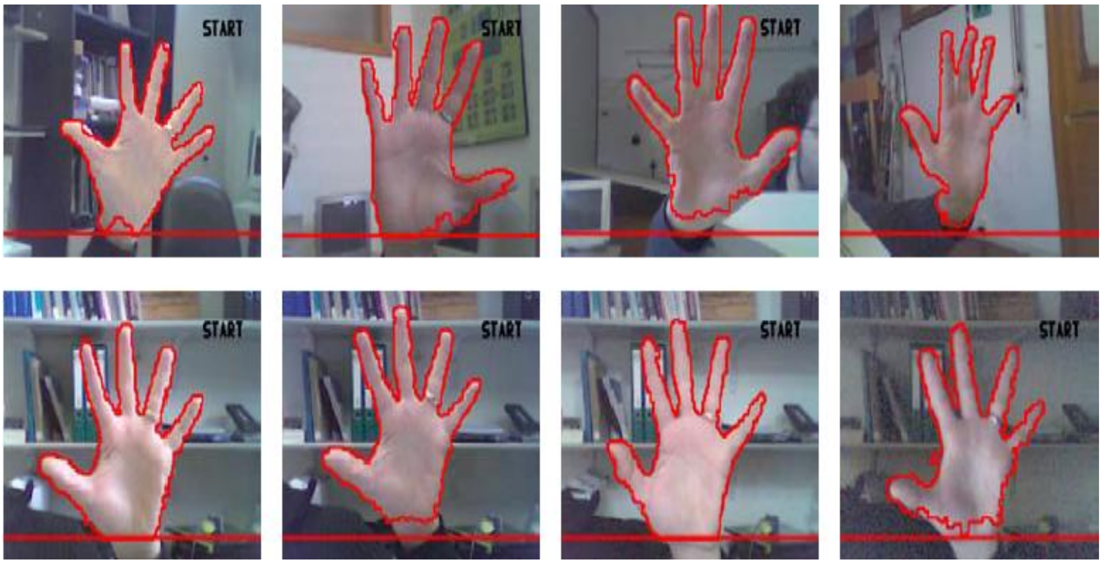


Figure 2.10 The different condition and background hand tracking[5]

2.3.5.3 Orientation histogram for hand movement

A dynamic signal is a moving motion, represented by an arrangement of pictures. The researcher focuses around the recognition of static motions, despite the fact that our strategy sums up normally to dynamic motions. The researcher applies a basic example recognition strategy to hand motion recognition, bringing about a quick, usable hand motion recognition framework and scientists have perceived gesture based communication and pointing motions.

We utilize an example recognition arrangement of the type of some transformation, T, changes over a picture or picture succession into an element vector, which we at that point contrast and the component vectors of a preparation set of motions. Apply some transformation T to the picture information to shape an element vector which speaks to that specific motion. To arrange the gesture, we contrast the element factor and the element vectors from a recently created preparing set. For dynamic signal recognition, the information would be a grouping of pictures.[22]

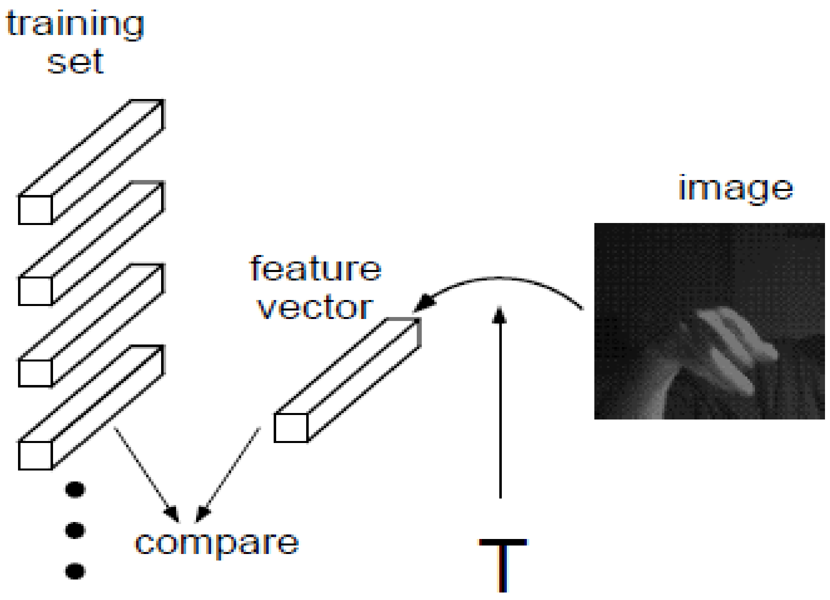


Figure 2.11 Hand recognition system[22]

2.3.5.4 Marker less hand orientation tracking

Capacities that a humanoid can display utilizing a marker less hand tracker run from skill learning, impersonation to helpful human interaction, for example, handling and exchanging objects with people by enable understanding of motions. Marker less hand tracking is generally founded on the clarification of a video input stream. The snatched casings are scanned for signals regular signs are the diagram of the hand, which can be found by applying an edge-filter on the input outline. Another signal is the visible region of a hand, which can be extricated by separating skin color.[23]

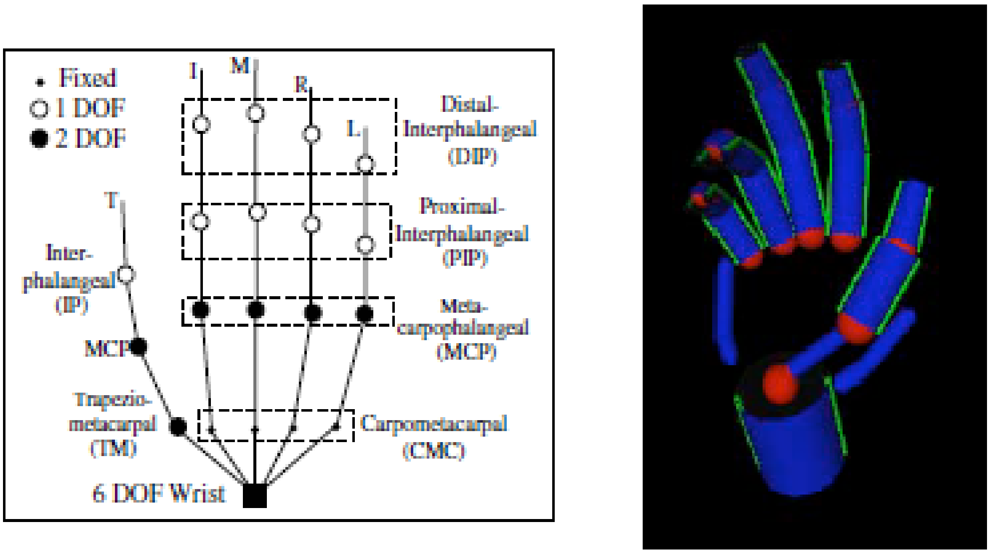


Figure 2.12 The structure of the hand [23]

In our framework, the researcher utilizes an adjusted stereo camera framework with little intra-visual separation, as it tends to be found in a humanoid head. Researcher have chosen stereo cameras, since two perspectives of the hand prompt a superior situating in 3D space, [18] as a mistake inside and out estimation may be insignificant in one view we utilize mask to cut every uninteresting parts of the picture. Furthermore, apply an edge channel in the subsequent territory of the first picture to get a hand edge picture.[23]

Figure 2.13 The hand edge detect[23]

2.3.5.5 Hand orientation measured using glove system

Hand motion information procurement is utilized in many building applications through the investigation of signals to the biomedical sciences. Glove-based scheme speaks to a standout among the most essential endeavors went for gaining hand motion information the goal of this paper, we characterize a glove-based scheme as a framework made out of a variety of sensors, hardware information obtaining/preparing and control supply, and a help for the sensors that can be worn on the client's hand.

3-D Trackers is an entire explanation of hand motion requires information of both hand design (measure of joint positions) and hand position in space (area and introduction of the hand, for 6 degree of freedom for interpretations and 3 for revolutions). While sharpened gloves record the previous kind of information, trackers record the last data. Most properly, usage of the gloves and trackers are combination. An magnetic tracker an attractive field to create by a stationary transmitter to decide the situation of a moving collector component.[24]

Figure 2.14 Glove system[24]

2.3.5.6 Hand orientation measured by markers

The inflexible body model of the furthest points comprises of three fragments namely the upper-arm, the forearm and the hand, connected by two ball-and-socket joints: the elbow and the wrist. The required least of three non-collinear markers per section is utilized to quantify each of the six degree of freedom of each section. Between markers movements are stifled by interfacing every three markers of a fragment. The lower arm cuff, markers are fixed near the wrist just to record the vast majority of the pro-/supination. he markers define a few portion and joint organize frameworks of which the relative movements are assessed to compute the joint edges. The coordinate systems of the upper-arm, the lower arm and the hand are self-assertively fixed at every three section markers. [25]

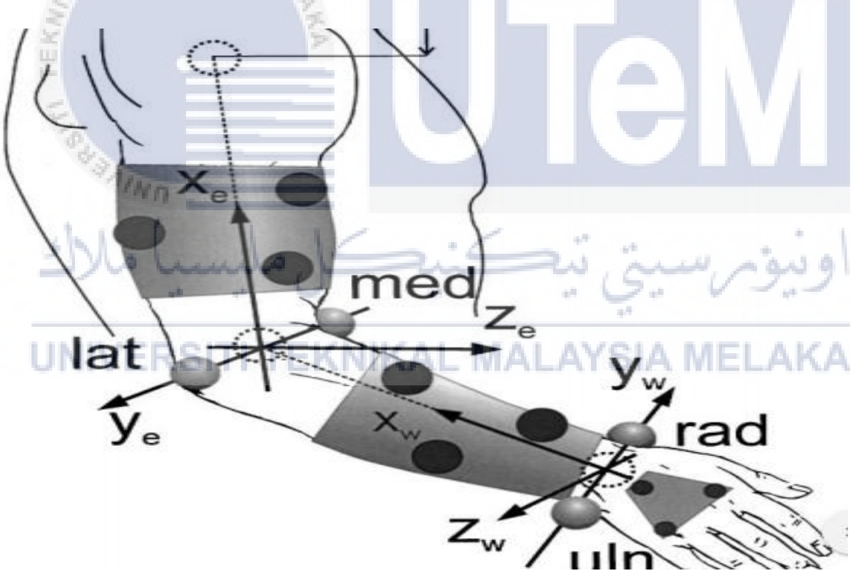


Figure 2.15 Marker arrangement[25]

2.3.5.7 Summary

As summary, all techniques are compared in Table 2.1.

Table 2.1 Analysis of hand orientation measurement techniques

Researcher	Technique	Application	Strength (+)/ Weakness (-)
L. Dipietro	Hand -glove	Biomedical	(+) Independent from surrounding lighting. (-) Wired and not contactless.
J. Rekimoto	Hand gesture position tracking	Biomedical	(+) two members can have a similar PC display very effective. (-) computationally expensive
C. Manresa, J. Varona, R. Mas, and F. J. Perales	Webcam	Biomedical	(+) can reach a huge number of people. (+) can offer fast turnaround time.\ (-) very sensitive to movement (-) will not work well in low light conditions.

T. Gumpp, P. Azad, K. Welke, E. Oztop, R. Dillmann, and G. Cheng,	histogram for hand movement	Biomedical	(+) accurate of small set of posture (+) small amount of calibration (-) does not work for large posture
R. Schmidt, C. Disselhorst-klug, J. Silny, and K. Rau	Hand orientation using marker	Biomedical	(+) accuracy (+) precision (+) flexible (+) wireless (-) detect by the position and id
Er. Garima Baweja	Hand gesture using accelerometer	Biomedical	(+) accuracy (+) precision (+) portable (+) wireless communication data rate is faster.

There are six type of techniques using to measure the hand orientation. Moreover, most of the techniques which are mention in the Table 2.1 have advantages and disadvantage, compare with the techniques. In this thesis, the hand gesture using the ADXL335 accelerometer to measure the hand orientation. An accelerometer is wireless communication data rate is faster and also no need lengthy wires. This project is mainly focused on the patient, if the device is too complex the patients may feel uncomfortable. For this project the device's accuracy played an important role because from the accelerometer angle the data will send in the range of 0 degree to 360 degrees by measure the hand orientation of pitch and roll movement. Besides that, in order to get the actual hand motion, the algorithm has been modified. As a conclusion, to reduce the unwanted signal and for an accurate measurement signal filtering process is required.

2.3.6 Review on performance evaluation techniques

The review of this is to have a clear understanding of the key elements those performance evaluation techniques that going to involved in this project. The ideas are originally taken from the others authors, however it is all written in own words by synthesizing and paraphrasing, there is several review paper that discuss about the performance using different method. There are many ways of performance evaluation technique and the types will be discussed in detail below.

2.3.6.1 High-accuracy Fiducial Markers and the camera distance

This paper researcher introduces a fiducial marker which accuracy time performance. As opposed to used just only the corners or edges for posture estimation, the marker has an outspread sinusoid design which has an anticipated appearance under viewpoint projection. As an option, this paper proposes a framework utilizing high-precision fiducial markers. Some of these markers would be set along the course with either precisely estimated or deliberately controlled stances.

At that point, at whatever point a marker is obvious to the multirotor camera, a high-precision present is accessible for ground truth. A usage with real-time and constant execution would like have different applications, for example, limitation, accuracy hover. The idea of an "marker pattern” is from, which a one-dimensional marker with a sinusoid design for separation estimation.

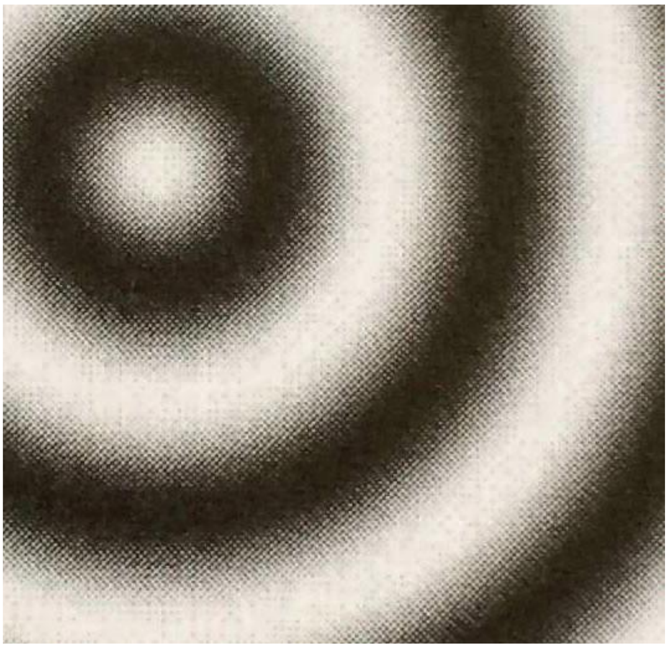


Figure 2.16 The marker pattern[26]

Researcher required the marker to be parallel to the camera and in the focal point of its edge. Their calculation is moderately straightforward: they tested a column of pixels along the local point of the picture, connected a Gaussian window, while assessing the marker represent each pixel of the marker is utilized, as opposed to conventional markers which utilize just corners or edges.

It may similarly be obscure, contingent upon the camera's central length, the separation from the camera to the marker, and any general movement of the camera and marker. The camera sensor itself includes different kinds of commotion, electronic commotion, enhancer commotion and quantization commotion.[26]

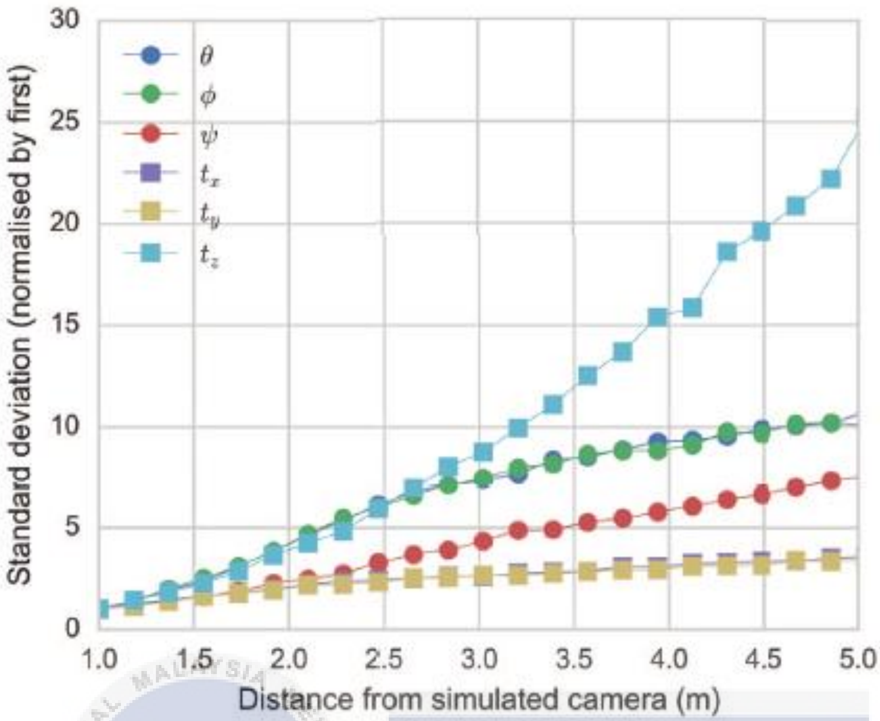


Figure 2.17 Accuracy plot toward the camera distance[26]

2.3.7 Review of accelerometer measurement and techniques

One of the general techniques for detecting orientation or reading of angle is to coordinate the yield of accelerometer. In spite of the fact that the utilization of accelerometer is an immediate technique, the mistake related with invalid predisposition solidness can be intricate if the joining time frame is expanded. This can cause a clear when the hand movements are static.

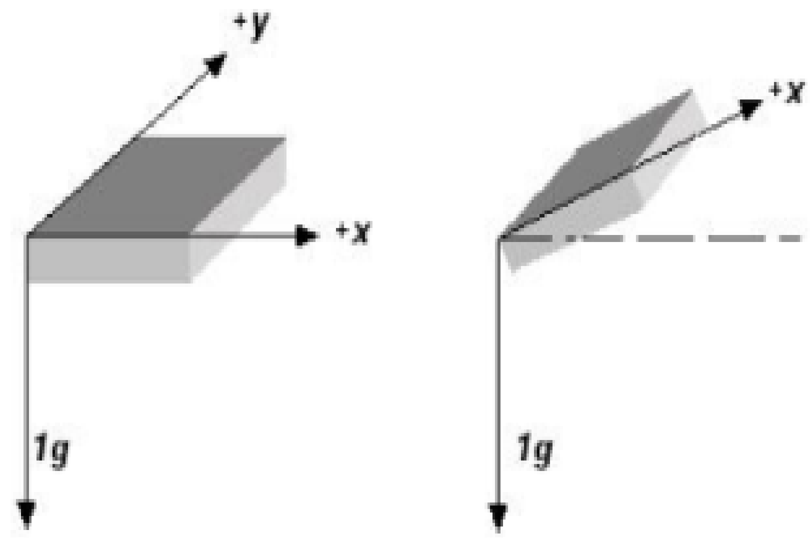


Figure 2.18 One axis of orientation

In the event that one hub (X-axis) is utilized to investigate the orientation point of the accelerometer the accompanying trigonometry used.

$$v_{off} = v_{outx} + s \times \sin \emptyset \qquad (2.1)$$

where, VOFF is the balanced voltage, VOUTX is the voltage output from the X-axis of the accelerometer and S is the affectability of the accelerometer. The accelerometer output on the X-axis because of gravity is equivalent to the following equation,

$$A_x = \frac{v_{outx} - v_{off}}{s} \qquad (2.2)$$

To solve for movement angle;

$$\emptyset = \sin^{-1}(A_X) \qquad (2.3)$$

The orientation affectability between - 900 and - 450 and somewhere in the range of +900 and +450. This goals issue between these qualities makes this technique estimation of the angle point off base when the accelerometer yield is close to the +1g or - 1g range.

2.3.7.1 Calculate accelerometer orientation by using dual direction

Introduction issues can be tended to by mounting the accelerometer vertically. With the goal that the Y-axis is parallel to gravity or by utilizing a tri-axis accelerometer utilizing something like 2 of the 3 axis. Utilizing more than one axis to compute orientation a progressively exact arrangement as appeared in Figure 3.2.

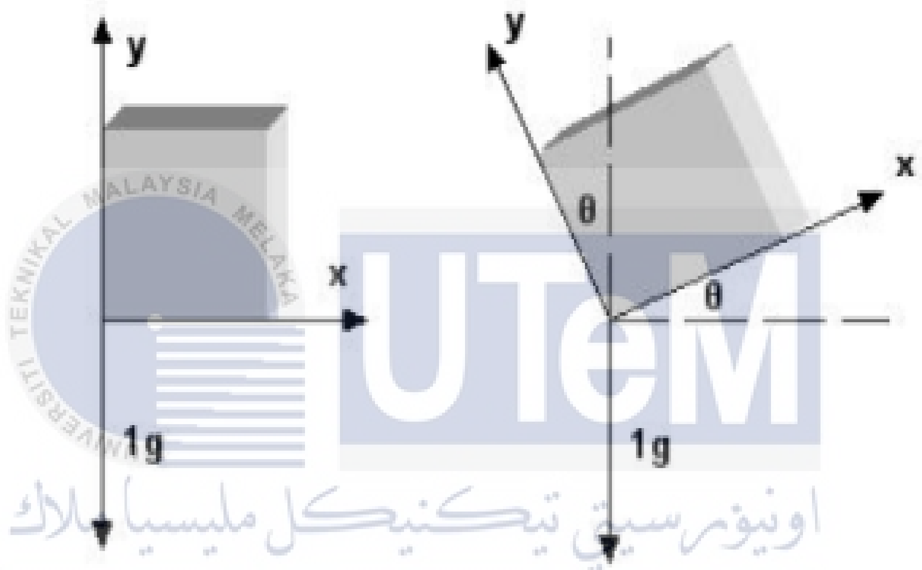


Figure 2.19 Dual axis of orientation

However, a simpler and increasingly effective methodology is to utilize the proportion of the two value, which results in the following,

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the process of the project will be discussed in detail. The method on how this project carried throughout the whole time will also be a part of this chapter. This chapter aims to provide details and evidence on how this project carried out. Here, the technique for the proposed work for the hand orientation is clarified.

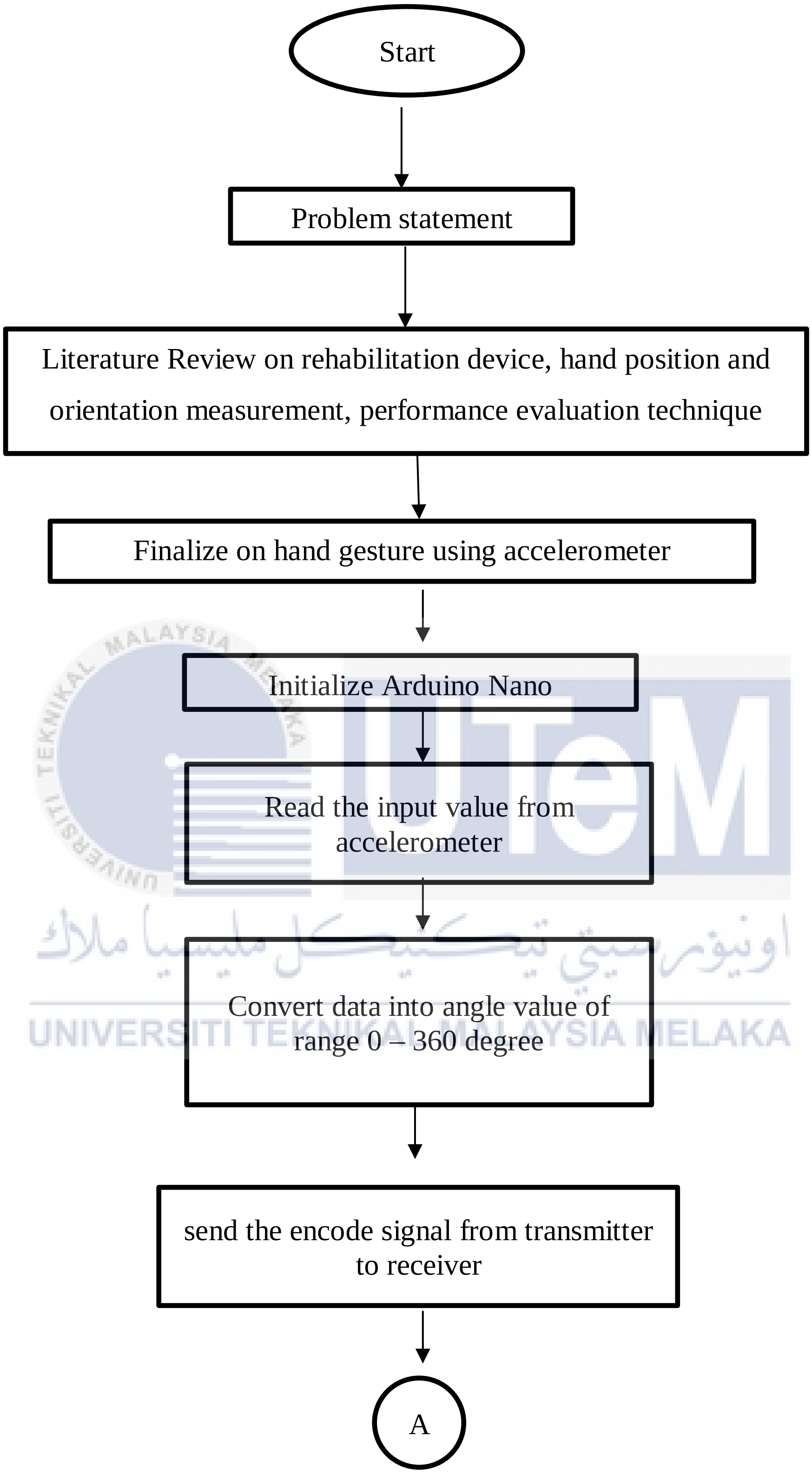
3.2 Process Flow

Gesture recognition is a dynamic area of research in human-computer interfaces. New input methods, closer to the human nature, are searched for replacing the traditional ones. Gestures are a very spread mean of communication among people. There are two implementations of gesture recognizing systems: sensor- based and vision-based. The sensor-based solutions use accelerometers or gyros for detecting the gestures. This paper presents a hand gesture recognition system built around an ADXL335 accelerometer. Hand rehabilitation device should achieve a meaningful task, for this project the hand orientation tracking coordinate is most important to move further steps to collect the orientation data. Accordingly, it must have some sort restriction method appliance. The system is made by a sensing and transmitting part, the angle of hand orientation measurement for hand muscle, this project is more to transmitting device which is any robot or integrated game can interface with this rehabilitation device.

Hand orientation tracker has worked in the accelerometer. Subsequently it is helpful to use it for deciding hand orientation. In this project, hand gesture is a dynamic region of research in human-computer interfaces. New information strategies, closer to the human instinct, are looked for replacing the conventional ones. Motions are a very spread mean of correspondence among individuals. There are two executions of motion perceiving frameworks: sensor-based and vision-based. The sensor-based arrangements use accelerometers.

This paper displays a hand motion acknowledgment framework worked around an accelerometer ADXL 335 sensor by using Arduino Nano. The Arduino Nano can be controlled by the USB association or with an outside power supply. If an outer power supply is utilized, it must be in the range of 2.7 and 5.5 volts. This can come either from an AC-to-DC connector (divider mole) or battery. The Arduino Nano cannot supply power in more than 5.5 volts. After completing the project, the electronics parts will be attached on the hand glove because that the Arduino Nano is suitable to be used and at the same time it is user friendly. Accelerometers are fit for estimating the quickening they experience with respect to free-fall, a similar increasing speed all living creatures could feel and sense. As an outcome, accelerometers are unequipped for estimating the increasing speed of gravity, yet can be utilized to gauge the upwards quickening that counters gravity when very still, from the accelerometer x-axis and y-axis will be used to calculate the angle.

The OLED show does not require backdrop illumination, which results in an extremely decent difference in dark conditions. Also, its pixels expend vitality just when they are on, so the OLED show devours less power when contrasted and different showcases. OLED will display the X-axis, Y-axis, the duration of use the device and angle, in this project the OLED is act as data presentation display, moreover the OLED will be attached with the Arduino Nano. The flow of the process is shown in Figure 3.21;


Start
Problem statement
Literature Review on rehabilitation device, hand position and orientation measurement, performance evaluation technique
Finalize on hand gesture using accelerometer
Initialize Arduino Nano
Read the input value from accelerometer
Convert data into angle value of range 0 – 360 degree
send the encode signal from transmitter to receiver
A

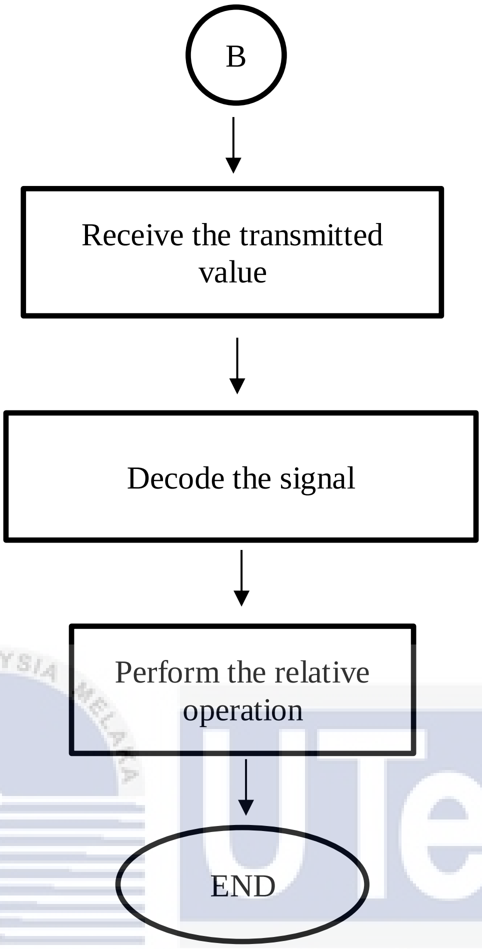
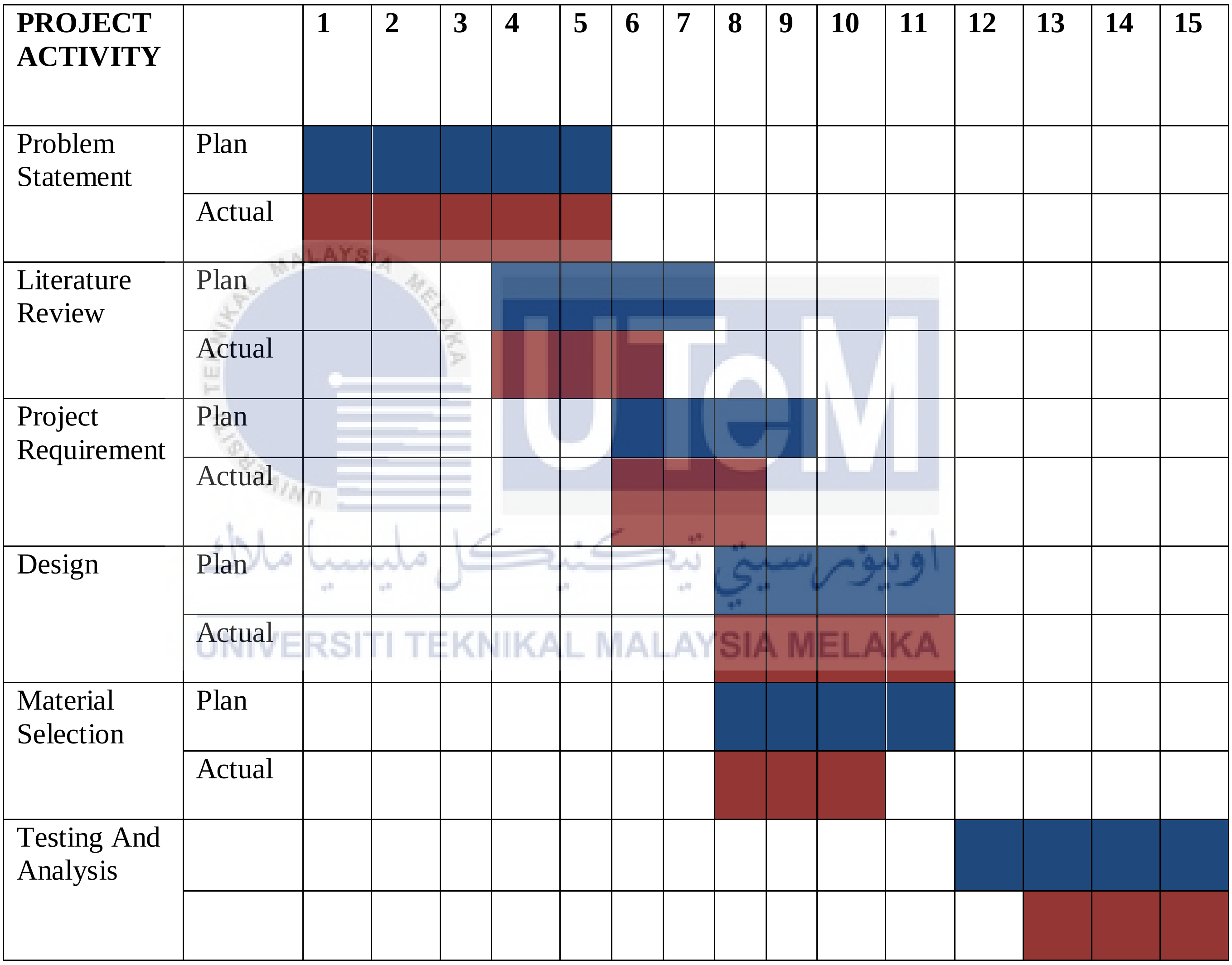


Figure 3.1 Flow chart of processes involved

3.3 Gantt chart

Gantt chart used for the plan and the time taken to complete the project. The Gantt chart below shows the time taken to complete the task. Along these lines, the arrangement was done in real length of time to finish.

Table 3.1 Gantt chart



3.3.1 Process Explanation

Process explanation is the flow in which the project was carried out. In sub-topic, the way this project was done is explained in detail in chronological order.

3.3.2 Literature review

In order to complete this project, information on the orientations and elements involved is needed. To gather this information, literature review on various topics was done. The articles, journals, books and other source of information were all legitimate and with proper details such as author name, year published, and many more. No open sourced information was included in literature review. Literature review further enhances the aim and focus of the project to be precise. As the project rolls out, the aim and direction of the project becomes clear.

3.3.3 Hand Gesture using 3-axis accelerometer

A hand gesture orientation measurement is constrained by utilizing hand instead of some other technique like catches or joystick. This project is to measure the orientation angle using 3-axis accelerometer. A transmitter is utilized in the grasp which contains RF Transmitter and accelerometer. This will transmit angle to output devices with the goal that it can do the required undertakings like movement of the hand in order with the pitch and roll direction. Every one of these assignments will be performed by utilizing hand orientation.

The main component that used to calculate the angle by using the Arduino Nano is 3-axis accelerometer. Accelerometer is a 3-axis quickening estimation gadget with +-3g territory. This gadget is made by utilizing sensor circuit to quantify increasing speed. The yield of this gadget is analog in nature and relative to the increasing speed. This gadget estimates the static speeding up of gravity when we tilt it.

3.3.4 Calculate 3-axis accelerometer orientation

For precise estimations of movement of orientation in the x and y planes we hence need a 3 axis accelerometer. We could utilize the equation below to ascertain the points utilizing x and z for the x axis whereas utilize y and z for the y- axis. Anyway we can improve things further by utilizing every one of the three output data to calculate each angle according to the orientation movement occur by the patients. The formulas are;

$$A_x = \arctan\left(\frac{x}{\sqrt{x^2 + y^2}}\right) \quad (3.1)$$

$$A_y = \arctan\left(\frac{x}{\sqrt{x^2 + z^2}}\right) \quad (3.2)$$

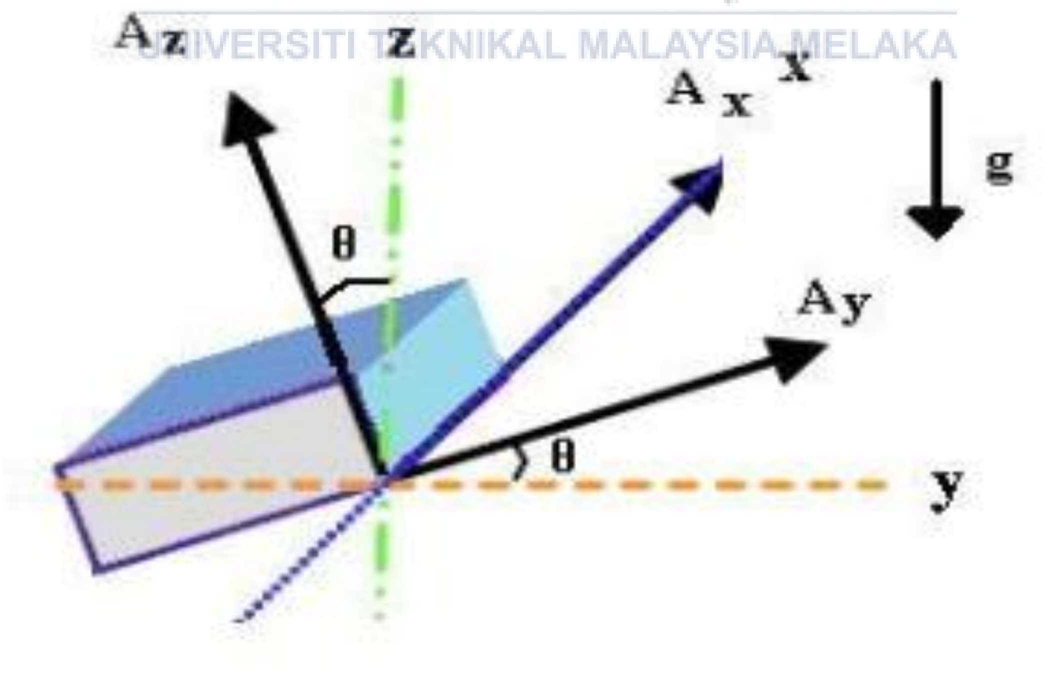
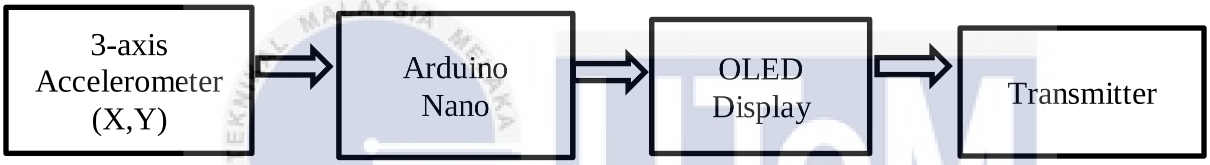


Figure 3.2 3- axis of orientation

3.3.5 Block Diagram of Hand Gesture using 3-axis accelerometer

The following shows the block diagram of the hand gesture using 3-axis accelerometer. There are two parts for this projects but the focus is on the input data. There are 3- axis accelerometer used to collect the data of hand orientation. The Arduino Nano used as software to collect and transfer the data from transmitter to receiver. Moreover, for the data presentation part there is OLED display used to present the data, it attached together with the Arduino Nano. The X- axis, Y-axis, angle and time of use the device will be presented by the display.



3.3.6 Project Requirement

There are numerous kinds of prerequisites, as there are numerous ways to deal with catching them. Before beginning the genuine catching of prerequisites, an arrangement for the necessities gathering process must be created. Frequently the initial step for that ought to be to figure out what is the suitable approach for the project. This is done with the help of survey on stroke patients in order to increase the strength of patients' health and also the reliability of the project design.

Table 3.2 Project Requirement

Requirement	Description
Safety	• The Arduino Nano is round package designed to minimize snagging, profile and light weight. • The Arduino and other electrical components will be sewn on the hand glove. So that, there is minimal chance to electrical minor shock. • Less operation faulty
Affordable cost	• Low cost materials • High level of strength
Simple	• Light weight, easy to assemble • Portable
Data presentation	• The time, roll and pitch angle used on the device will display by the OLED. • They can self-motivate by seeing the duration of usage device.

3.3.7 Arduino

Arduino refer to an open-source software stage or board and the product used to program it. Arduino is intended to make electronics increase the availability to specialists, and planners. An Arduino board can be acquired, pre-collected or, in light of the fact that the equipment configuration is open source, worked by hand. In any case, clients can adjust the sheets to their necessities, just as update and disseminate their very own versions.

Figure 3.3 The Arduino board used in this project and corresponding

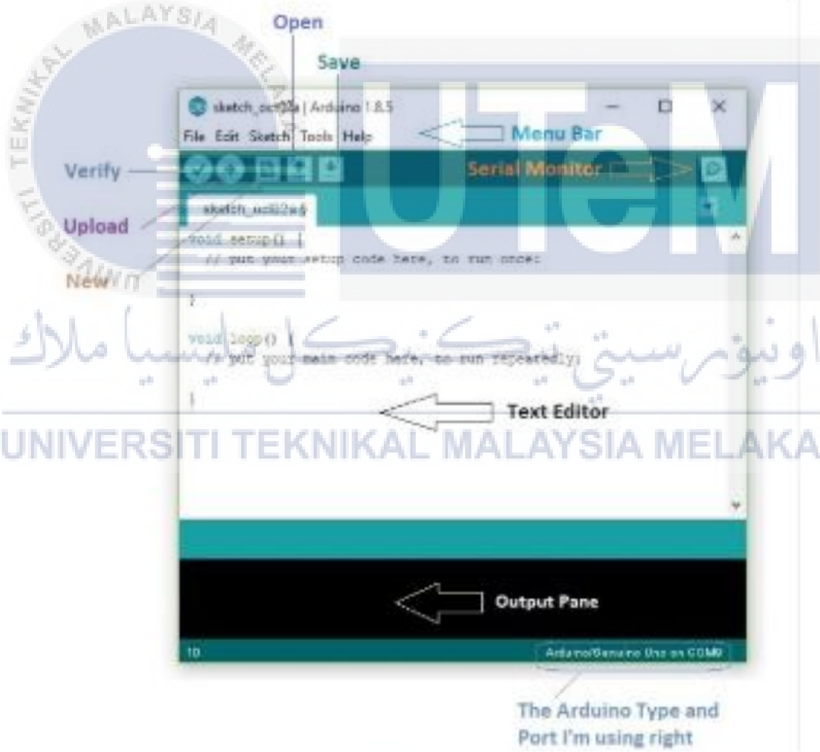


Figure 3.4 Arduino software

The Arduino IDE gives an editorial manager to set up the sketch of equipment. The Arduino IDE code supervisor was in all respects skillfully structured. It gives an extremely recognized view (in shading and text styles) to the factors, constants, work, and so on of the source code. It incorporates highlights like language structure featuring, prop coordinating and programmed code space. There is no compelling reason to control the made files or go on direction line to dump the code into the equipment.

3.3.8 Termite

The termite software is act as a simple RS232 terminal; it is easy friendly to configure the terminal. In the Termite utilizes an interface like that of collecting the roll pitch and time data from the Arduino to Pc. Moreover, there are some feature have in the termite software, there has plug-in interface example, auto reply, function key, log file and hex view the main plug-in interface that using for this project is the log file, from the Arduino the transmitter APC220 collect the data and transfer to the receiver, the termite will act as collect all the data and transfer to the log file to excel. The data can be forward and interface between two RS232 ports. There have multiple user interface languages.

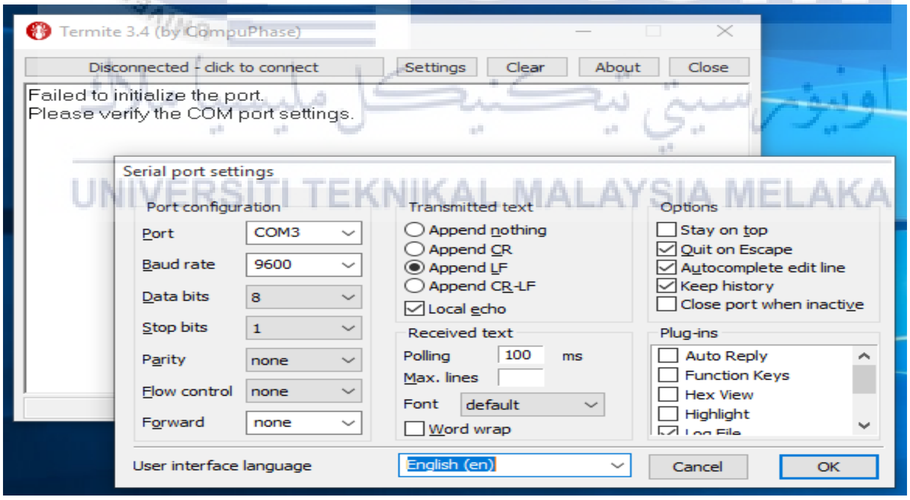


Figure 3.5 Termite

3.4 Proposed System Design

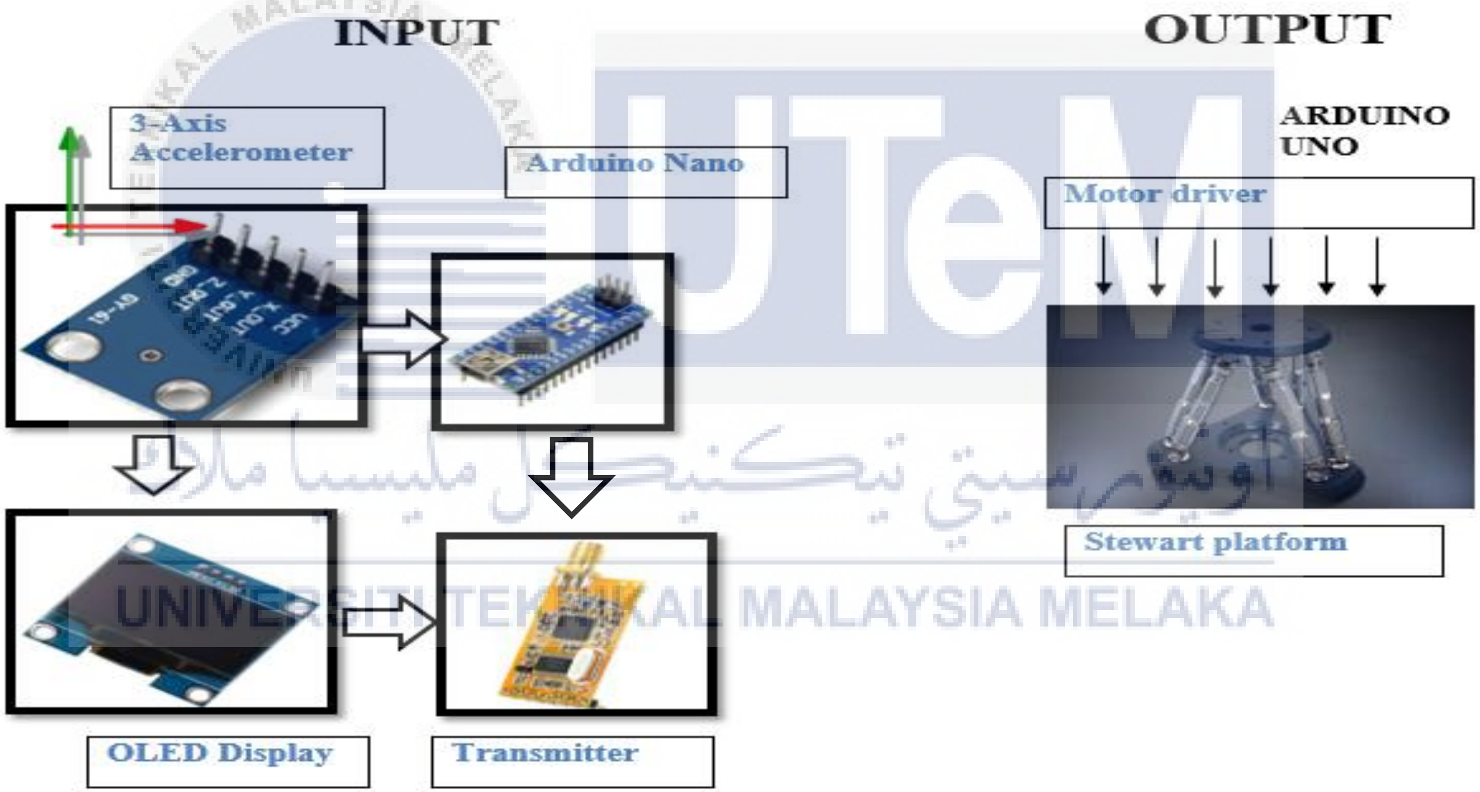


Figure 3.6 Design

The figure 3.8 show the design of this project, the 3-axis accelerometer played main role. The Arduino used to collect data and transfer data through the transmitter APC 220. The data will display through the OLED display, in the OLED display there will be present the x-axis, y-axis, angle and the time duration will be display. After read the input value from the accelerometer, the data convert into angle value of range 0-180 degree and send the encode signal from transmitter to receiver.

3.5 Signal Conditioning

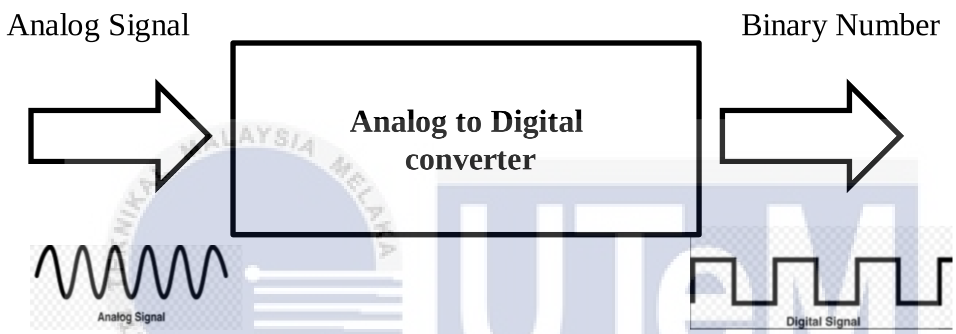
Most simple sign requires some type of planning before they can be digitized. Signal conditioning is the control of a sign in a manner that sets it up for the following phase of preparing. application include environmental estimation. Process signal to make it suitable for the next operation. Some of the main process are:

1. Protection to prevent damage e.g. fuses or current limiters
2. Getting the signal into the right type of signal e.g. A/D or D/A converters
3. Getting the level of the signal right e.g. mV to V
4. Eliminating or reducing noise e.g. filters
5. Signal manipulation e.g. non-linear to linear signals

Those are important elements for the signal conditioning but in this project going to focus getting the signal into the right type of signal Analog to digital converter.

3.5.1 Analog to Digital convertor

The input to an analog-to-digital converter is an analog signal and the output is binary word that represent the level of input signal. There are a number of form of analog-to-digital converter, the most common being successive approximation, ramp, and flash. Successive-Approximation ADC, a progression of codes, each relates to a fix simple analog level, are produced progressively by an interior counter to compare and the analog converter.



$$(\textbf{Digital Output}) = \frac{2^N \; X \; Analog \; Input \; Voltage}{Reference \; Voltage} \tag{3.3}$$

3.6 Sensitivity

The sensitivity is defined in terms of the relationship between input physical signal and output electrical signal. The sensitivity is generally the ratio between a small change in electrical signal to a small change in physical signal. As such, it may be expressed as the derivative of the transfer function with respect to physical signal. sensitivity of an accelerometer characterizes at what rate the sensor changes over mechanical energy into an electric energy (the yield); and this will characterize the speeding up measurement scope of the accelerometer. Sensitivity is the ability of the sensor the respond to changes in the measured input. The sensitivity that you want relies upon the dimension of the sign you wish to measure.

Table 3.3 The ADXL 335 data sensitivity parameters

Parameter	**Conditions**	**Min Typ Max**	**Unit**
Sensitivity at Zout, Yout, Zout	VS = 3 V	270 300 330	mV/g
Sensitivity Change Due to Temperature	VS = 3 V	±0.01	%/°C

3.7 Angle of rotation using ADXL 335

In arithmetically, the angle can be estimation of the axis, in particular the angle, that a figure is turned about a fixed point, regularly the point of a circle. Respect to x-axis, y-axis and z-axis there is calculation can calculate the angle from the movement of the accelerometer, but the first place need to change the 10-bit ADC values in to the g units. Before that, need to gather the important values from the ADXL 335 data sheet, for using the formulas and the accuracy of calculation will be depending on the specification of the product values, there are:

Table 3.4 ADXL 335 data sheet

Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Sensitivity at Xout, Yout, Zout	Vs = 3 V	270	300	330	mV/g
Zero g Bias Level **0 g Voltage at Xout, Yout**	Vs = 3 V	1.35	1.5	1.65	V

3.7.1 Calculation of acceleration in g units

$$A_{OUT} = \frac{\frac{ADC\ Value * Vref}{2^{10}} - voltage\ Level\ at\ 0g}{Sensitivity\ Scale\ Factor} \quad (3.4)$$

1. $voltage\ Level\ at\ 0g$ = typically 1.65 v
2. ADC bits = 2^{10} = 1024
3. $Sensitivity\ Scale\ Factor$ = 330 mV/g

Calculation in the IDE Arduino coding form;

```
xv = (valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;
yv = (valueADC_y / 1024.0 * ADC_ref - zero_y) / sensitivity_y;
zv = (valueADC_z / 1024.0 * ADC_ref - zero_z) / sensitivity_z;
```

3.7.2 Angle of rotation

Roll - Angle of rotation along the y-axis

Pitch – Angle of the rotation along the x-axis

Yaw – Angle of the rotation along the z – axis will be (neglected).

3.8 Material Selection

In the determination of materials, a systematic methodology is important to choose the materials for a specific application. In the event that an appropriate strategy is pursued, first it is required to application characterize the application requirement as far as electrical parts, and mechanical properties. Material selection is one of the elements of effective engineering plan as it decides the reliability quality of the structure as far as modern and economic perspectives. An incredible plan may neglect to be a beneficial item if unable to locate the most suitable material mixes. So it is imperative to recognize what the best materials for a specific plan.

3.8.1 Arduino Nano

The **Arduino Nano** is very much similar to the Arduino UNO. They use the same Processor (Atmega328p) and hence they both can share the same program. One big difference between both is the size UNO is twice as big as Nano and hence occupies more space on project. The Arduino Nano is a microcontroller board intended for wearable and materials. It very well may be sewn to fabricate and also mounted power supplies, sensors and actuators with conductive string. The board depends on the ATmega168V (the low-control form of the ATmega168). simple function like pinMode() and digitalWrite() can be used to control their operation. The operating voltage is 0V and 5V for digital pins. The analog pins can measure analog voltage from 0V to 5V using any of the 8 Analog pins using a simple function liken analogRead().

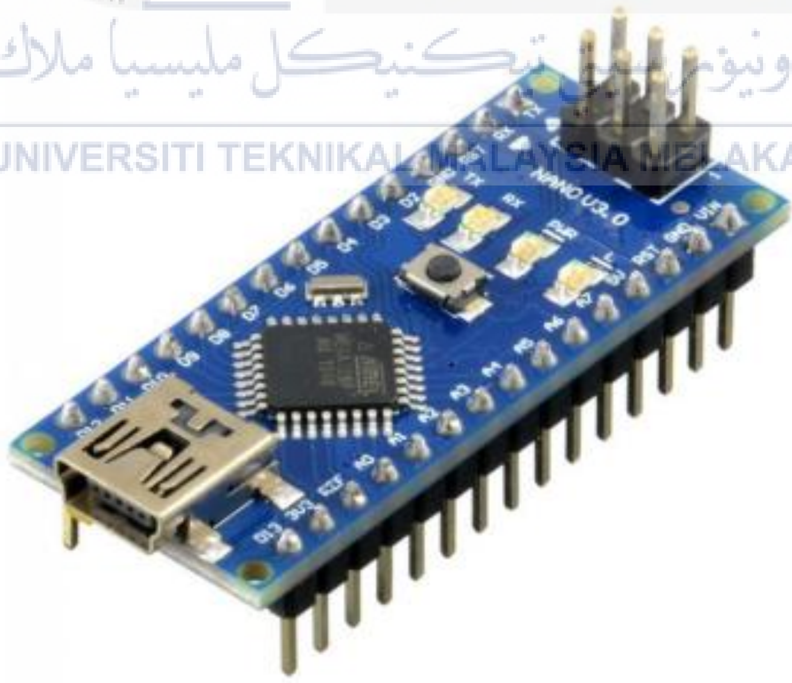


Figure 3.7 Arduino Nano

The Arduino Nano can be powered by the USB association or with an external power supply. In the event that an outer power supply is utilized, it gives somewhere in the range of 2.7 and 5.5 volts. This can come either from an AC-to-DC connector or battery. Arduino Nano increment the safety for patient and it is portable to use by collecting the data, analyzing and transmitting information data. Moreover, Arduino Nano portable, it is easy to be attached in the glove, shoes or shirt.

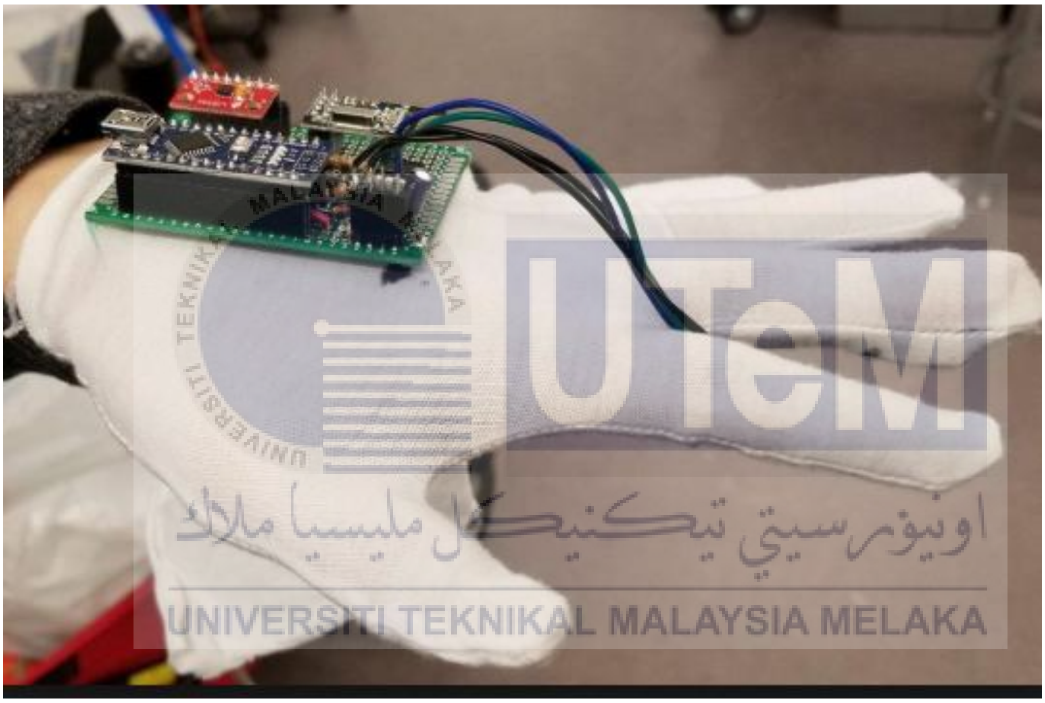


Figure 3.8 Arduino Nano attached with glove

3.8.2 3-axis accelerometer

Accelerometer sensors measure the difference between any linear acceleration in the accelerometer’s reference frame and the earth's gravitational field vector. The accelerometer output is an estimation of the axis of gravitational field vector and can be utilized to decide the accelerometer pitch and roll hand orientation. The accelerometer is focusing and collecting the data due to the hand orientation. 3- axis Accelerometer is inhumane toward rotation about the gravitational field vector. The conditions for the roll and pitch angles consequently have mathematical error when rotation happen to in a straight line with gravity and point upwards or downwards. The accelerometer estimates quickening with a maximum scale range ±3 g. It can quantify the static acceleration of gravity in angle-detecting applications.

Table 3.5 Feature of 3-axis accelerometer

Axis	3-axis sensor
Profile	Small, low profile package
Size	4 mm × 4 mm × 1.45 mm
Power	Low 350 µA
Shock Survival	10,000 g
Temperature Stability	Excellent
Bandwidth	BW adjustment with a single capacitor per axis

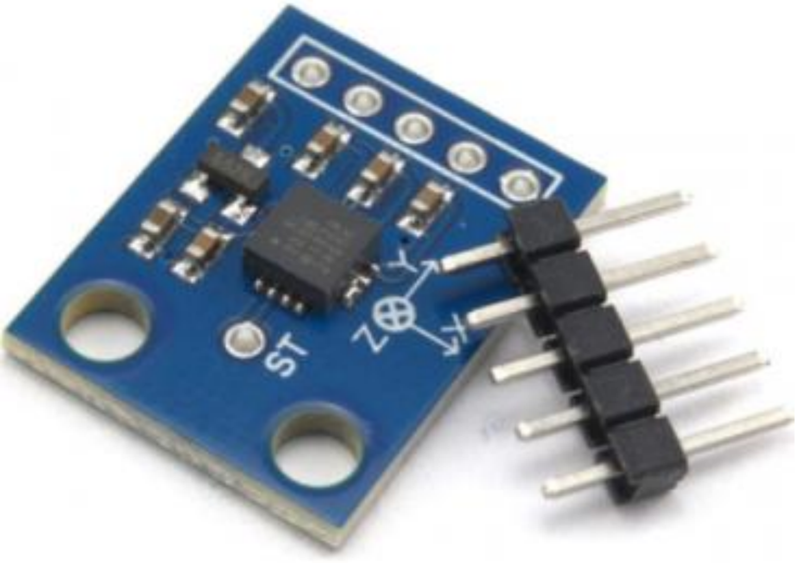


Figure 3.9 3-axis accelerometer

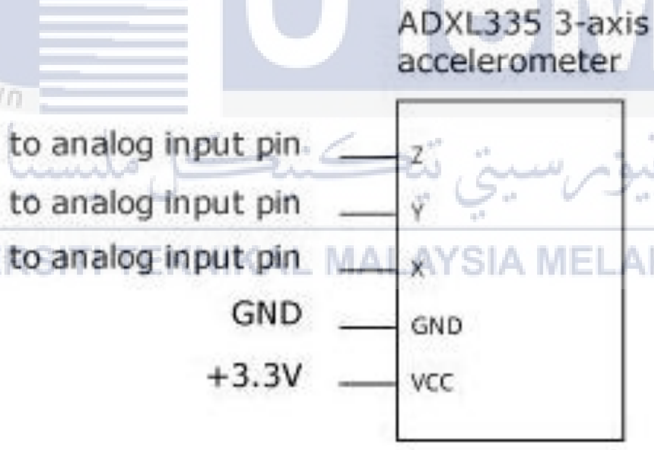


Figure 3.10 3-axis accelerometer connection

3.8.3 Organic light-emitting diode (OLED)

OLED (Organic Light Emitting Diodes) is a level light producing innovation. At the point when electrical flow is connected, a light is transmitted. OLEDs are displays that do not require a backdrop illumination as are slenderer and more proficient than LCD shows (which do require a white backdrop illumination). The OLED will have attached with the Arduino Nano the OLED is act as a data presentation for this project. In the OLED there will be x- axis, y-axis, time duration that patient will use the device and the angle of orientation will be display. The OLED have following advantage;

1) More contract, better brightness, more flexible
2) Low power consumption
3) Better durability

Figure 3.11 OLED 0.96

3.8.4 Battery

A battery is a device comprising of at least one electro chemical cells with outer associations provide to control electrical device. At the point when a battery is providing electric power, its positive terminal is the cathode (+) and its negative terminal is the anode (-). The terminal label negative (-) is the wellspring of electrons that will course through an outside electric circuit to the positive (+) terminal. The battery 9v is a purchaser replaceable, high vitality thickness battery that can last multiple times longer than conventional alkaline 9-volt batteries and up to multiple times longer than carbon-zinc batteries in numerous.

Figure 3.12 Battery 9v

3.8.5 APC 220 Transmitter

The APC220 transmitter module gives a straightforward transfer the collecting data from transmitter to receiver for communicating the data. Coordinates an inserted rapid chip and superior IC that makes a transparent UART/TTL interface, and eliminates any requirement for information encoding. Searching for a minimum effort arrangement with better range execution. The APC 220 is it can have a good presentation. There are 7 pins;

Table 3.6 Pins description

Pin	Definition	Details
1	GND	OV ground
2	VCC	3.3v to 5.5v power
3	EN	Enable the device more than 1.6v Disable the device less than 0.5v
4	RXD	UART RX
5	TXD	UART TX
6	AUX	UART signal receive (low) and transmit (high)
7	SET	Set parameter (low)

To connect the PC to Arduino via APC220 transmitter, to collecting the data.

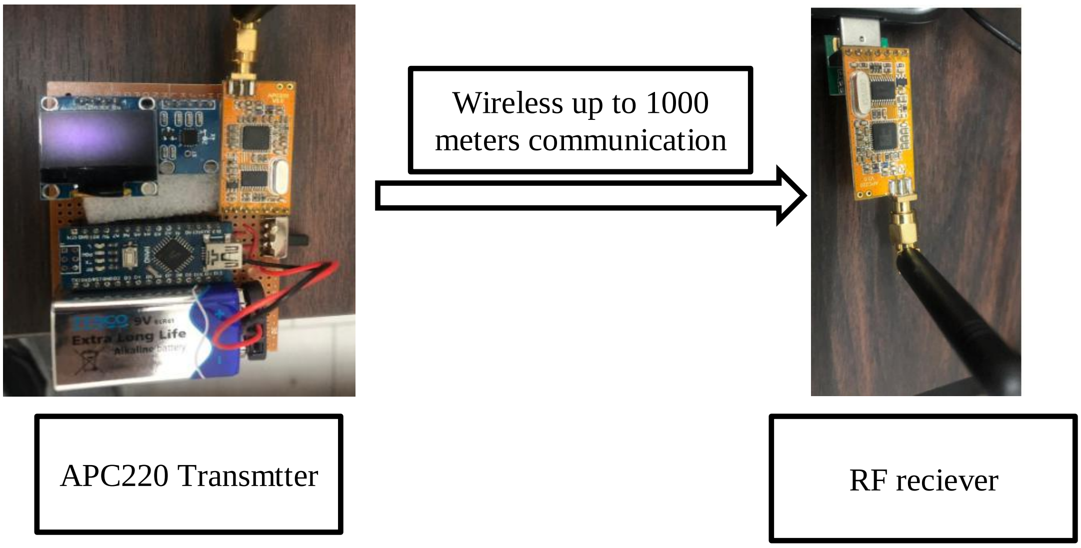


Figure 3.13 interface conection between APC220 Pc

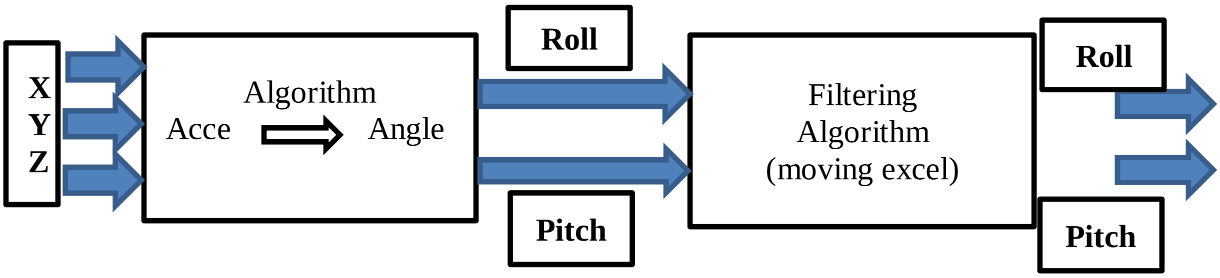
3.9 Digital Filtering

In signal processing, the digital filter is used to remove or decrease the unwanted signal to make the system smooth without any unwanted signal errors. A filter in digital signal is a framework that performs numerical tasks on a discrete and tested time signal, in order to upgrade the system to remove the unwanted signal to make a smooth movement.

3.9.1 Moving average

The data is collected and transmit to PC where the data collected is stored in with to be smooth. Analysis order gives an instrument to ascertaining moving and exponentially smoothed. In the signal processing, in filter preforms the same function as digital filter. It selectively eliminates the unwanted signal. Standard digital (and analog) filters come in 4 basic types: low pass filter high frequencies; high pass filter low frequencies; and band pass filter frequencies, the moving average is collected from the same data set as well.

$$\boldsymbol{Moving\ Average} = \frac{\boldsymbol{A1+A2+A3+A4+A5}}{\boldsymbol{N}} \quad \textbf{(3.5)}$$



3.9.2 Infinite impulse response (IIR)

Infinite impulse response (IIR) it is a low pass filter use to reduce the unwanted noise, filter that using a numerical where the estimation of the output depends not just on the estimations of the contribution, at test time "n" and past examples, yet in addition on the status of the previous at past inspecting times. The IIR is a property applying to numerous direct time-invariant framework. An initial IIR low pass filter can be actualized. The motivation behind this sort of first order IIR filter is so broadly utilized, is that it requires only an extra factor in RAM memory, to store the past estimation of output signal, which is y(n-1). The scientific equation to be executed for a first order IIR is as demonstrated as follows. y(n) is the sifted sign (output signal), while x(n) is an input signal value and y(n-1) are the information signal, and the output signal. The frequency response uses the 1st order IIR filter calculate by using the Z-transform.

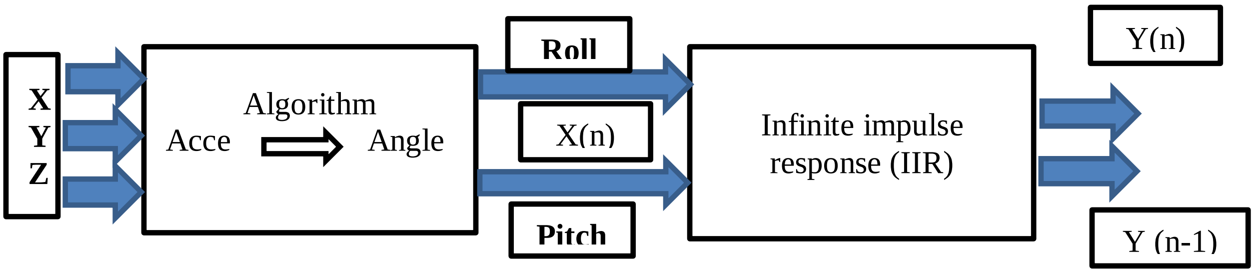
$$\boldsymbol{Y}\ (\boldsymbol{n}) = \boldsymbol{k}.\boldsymbol{X}(\boldsymbol{n}) + (\mathbf{1} - \boldsymbol{k}) * \boldsymbol{Y}(\boldsymbol{n} - \mathbf{1}) \qquad (3.6)$$

K = Filtering effect

X(n) = Input signal

Y(n) = output signal

Y(n-1) = output signal at previous sample



3.9.3 Prototype of Accelerometer based Hand Gesture controlled

Gesture recognition is a topic in computer science and language technology with the goal of interpreting human gestures through mathematical algorithms. Gestures can originate from any bodily motion or state but commonly originate from the face or hand. This paper deals with the hand orientation measurement using the ADXL 335 accelerometer with the Arduino Nano. The purpose for this project is to measure the performance of accuracy. In this device, the Arduino Nano act as a controller, the ADXL335 is using to measure the position of angle, the data will transmit from the APC220, all together will be attached in the patient hand with the glove. The following figure will show the prototype of the project.

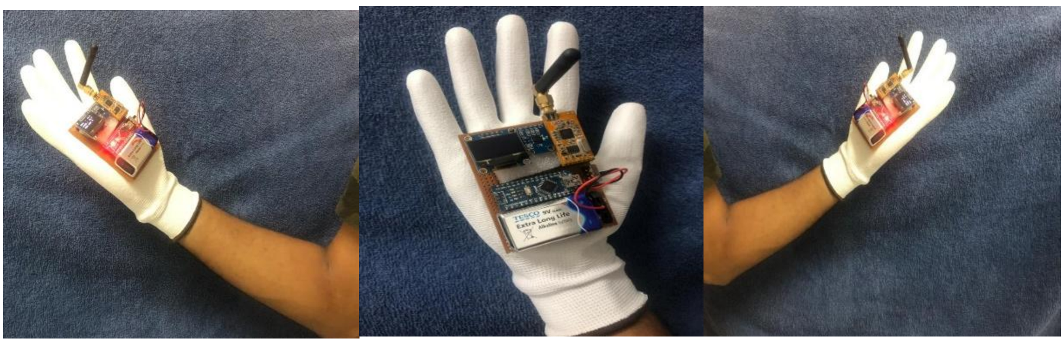


Figure 3.14 Hand orientation measurement device for hand

3.9.4 Circuit Design

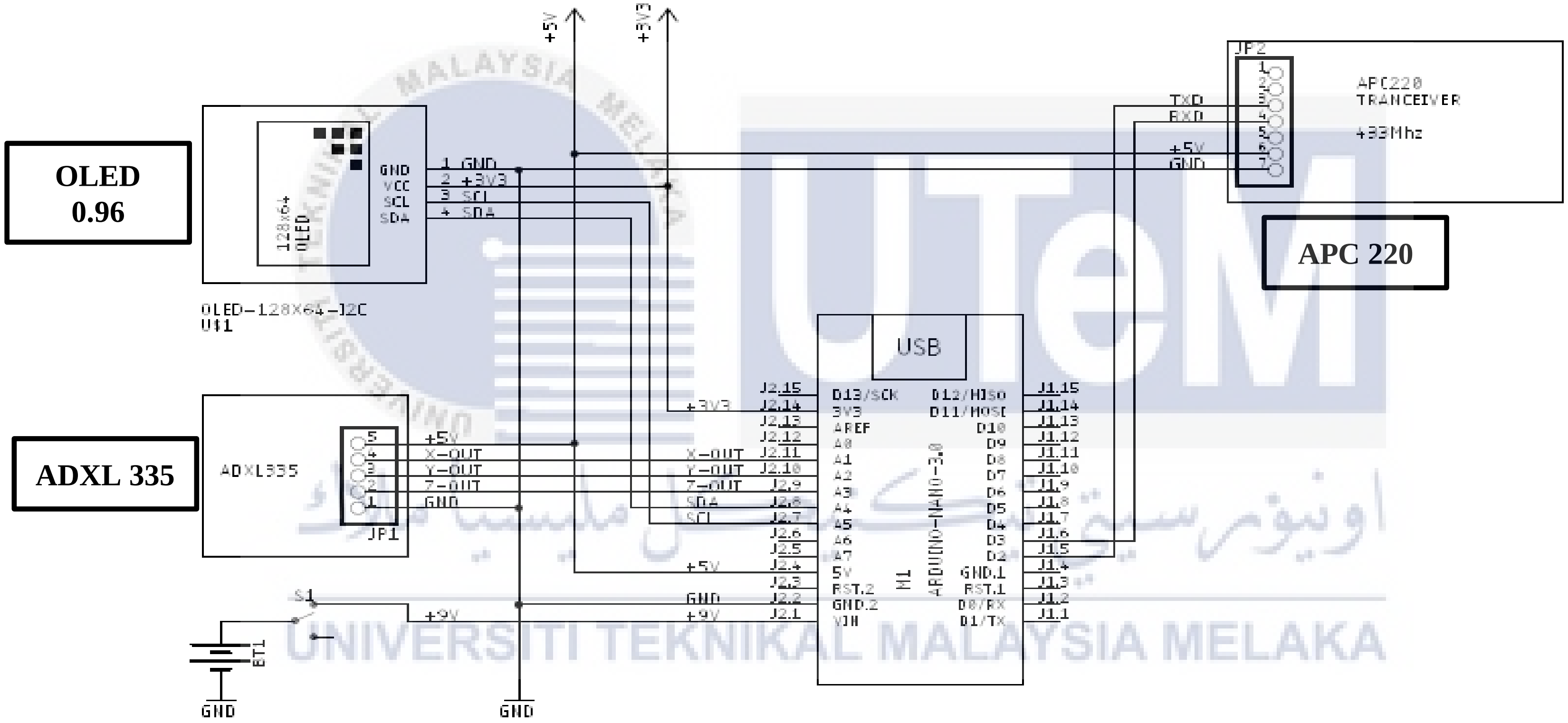


Figure 3.15 Schematic diagram

The development of hand orientation measurement for a hand muscle and motor rehabilitation device, the Arduino Nano act as a controller to for building the digital device and interactive object that can sense. Moreover, the ADXL 335 is used to detect the orientation angle by the value of acceleration 3-axis in g units, x-axis is stand for pitch position and the y-axis stand for roll position. In the ADXL 335 have 5 pins which is voltage source, x-out, y-out, z-out and ground. Besides that, for all the pins have an initial reference value which is x-out is 1.67v, y-out is 1.62, z-out is 1.65 and the analog to digital converter digital reference value is 5.09. Furthermore, OLED 0.96 is act as a data presentation the data of time, pitch angle and roll angle will be presented in the OLED 0.96. The main source to operate the device is the direct current which is battery with the 9volts and also there have one on/off button to normally open and normally closed the device. In this project have two parts which is transmitter and receiver. Transmitter part the APC220 is used to transmit the data to the receiver and the RF receiver will receive the following data and visualize in the PC.

3.10 Coding and function of IDE Arduino

The integration of Arduino done using interface with the sensory part which is ADXL 335, to calculate the angle of rotation there have define the ADC reference value, from the data sheet finalize the sensiticity level,there following table mentioned that the steps and the function of coding.

Table 3.7 Coding and functions

Coding	Function
`#define ADC_ref 5.09` `#define zero_x 1.67` `#define zero_y 1.62` `#define zero_z 1.65`	Analog to Digital Converter Reference voltage X-axis Zero reference voltage y-axis Zero reference voltage z-axis Zero reference voltage
`#define sensitivity_x 0.3` `#define sensitivity_y 0.3` `#define sensitivity_z 0.3`	Typical 300mV/g, max 330mV/g Decide the sensitivity value by the data sheet ADXL335, finalize with the value of 300mV/g for the device requirements
`#define x_input   A1` `#define y_input   A2` `#define z_input   A3`	Accelerometer axis input pins
`valueADC_x = analogRead(x_input);` `valueADC_y = analogRead(y_input);`	Read accelerometer output voltages, the acceleration value read in g units

valueADC_z = analogRead(z_input)	
xv = (valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;	Acceleration in g units, the 1024 is comes from the 10 bits value 2 power of 10bits.
angle_x = atan2(-yv, -zv) * 57.2957795 + 180;	Convert to angles, 57.29 is radians to degree convert and add 180 degree offset, the 57.29 value comes from 180 divided by pi. Y-axis define as roll position and X-axis define as pitch position.
delay(300);	Represent to milliseconds, the program will wait until moving on next coding step for the mentioned milliseconds.

3.11 Summary of methodology

Hand motion using the accelerometer for hand orientation measure is divided into two different parts, such as transmitter and receiver. In the receiver part the APX 220, as mentioned in the methodology the accelerometer gives the data to analog signal the algorithm will convert the analog to digital signal. In this project the Arduino Uno act as controller, in that algorithm there is some mathematical formula attachment to calculate the angle of roll and pitch, the roll position is the x- axis and the y-axis is pitch position, the acceleration value will be in g unit. Moreover, from the x (acce), y(acce) and z(acce) in g unit will be carried to calculate the angle of the roll and pitch from the angle is converted to radian to angles by adding the 180 degree offset. After the angle is calculated, the APPC 220 which is wireless transmitter will send the value to receiver where the data is collected by the termite software. The OLED 0.96 act as data presentation, the angle of the pitch and roll angle will appear on the screen together with time duration.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

In this chapter of this report, the results and discussion of the project will be discussed. Moreover, attached are the objective of experiment, steps, the complete sampling data and the graph. The results include the established collected data from the hand orientation using the accelerometer, the analysis data and graph after the moving average process and infinite impulse response (IIR), the analysis about the sensitivity changes, and patient movement data and graph.

4.2 Hand orientation measured data by ADXL335

In this project, ADXL 335 is used as a sensory device to measure the angle of analog input, in the direction of 3-axis which is x, y and z. It used for measure the angles, the interface with the Arduino Nano. Furthermore, in this project there is an initializer that pitch is x-axis and roll is y-axis, for roll movement the value will calculate using the arctan argument by the formula

```
angle_y = atan2(-xv, -zv) * 57.2957795 + 180;

angle_x = atan2(-yv, -zv) * 57.2957795 + 180;
```

The controller will receive the angle measurement and produce the output to the transmitter APC220. After the data received by the PC there is another software application called as termite, an application that converts data to excel format.

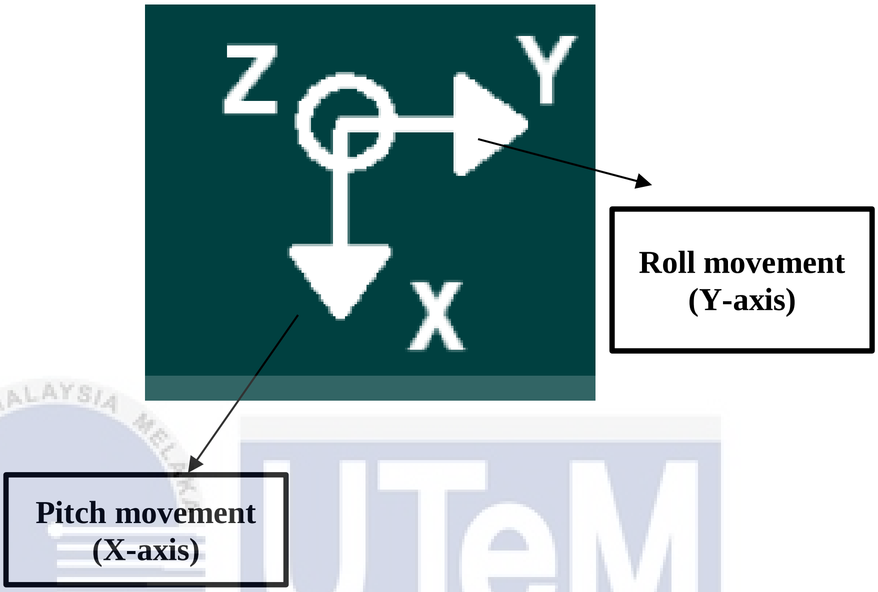
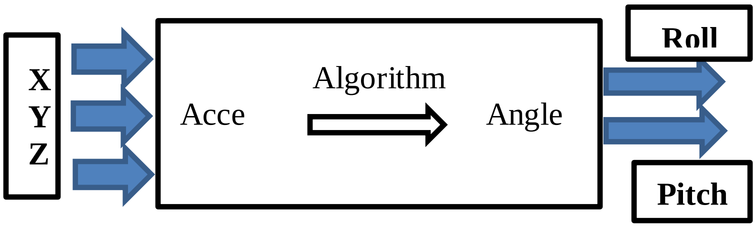


Figure 4.1 Accelerometer ADXL 335 Axis orientations

4.3 Objective of hand orientation measured data by ADXL335

1. To measure the performance in terms of hand orientation
2. Collect the pitch and roll angle data for 10 sampling angle and present the data in graph.
3. To capture the real hand motion for in 1 sec on duration.

4.3.1 Steps



1. Accelerometer measure the acceleration in unit of the (g), it is give a 3-axis value measurement from the ADXL 335 motion.
2. The value of 3-axis will be given by the analog digital, microcontroller convert those value to digital value by using the signal conditioning of analog to digital.
3. Before calculate the roll and pitch three axis must convert 10-bit ADC value into g unit
4. Read accelerometer output voltages

```
valueADC_x = analogRead(x_input);
valueADC_y = analogRead(y_input);
valueADC_z = analogRead(z_input);
```

5. Acceleration in g units

```
xv = (valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;
yv = (valueADC_y / 1024.0 * ADC_ref - zero_y) / sensitivity_y;
zv = (valueADC_z / 1024.0 * ADC_ref - zero_z) / sensitivity_z;
```

6. Calculate the angle

Roll

```
angle_y = atan2(-xv, -zv) * 57.2957795 + 180;
```

Pitch

```
angle_x = atan2(-yv, -zv) * 57.2957795 + 180;
```

Yaw angle does not appear because there is no accurate orientation angle for yaw. We could use a gyro sensor to get the Yaw, however this project limitation is roll and pitch angles only. The 180-degree addition process is used to make the degree in the range of 0 degree to 360 degrees.

```
angle_z = atan2(-yv, -xv) * 57.2957795 + 180;
```

7. APC 220 will transmit the data through the termite, it will convert the data files to Microsoft excel.

4.3.2 Collected data

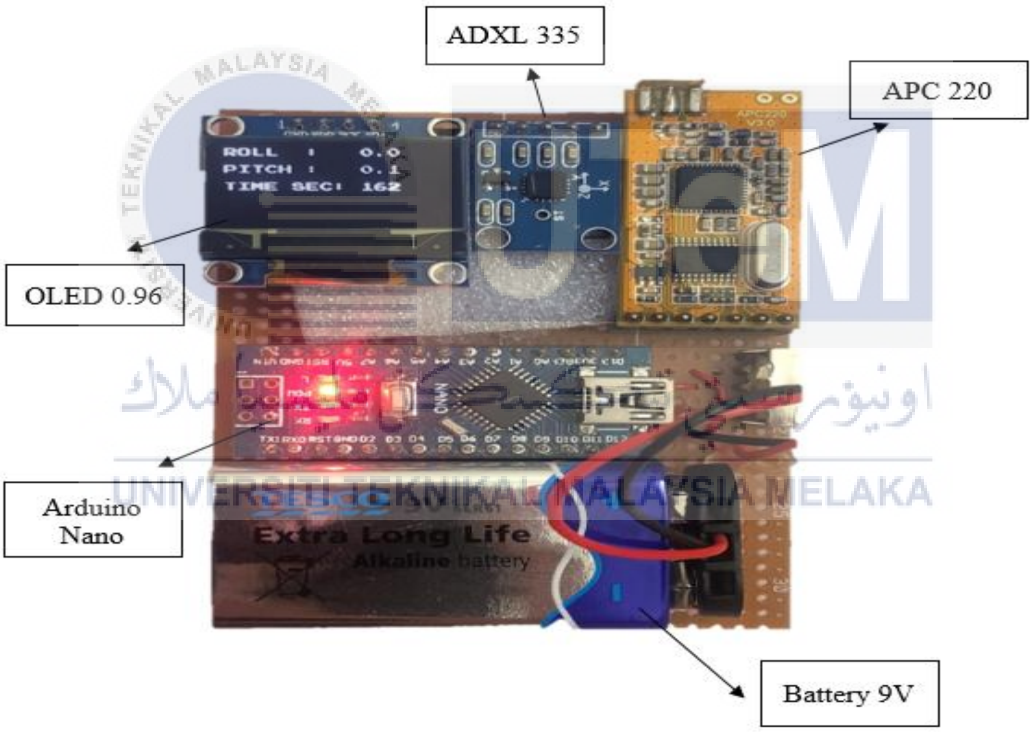


Figure 4.2 Constant position

4.3.2.1 Horizontal Rest Position

The collected data of the x (acceleration), y (acceleration), z (acceleration), time(sec), roll and pitch, the all data taken while there is no movement in the accelerometer.

Table 4.1 Measured data of constant orientation

X (acceleration), g	Y (acceleration), g	Z (acceleration), g	Time (sec)	Roll (Degree)	Pitch (Degree)
0	0	1.01	0	0	0.1
0	0	1.01	1	0	0.1
0	0	1.01	2	0	0.1
0	0	1.01	3	0	0.1
0	0	1.01	4	0	0.1
0	0	1.01	5	0	0.1
0	0	1.01	6	0	0.1
0	0	1	7	0	0.1
0	0	1.01	8	0	0.1
0	0	1.01	9	0	0.1
0	0	1.01	10	0	0.1
0	0	1.01	11	0	0.1
0	0	1.01	12	0	0.1

Table 4.1 shows the collected output data if there is no movement in the ADXL 335 the data will show as 0 degree of angle for roll movement and 0.1 degree for pitch movement at the same time the device can estimates the accelerometer values in a particular direction from gravity and the movement of the accelerometer. For this situation ADXL335 is a 3 axis of accelerometer. On Earth, accelerometer when put on a flat surface level will measure 1g as the table shown in the column of z (acceleration).

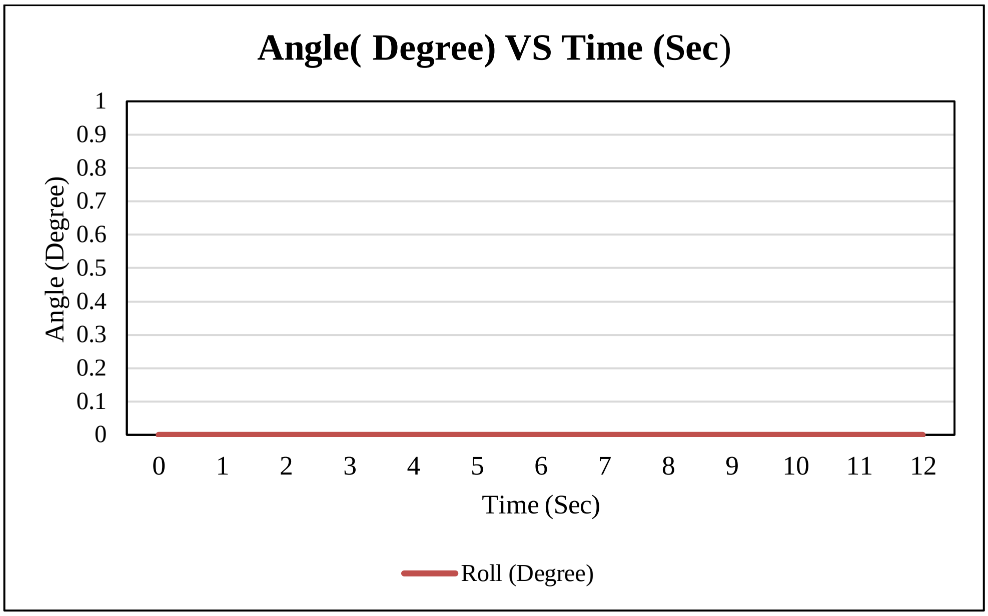


Figure 4.3 : Angle of Roll (degree) vs Time (sec)

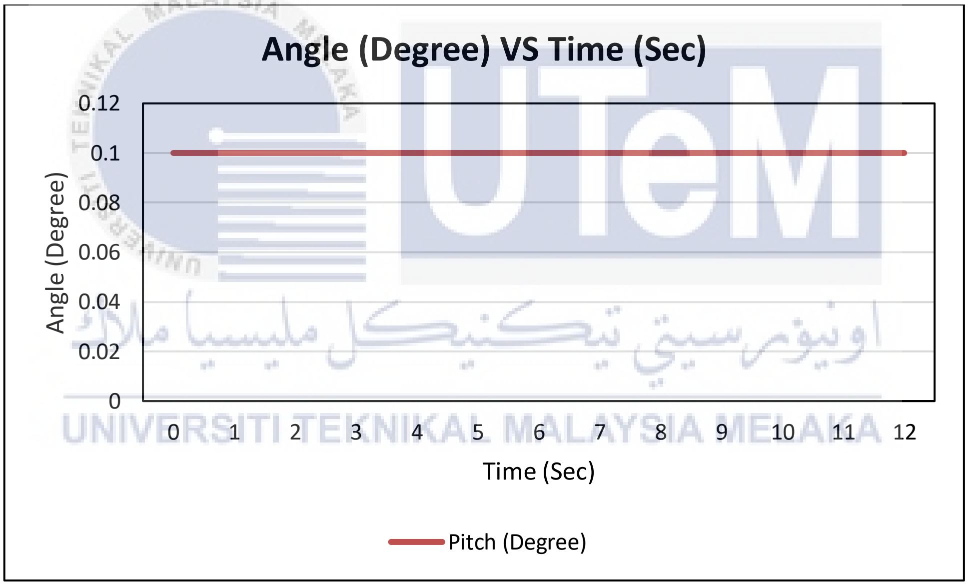


Figure 4.4 Angle of Pitch (degree) vs Time (sec)

Figure 4.3 and Figure 4.4 show the data from the 12 sample of time. The data collected while the ADXL 335 is due to the rest position. The sensor is considered in steady state on the horizontal rest position, so there is no angle calculate. This data collected to ensure there is no error detect while the accelerometer is in the horizontal rest position.

4.3.2.2 Analysis on the maximum collected data hand movement toward roll position

The results from the roll movement analysis carried during this project will be tabulated and shown in graph. The analysis focused on the capturing real-time hand motion that could make move 10 data in per seconds. Moreover, in real application, 1 data/sec is might too slow for hand movement, from this analysis can know the real-time to capture hand movements. The following collected data from the hand movement towards the roll axis, there are 100 sampling data collected from the anti-clockwise direction.

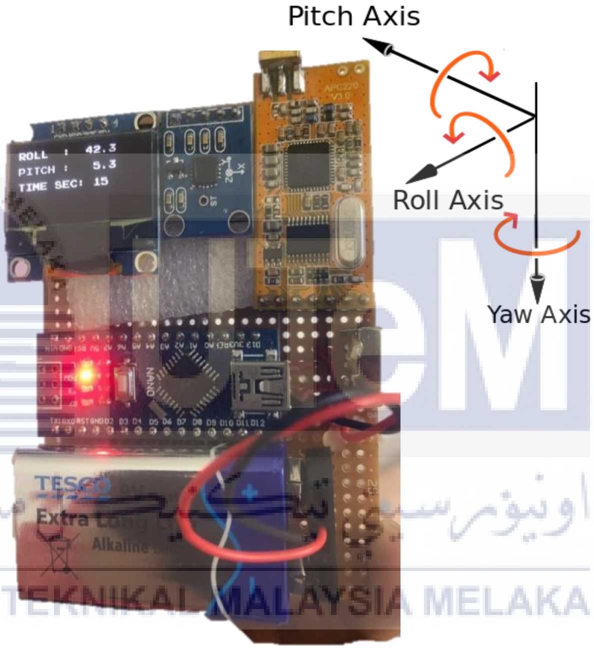


Figure 4.5 Rotation along to roll position

Appendices B (Table 5.2) shows the 100 sampling data of 10 second. There is 5 type of data included in this table such as, The x (acceleration), y (acceleration), z (acceleration), Roll(degree) and Pitch(degree). The data are collected by following the steps described in section 4.3.1. The x (acceleration), y (acceleration), z (acceleration), are calculated using the formula;

```
xv = (valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;
yv = (valueADC_y / 1024.0 * ADC_ref - zero_y) / sensitivity_y;
zv = (valueADC_z / 1024.0 * ADC_ref - zero_z) / sensitivity_z;
```

This hand orientation measurement designed to calculate the performance of real time for that there is data collected 10 data in per second to analysis the accuracy, performance and the speed of receiving data.

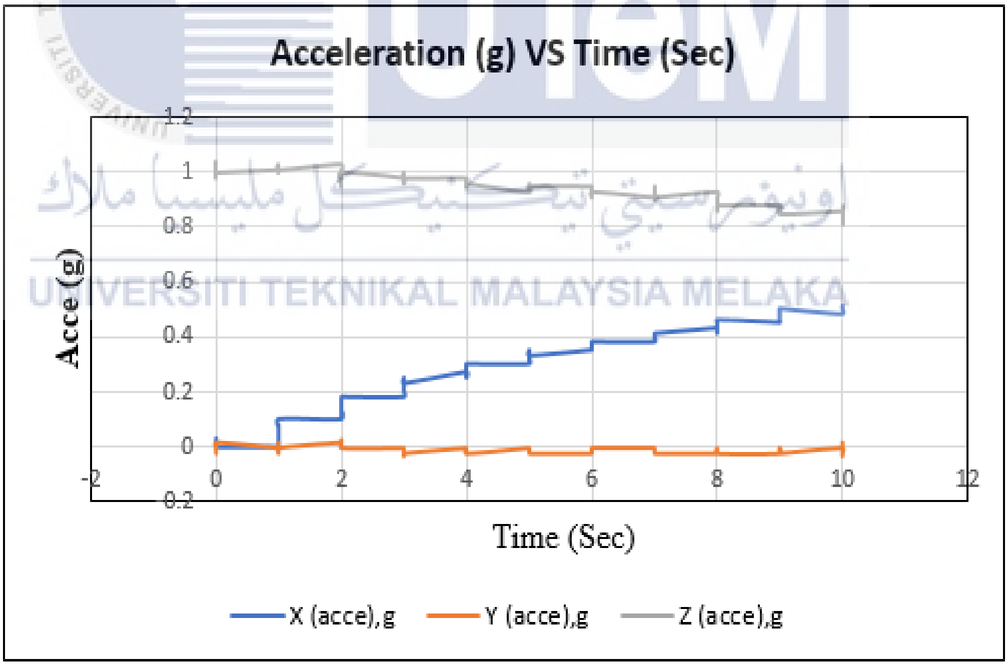


Figure 4.6 Roll movement of Acceleration(g) vs Time (sec)

Figure 4.6 shows the roll movement of Acceleration(g) vs Time (sec), the x (acceleration), y (acceleration), z (acceleration), are detect while the accelerometer detects any motion movement. The three acceleration value calculate by the formula;

```
xv = (valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;

yv = (valueADC_y / 1024.0 * ADC_ref - zero_y) / sensitivity_y;

zv = (valueADC_z / 1024.0 * ADC_ref - zero_z) / sensitivity_z;
```

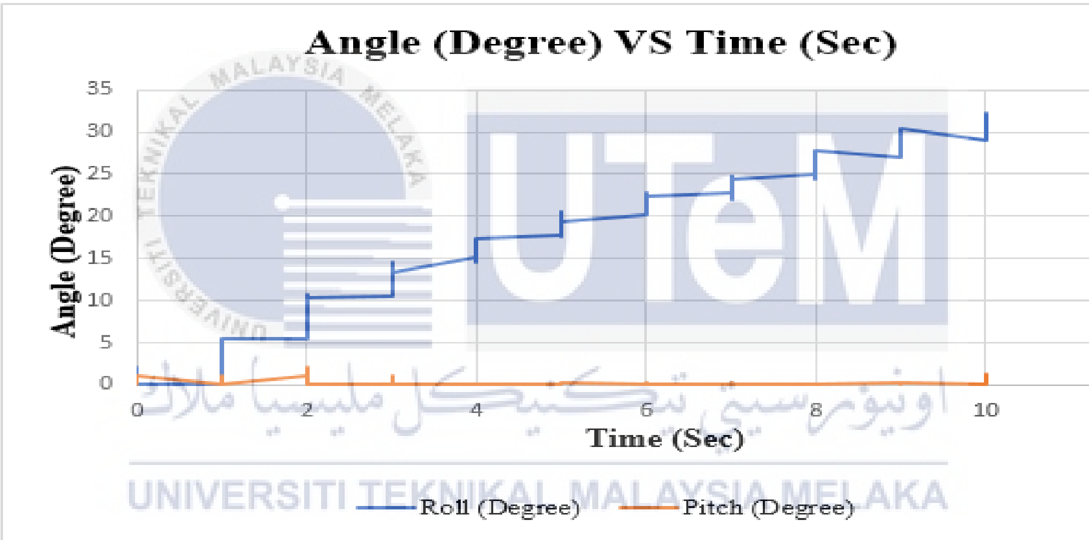


Figure 4.7 Roll movement of Angle (Degree) vs Time (sec)

Figure 4.7 shows angle (degree) versus time (sec), for anti-clockwise hand movement of anti-clockwise the data are from 1.8 degree to 32.3 degree with 10 angles in per seconds. The graph includes all the 100 datas, in the one time sec the data collected 10 data as shown in the graph.

4.3.2.3 Analysis on the maximum collected data by hand movement toward Pitch movement

The results from the pitch movement analysis carried during this project will be tabulated and shown in graph. The analysis focused on the capturing real-time hand motion that could make move 10 data per seconds. Moreover, in real application, 1 data/sec is too slow for hand movement, from this analysis can know the real-time to capture hand movements. The following data collected from the hand movement toward the x-axis.

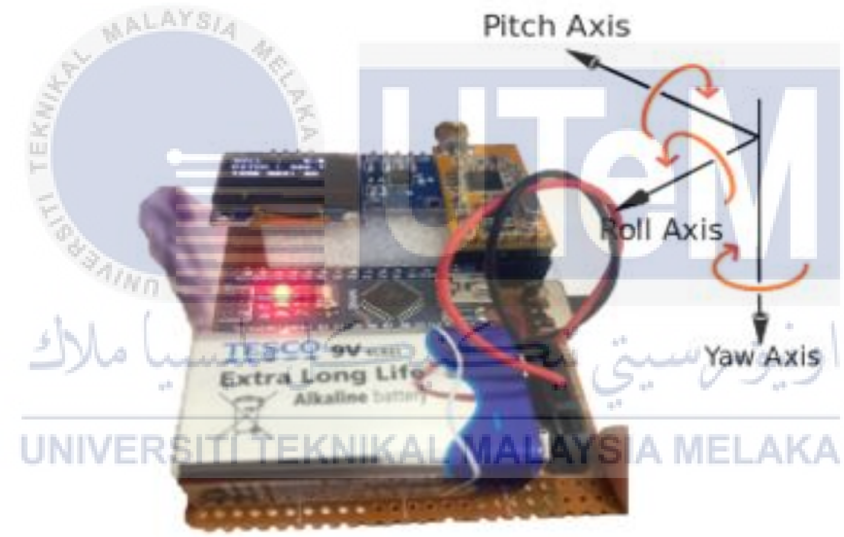


Figure 4.8 Rotation along Pitch position

Appendices B, (Table 5.3) shows the 100 sampling data of 10 second. There is 5 type of data included in this table such as, x (acceleration), y (acceleration), z (acceleration), Time(sec), Roll(degree) and Pitch(degree). As mentioned in the 4.3.1 the all data collected by the following steps. The x (acceleration), y (acceleration), z (acceleration), all calculate the angle for pitch using the formula;

```
xv = (valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;
yv = (valueADC_y / 1024.0 * ADC_ref - zero_y) / sensitivity_y;
zv = (valueADC_z / 1024.0 * ADC_ref - zero_z) / sensitivity_z;
```

This hand orientation measurement is designed to calculate the performance of real time for that there is data collected 10 data in per second to analysis the accuracy, performance and the speed of receiving data. Moreover, the angle calculation occurs from the formula

```
angle_x = atan2(-yv, -zv) * 57.2957795 + 180
```

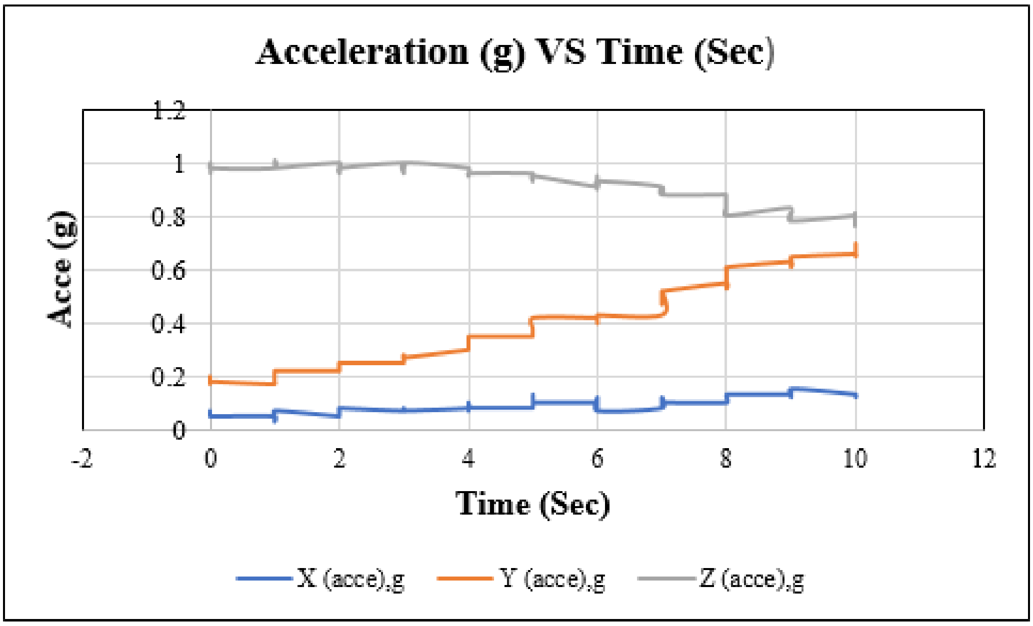


Figure 4.9 Pitch movement of Acceleration(g) vs Time (sec)

Figure 4.9 shown the pitch movement acceleration versus time graph the data collected Acceleration(g) vs Time (sec), the x (acceleration), y (acceleration), z (acceleration), are detect while the accelerometer detects any motion movement. The three acceleration value calculate by the formula;

```
xv = (valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;
yv = (valueADC_y / 1024.0 * ADC_ref - zero_y) / sensitivity_y;
zv = (valueADC_z / 1024.0 * ADC_ref - zero_z) / sensitivity_z;
```

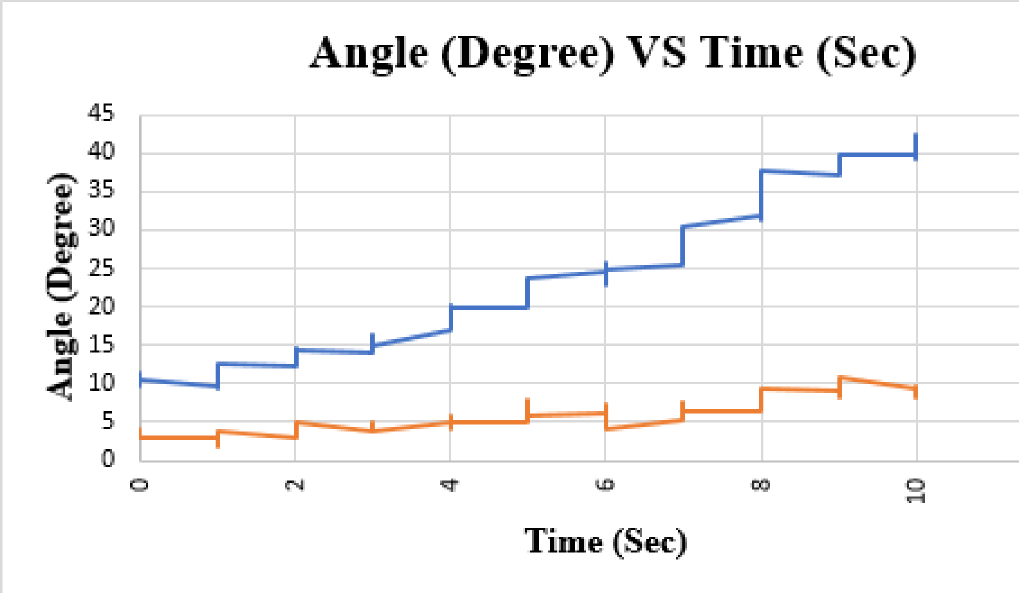


Figure 4.10 Pitch movement of Angle (Degree) vs Time (Sec)

The Figure 4.10 shows angle(degree) versus time(sec) graph, the data collected with the hand movement backward of pitch axis. I took the data from 11.2 degree to 42.4 degree, 10 angles in per seconds. The graph has include all 100 datas, in one time sec the data collected 10 data as shows in the above graph.

4.3.2.4 Summary of analysis maximum collected data

The aim of the analysis is fulfilled by collecting 10 data within 1 sec duration, it shows the system can capture the real time performance of hand motion. Moreover, to achieve the objective of this analysis, there are several steps as mentioned in the section of 4.2.2, at the same time there are two types of sampling data for roll and pitch from the collected data, shown in Figure 4.7 to Figure 4.10.

4.3.2.5 Discussion on analysis of maximum collected data

There have a lot of challenges that gone through while complete the analysis, first is the collecting data, to collect the 10 data in 1 sec that is really very challenging because for collecting data, should noticed about the real capture by hand motion at the same time the accuracy of outputs. Besides that, to collect the highest sampling data in the algorithm attached delay process must be reduced. Furthermore, to collect the 10 sampling data in 1 sec duration the delay that used is delay (40), that is maximum that can reduce but to ensure that to increase the sampling data by reducing the delay process, it still can reduce to delay (30), but it is less possible get the real capturing hand motion because some error occur example lack of output data sending, the OLED not presented and values.

Other than that, according to the data sheet for sensitivity value is typical 300mV/g and the maximum 330mV/g. For this project the value, typical 300mV/g is used. In the articles of the ADXL 335 the sensitivity level of the accelerometer is very high. There are some errors, such as when there is hand motion toward the pitch position, there is some roll value also appeared. It is because of the vibration of hand motion and causes high sensitivity level as a Figure 4.11 shown. The capacity of the APC 220 as a data sheet mentioned that, in one second the transmitter cannot send more than 10 data in trials.

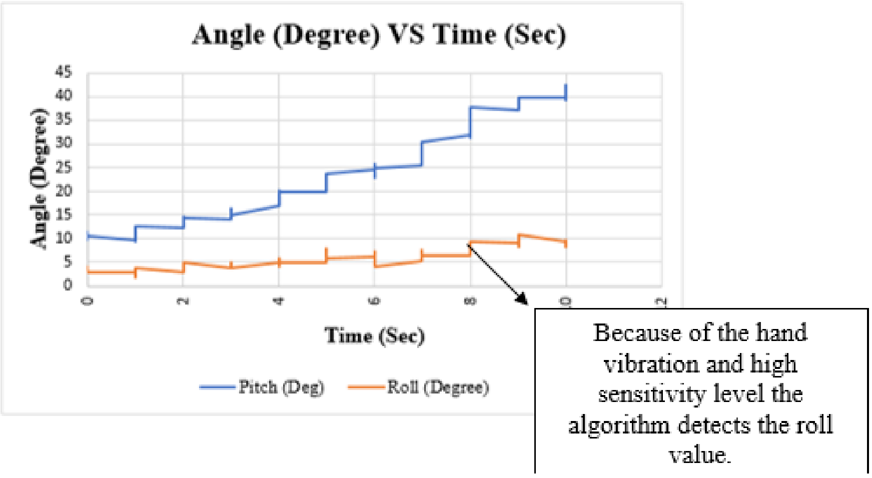


Figure 4.11 Errors while collecting data for each position

4.4 Analysis on the filtering process

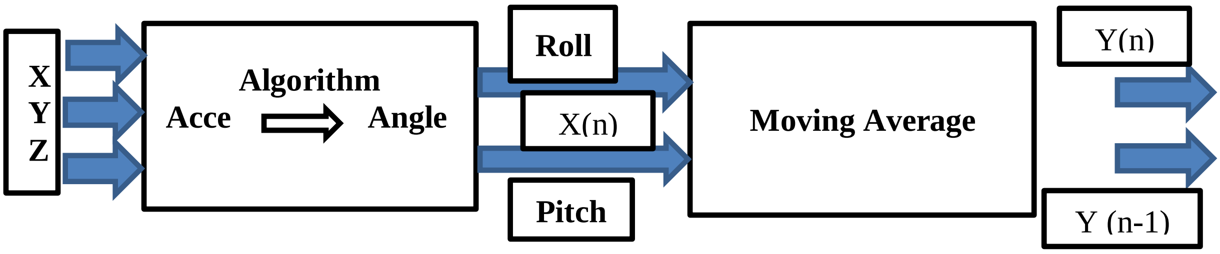
Signal conditioning is the control of a sign in a manner that sets it up for the following phase of preparing. application include environmental estimation. Process signal to make it suitable for the next operation. Besides that, for this analysis there will be 2 type of digital filter analysis test such as moving average and IIR (Infinite Impulse Response). This analysis helps the system to remove or eliminated the unwanted digital noise. The data for this analysis will be collected from the hand movement of pitch and roll but for the data are 0 degree to 360-degree range. The main aim for this analysis is to figure out the suitability and effective filtering process to remove the unwanted digital noise. The data collected from the transmitter to the receiver and to the Microsoft excel, the analysis of filter will be calculated using the excel platform.

4.4.1 Objective filtering process

1. To remove or eliminating the unwanted signal.
2. To analysis the performance of the filters in collecting data.

4.4.2 Steps

4.4.2.1 Moving average filter



1. Accelerometer measured the acceleration in unit of the (g), it is give a 3-axis value measurement from the ADXL 335 motion.
2. The value of 3-axis will give by the analog digital, microcontroller convert those value to digital value by using the signal conditioning of analog to digital.
3. Before calculate the roll and pitch three axis must convert 10-bit ADC value into g unit
4. Read accelerometer output voltages


```
valueADC_x = analogRead(x_input);
valueADC_y = analogRead(y_input);
valueADC_z = analogRead(z_input);
```

5. Acceleration in g units

```
xv = (valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;
yv = (valueADC_y / 1024.0 * ADC_ref - zero_y) / sensitivity_y;
zv = (valueADC_z / 1024.0 * ADC_ref - zero_z) / sensitivity_z;
```

6. Calculate the angle

   Roll

```
angle_y = atan2(-xv, -zv) * 57.2957795 + 180;
```

Pitch

```
angle_x = atan2(-yv, -zv) * 57.2957795 + 180;
```

Yaw it is not will be appear because there is not get any accurate orientation angle for yaw, must use the gyro sensor to get the Yaw, at the same time this project limitation is roll and pitch only. The 180-degree addition process to make the degree in the range of 0 degree to 360 degrees.

```
angle_z = atan2(-yv, -xv) * 57.2957795 + 180;
```

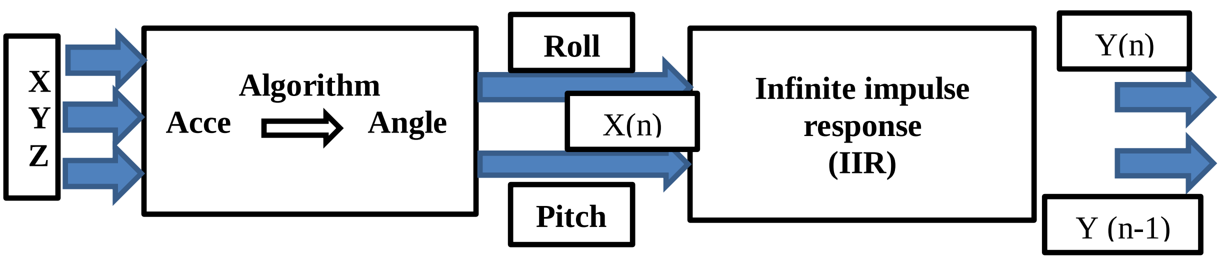
7. Collecting sampling data of 1 data in 1 sec duration, the data taken from 0 degree to 360 degrees for both hand motions.

8. APC 220 will transmit the data through the termite, it will convert the data files to Microsoft excel, from the excel analysis about the filtering process.

9. $Moving\ Average = \frac{A1+A2+A3+\cdots}{N}$, this the formula that used to calculate the moving average and produce graph.

N = sampling date; for the number of average data there will be 3.

4.4.2.2 Infinite impulse response



1. Accelerometer measured the acceleration in unit of the (g), it is give a 3-axis value measurement from the ADXL 335 motion.

2. The value of 3-axis will give by the analog digital, microcontroller convert those value to digital value by using the signal conditioning of analog to digital.
3. Before calculate the roll and pitch three axis must convert 10-bit ADC value into g unit
4. Read accelerometer output voltages

```
valueADC_x = analogRead(x_input);
valueADC_y = analogRead(y_input);
valueADC_z = analogRead(z_input);
```

5. Acceleration in g units

```
xv = (valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;
yv = (valueADC_y / 1024.0 * ADC_ref - zero_y) / sensitivity_y;
zv = (valueADC_z / 1024.0 * ADC_ref - zero_z) / sensitivity_z;
```

6. Calculate the angle

Roll

```
angle_y = atan2(-xv, -zv) * 57.2957795 + 180;
```

Pitch

```
angle_x = atan2(-yv, -zv) * 57.2957795 + 180;
```

Yaw it is not will be appear because there is not get any accurate orientation angle for yaw, must use the gyro sensor to get the Yaw, at the same time this project limitation is roll and pitch only. The 180-degree addition process to make the degree in the range of 0 degree to 360 degrees.

```
angle_z = atan2(-yv, -xv) * 57.2957795 + 180;
```

7. Collecting sampling data of 1 data in 1 sec duration, the data taken from 0 degree to 360 degrees for both hand motions.

8. APC 220 will transmit the data through the termite, it will convert the data files to Microsoft excel, from the excel analysis about the filtering process.

9. Use the formula $y(n) = k * x(n) + (1 - k) * y(n - 1)$ to calculate the infinite impulse response and produce graph, where

   $Y(n)$ = output signal

   k= filtering effect

   x(n)=input signal

   y(n-1)= output signal previous sample

4.4.2.3 Measured data of roll position

Calculation to analyze data points by creating a series of averages of different subsets of the full data set. A moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles. It can be viewed as an example of a low-pass filter used in signal processing.

Table 4.2 Measured data of roll movement

X **(acce),g**	**Y (acce),g**	**Z (acce),g**	**Time (Sec)**	**Roll (Degree)**	**Pitch (Degree)**
0	0.1	0.96	0	4.9	0
0.05	0.1	0.98	1	2	5.9
0	0.1	1	2	2.9	5.8
0.25	0.07	0.93	4	15	4.2
0.45	0.08	0.86	5	27.4	5.6
0.58	0.08	0.76	6	37.3	6.3
0.8	0.12	0.65	7	50.9	10.3
0.85	0.15	0.5	8	59.5	16.8
0.35	0.1	0.9	9	21.3	6.4
0.33	0.05	0.95	10	19.3	3.1
0.15	0.03	1.01	11	8.4	2
0.05	0.03	1.01	12	2.8	2
-0.21	0.1	1.01	13	348	5.7
-0.23	0.12	0.98	14	346.7	6.8
-0.36	0.08	0.96	15	339.3	5
-0.41	0.12	0.91	16	335.6	7.3
-0.56	0.1	0.88	17	327.4	6.5
-0.6	0.08	0.85	18	324.8	5.7
-0.63	0.12	0.86	19	323.9	7.8
-0.68	0.13	0.78	20	319	9.8
-0.73	0.12	0.73	21	315.1	9.1
-0.43	0.05	0.91	22	334.7	3.2
-0.3	0.05	0.98	23	343.1	3
-0.17	0.03	1	24	350.6	2
0.05	0.03	1	25	2.9	2
0.3	0.03	0.95	26	17.5	2.1
0.4	0.02	0.9	27	24	1.2
0.55	0.03	0.8	28	34.5	2.5
0.71	0.08	0.68	29	46.3	7.1
0.73	0.08	0.7	30	46.3	6.9

The Table 4.2 Measured data of roll movement, the data collected for 1 data in per seconds, with 30 sampling data rate.

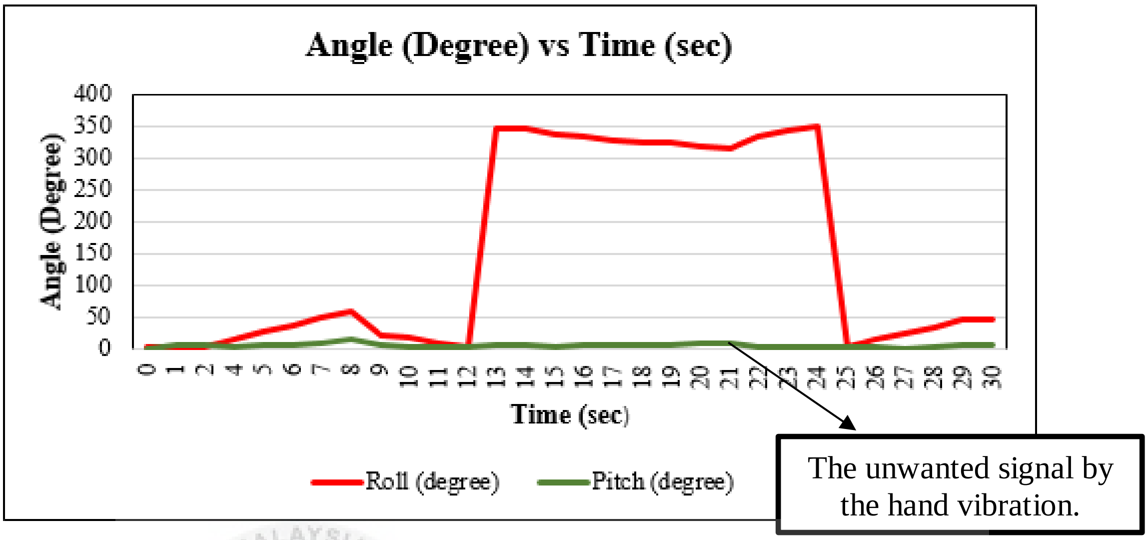


Figure 4.12 Roll movement Angle (degree) vs Time (sec)

Figure 4.12 shows the data of roll position movement in clockwise and anti-clockwise for y-axis ADXL335 accelerometer direction. The red line shows the roll position data and the green line shows he unwanted signal. The above graph shows before the filter process occurs. The x-axis graph shows the angle (degree) of roll position movement and the y-axis shows the time duration. There has include 30 data the angles between 0 degree to 360 degrees.

4.4.2.4 Measure data for roll position after moving average filter

The moving average is used to reducing the unwanted random signal, the moving average help to make the have slightly better performance and eliminating the unwanted signals. The unwanted signal is when move the hand to roll position by our hand vibration the algorithm calculate the pitch angle also, but it is slightly very low in value.

Table 4.3 Measured data roll position after moving average

Time (sec)	Roll (degree)	Pitch (degree)	Moving Average (Roll)	Moving Average (Pitch)
0	4.9	0	0	0
1	2	5.9	0	0
2	2.9	5.8	3.3	3.9
4	15	4.2	6.6	5.3
5	27.4	5.6	15.1	5.2
6	37.3	6.3	26.6	5.4
7	50.9	10.3	38.5	7.4
8	59.5	16.8	49.2	11.1
9	21.3	6.4	43.9	11.2
10	19.3	3.1	33.4	8.8
11	8.4	2	16.3	3.8
12	2.8	2	10.2	2.4
13	348	5.7	119.7	3.2
14	346.7	6.8	232.5	4.8
15	339.3	5	344.7	5.8
16	335.6	7.3	340.5	6.4
17	327.4	6.5	334.1	6.3
18	324.8	5.7	329.3	6.5
19	323.9	7.8	325.4	6.7
20	319	9.8	322.6	7.8
21	315.1	9.1	319.3	8.9
22	334.7	3.2	322.9	7.4
23	343.1	3	331.0	5.1
24	350.6	2	342.8	2.7
25	2.9	2	232.2	2.3
26	17.5	2.1	123.7	2.0
27	24	1.2	14.8	1.8
28	34.5	2.5	25.3	1.9
29	46.3	7.1	34.9	3.6
30	46.3	6.9	42.4	5.5

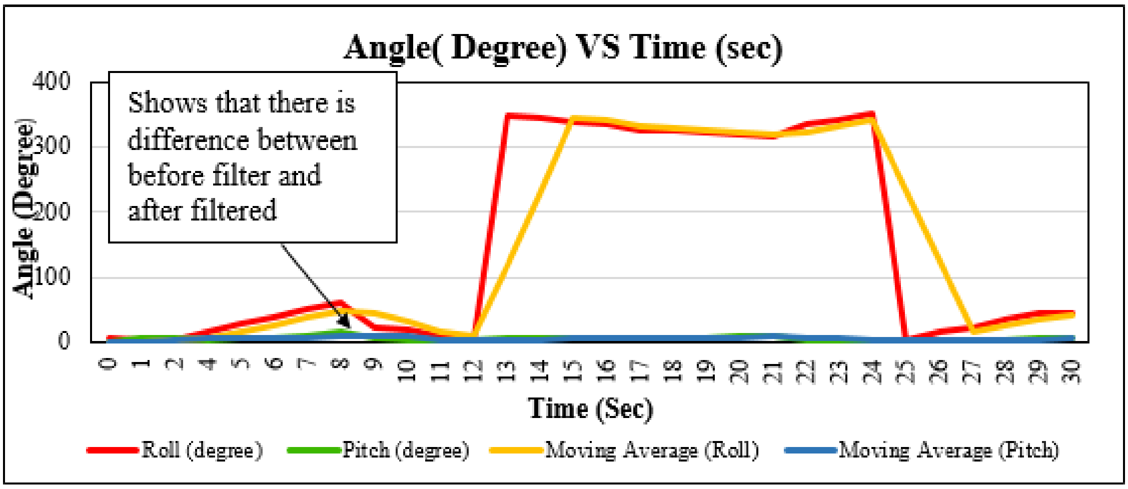


Figure 4.13 Roll movement of angle(degree) vs Time (sec) after moving average filtered

Figure 4.13 shows 4 different data, which is the Roll(degree), Pitch (degree) before the filter, and moving average(roll), moving average(pitch) after the filter processing occur, by the graph we can see there are some signal reducing, as labelled at the graph labeled that there is roll position movement before the filter and after the filter process occur the line changes to smooth line.

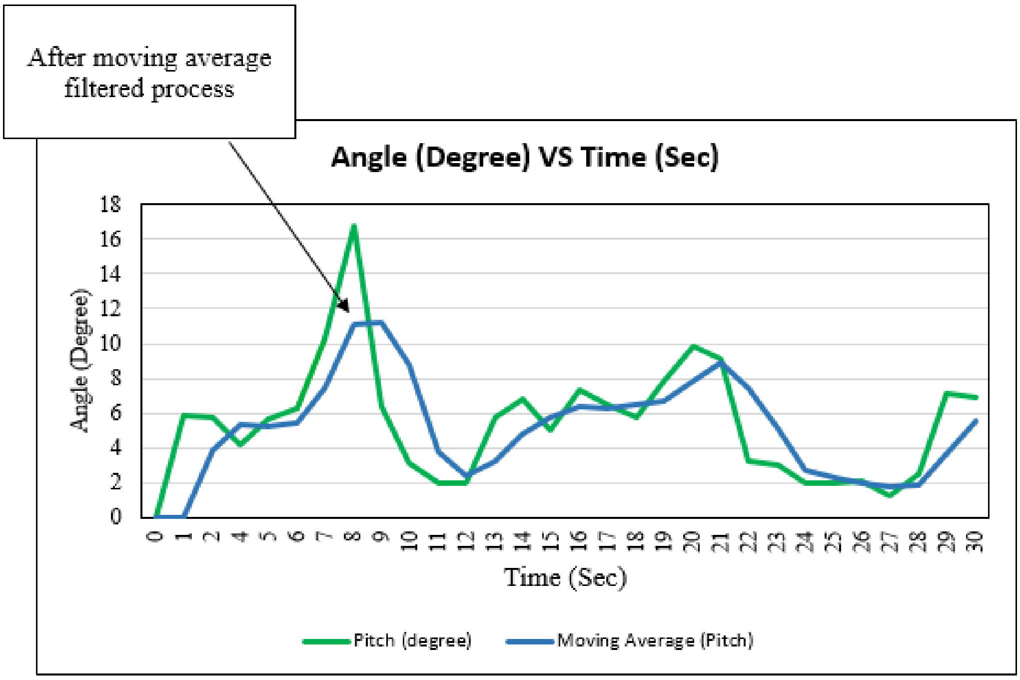


Figure 4.14 Angle (Degree) vs Time (Sec) unwanted signal moving average filtered data

Figure 4.14 is the zoom view of the Figure 4.13 moving average filtered shows the unwanted signal filter process in the collected data of roll position movement. The unwanted signal act in this analysis is the pitch angle when there is roll hand movement in the algorithm which calculates the roll degree only instead of hand vibration and high sensitivity the pitch angle also detected. Moreover, the aim of the analysis is to eliminate or reducing the unwanted signal moving average filter process. As labeled on that Figure 4.14 above that there is the difference between the before filtered and after filtered.

4.4.2.5 Measured data for pitch movement

The collecting data 1 data per second duration for this analysis, in algorithm there have some change that make the delay to 1000, to take a data every second one data only. Besides that, collected data by the hand movement of x-axis of the ADXL335 accelerometer.

Table 4.4 Measured data of pitch movement

X (acce),g	Y (acce),g	Z (acce),g	Time (Sec)	Roll (Degree)	Pitch (Degree)
0	0.07	1.01	0	0	358.2
0	0.07	1.03	1	0	356.2
0	-0.13	1.01	2	0	352.6
0	-0.18	1	3	0	349.7
-0.02	-0.35	0.95	4	1.2	339.9
0.02	-0.4	0.93	5	1.1	336.9
0	-0.63	0.78	6	0	321.1
-0.02	-0.48	0.95	7	2	333.1
-0.05	-0.3	1.08	8	2	344.6
0	-0.18	1.09	9	0	350.6
0	-0.03	0.98	10	0	358.1
0.07	0.02	1	11	3.8	1
0.05	0.05	1	12	2.9	2.9
0.05	0.07	1	13	2.9	3.9
0.07	0.12	0.98	14	3.9	6.8
0.08	0.18	0.96	15	5	10.8
0.1	0.23	1	16	5.7	13.2
0.13	0.37	0.95	17	8	21.2
0.1	0.45	0.91	18	6.3	26.2
0.08	0.53	0.88	19	5.4	31.2
0.12	0.55	0.85	20	7.8	32.9
0.15	0.61	0.81	21	10.4	37.1
0.13	0.33	0.96	22	7.9	19.1
0.12	0.48	0.88	23	7.5	28.7
0.08	0.18	0.98	24	4.9	10.6
0.08	0	1	25	4.8	0.1
0.07	-0.06	1.01	26	3.8	356.3
0.05	-0.1	1	27	2.9	354.4
0.05	-0.16	1	28	2.9	350.6
0.05	-0.2	1	29	2.9	348.8
0.05	-0.1	1	30	2.9	357.9

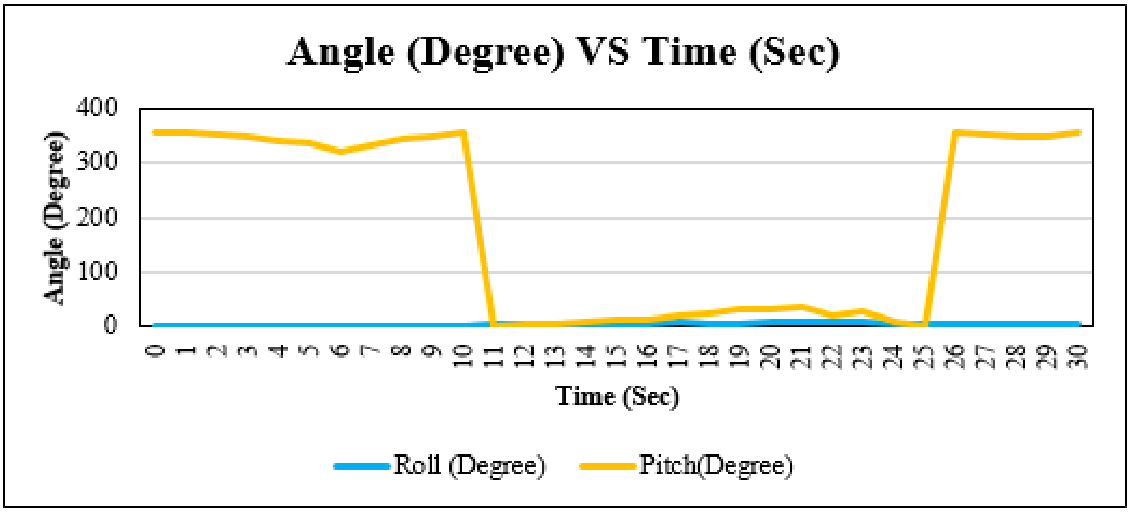


Figure 4.15 Pitch movement Angle (degree) vs Time (sec)

The Figure 4.15 shows the collecting data of pitch movement by the forward and backward in x-axis of the hand motion. The above graph shows before the filter process occurs. The y-axis graph shows the angle(degree) of pitch movement and the x-axis shows the time duration. There has include 30 data with the angle between 0 degree to 360 degrees.

4.4.2.6 Measured filter for pitch position after moving average filter

The moving average use to reducing the unwanted random signal, the moving average help to make the have slightly better performance and eliminating the unwanted signals. The unwanted signal is when movement of the hand to pitch position by our hand vibration the algorithm calculates the roll angle also, but it is slightly very low in value.

Table 4.5 Measured data of moving average filter process

Time (Sec)	Pitch(Degree)	Roll (Degree)	Moving Average (Pitch)	Moving Average (Roll)
0	358.2	0	358.2	0
1	356.2	0	356.2	0
2	352.6	0	355.7	0
3	349.7	0	352.8	0.4
4	339.9	1.2	347.4	0.8
5	336.9	1.1	342.2	0.8
6	321.1	0	332.6	1.0
7	333.1	2	330.4	1.3
8	344.6	2	332.9	1.3
9	350.6	0	342.8	0.7
10	358.1	0	351.1	1.3
11	1	3.8	236.6	2.2
12	2.9	2.9	120.7	3.2
13	3.9	2.9	2.6	3.2
14	6.8	3.9	4.5	3.9
15	10.8	5	7.2	4.9
16	13.2	5.7	10.3	6.2
17	21.2	8	15.1	6.7
18	26.2	6.3	20.2	6.6
19	31.2	5.4	26.2	6.5
20	32.9	7.8	30.1	7.9
21	37.1	10.4	33.7	8.7
22	19.1	7.9	29.7	8.6
23	28.7	7.5	28.3	6.8
24	10.6	4.9	19.5	5.7
25	0.1	4.8	13.1	4.5
26	356.3	3.8	122.3	3.8
27	354.4	2.9	236.9	3.2
28	350.6	2.9	353.8	2.9
29	348.8	2.9	351.3	2.9
30	357.9	2.9	352.4	2.9

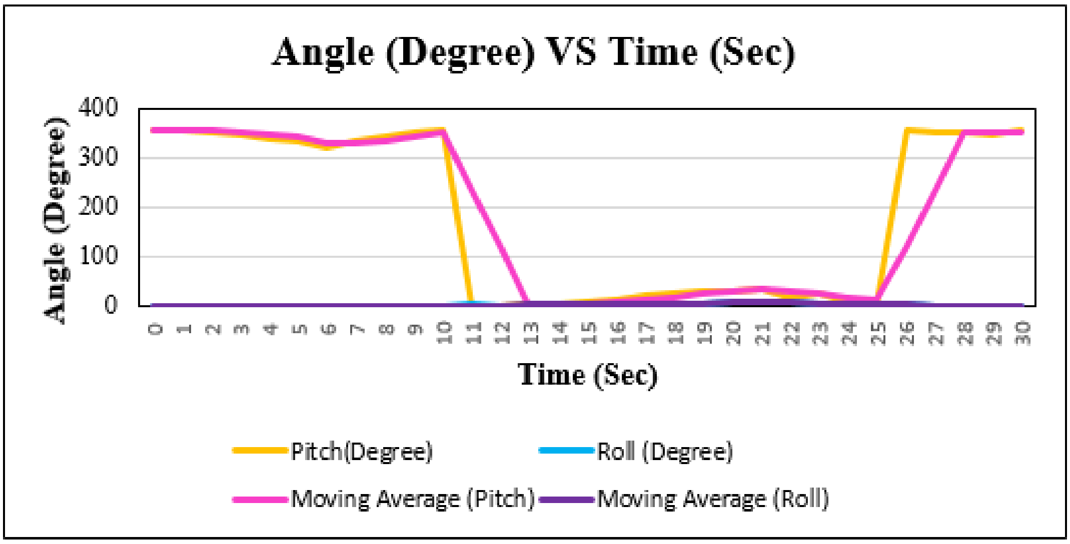


Figure 4.16 Pitch movement of angle(degree) vs Time (sec)
after moving average filtered

The graph shows 4 different data, which is the Pitch(degree), Roll (degree) before the filter process occur, and moving average(pitch), moving average(roll) after the filter processing occur, by the graph we can see there have some signal detection is happened, after the filter process occur the line is change to smooth line.

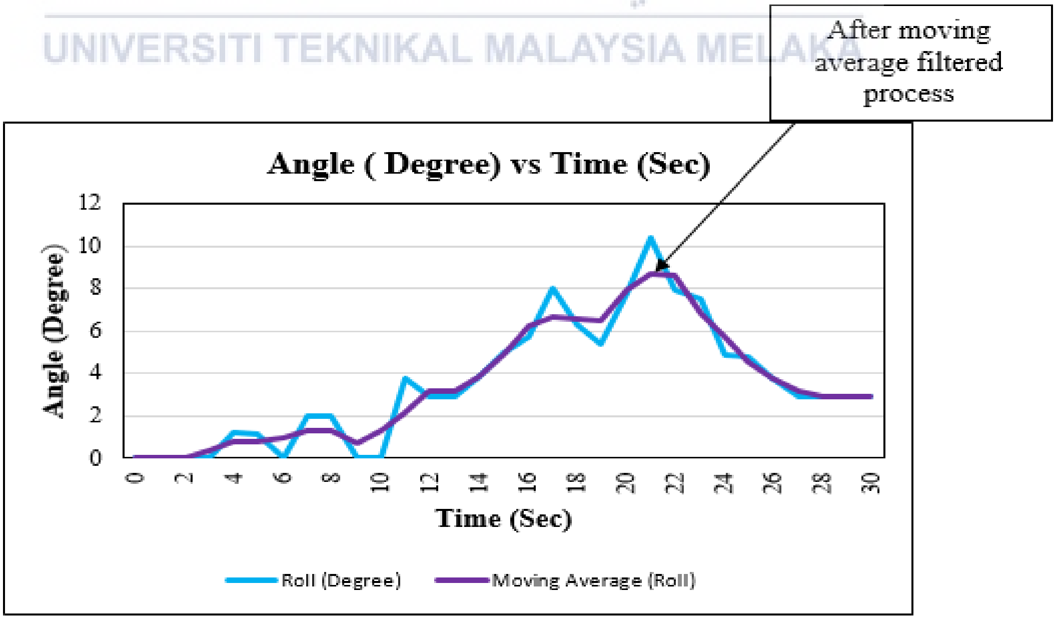


Figure 4.17 Angle (Degree) vs Time (Sec) unwanted signal moving
average filtered data

Figure 4.17 is the zoom view of the Figure 4.16 the unwanted signal filter process in the collected data of pitch position movement. The unwanted signal act in this analysis is the roll angle when there is pitch hand movement happen the algorithm calculate pitch degree only but with the hand vibration and high sensitivity the pitch angle signal also included. Moreover, the aim of the analysis is to eliminate or reducing the unwanted signal moving average filter process. As labeled on that graph above that is the difference between the before filtered and after filtered.

4.4.2.7 Infinite impulse response (IIR) for roll position

Infinite impulse response (IIR) is a property applying to many linear time-invariant systems In order to reduce the noise on the accelerometer sensor signal. For this purpose, decided to use a 1st order IIR (Infinite Impulse Response) filter, because it is easy to implement and run on a microcontroller the IIR filter in the Microsoft excel by using formula. IIR (Infinite Impulse Filter) is a numeric filter in which the value of the output depends not only on the values of the input, at sample time "n" and previous samples, but also on the status of the output at previous sampling times. The ‘k’ stands for filter effect by using the three different values the analysis the graph produce. The infinite impulse response filter is a numeric filter which is there is not the output value, it is depends on the input signal values at the sampling time.

Table 4.6 Measured data of roll position by infinite impulse response filter process k=0.5

Time (sec)	Roll (degree)	Pitch (degree)	IIR Filter k=0.5 (Roll)	IIR Filter k=0.5 (Pitch)
0	4.9	0	0	0
1	2	5.9	1	3.0
2	2.9	5.8	2.0	4.4
4	15	4.2	8.5	4.3
5	27.4	5.6	17.9	4.9
6	37.3	6.3	27.6	5.6
7	50.9	10.3	39.3	8.0
8	59.5	16.8	49.4	12.4
9	21.3	6.4	35.3	9.4
10	19.3	3.1	27.3	6.2
11	8.4	2	17.9	4.1
12	2.8	2	10.3	3.1
13	348	5.7	179.2	4.4
14	346.7	6.8	262.9	5.6
15	339.3	5	301.1	5.3
16	335.6	7.3	318.4	6.3
17	327.4	6.5	322.9	6.4
18	324.8	5.7	323.8	6.0
19	323.9	7.8	323.9	6.9
20	319	9.8	321.4	8.4
21	315.1	9.1	318.3	8.7
22	334.7	3.2	326.5	6.0
23	343.1	3	334.8	4.5
24	350.6	2	342.7	3.2
25	2.9	2	172.8	2.6
26	17.5	2.1	95.1	2.4
27	24	1.2	59.6	1.8
28	34.5	2.5	47.0	2.1
29	46.3	7.1	46.7	4.6
30	46.3	6.9	46.5	5.8

Table 4.6 shows the data collected by using the infinite impulse response filter. The mathematical formula to be implemented for a first order IIR filter is as shown below. y (n) is the filtered signal (output signal), while x(n) and y(n-1) are the input signal, and the output signal at previous sample, respectively of 30 sampling time in 30 sec duration time. The k=0.5 filter effect value used for collecting the data.

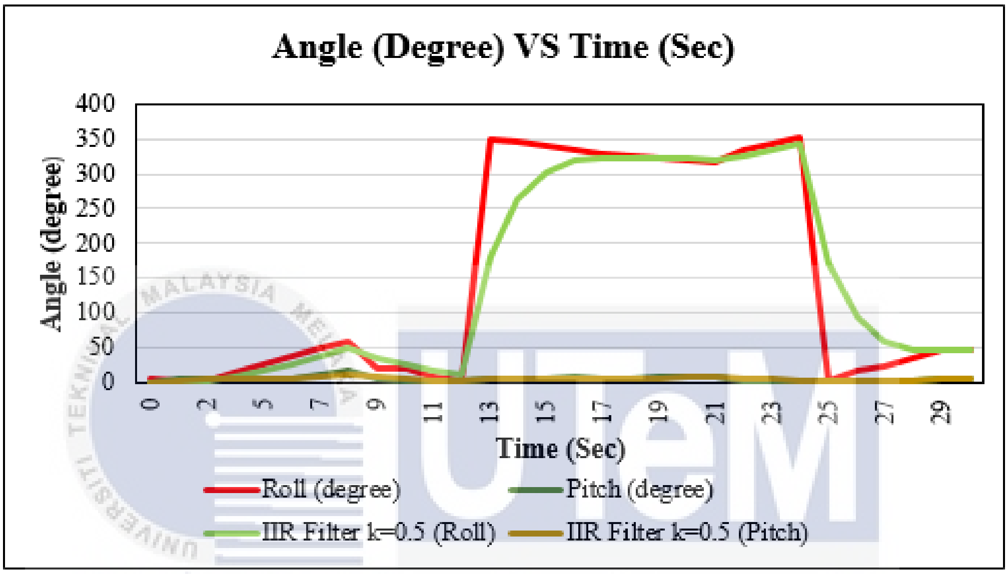


Figure 4.18 Angle (Degree) vs Time (Sec) the unwanted signal of data IIR filter k=0.5

Figure 4.18 shows the output signal after using the infinite impulse response mathematical formula in the excel, the x-axis is representing to the time (sec) and the y-axis is representing as angle in degree.

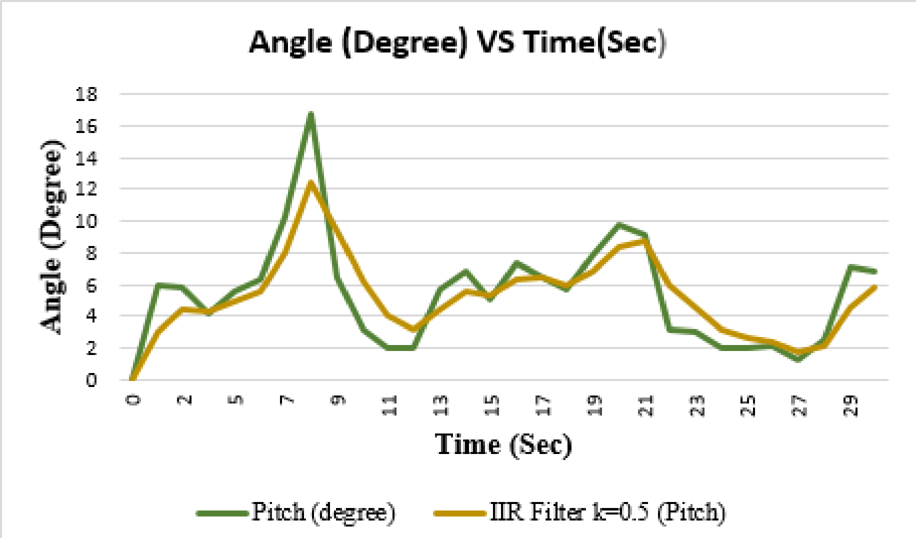


Figure 4.19 Angle (Degree) vs Time (Sec) the unwanted signal of data IIR filtered k=0.5

Figure 4.19 shows the zoom view of Figure 4.18 unwanted output signal which is when there is roll movement by the hand vibration the sensor detects the angle and produce the value. In the graph above show if the effect of k = 0.5 the reducing of the unwanted signal.

Table 4.7 Measured data of infinite impulse response filter process k=0.2

Time (sec)	Roll (degree)	Pitch (degree)	IIR Filter k=0.2 (Roll)	IIR Filter k=0.2 (Pitch)
0	4.9	0	0	0
1	2	5.9	0.4	1.2
2	2.9	5.8	0.9	2.1
4	15	4.2	3.7	2.5
5	27.4	5.6	8.5	3.1
6	37.3	6.3	14.2	3.8
7	50.9	10.3	21.6	5.1
8	59.5	16.8	29.1	7.4
9	21.3	6.4	27.6	7.2
10	19.3	3.1	25.9	6.4
11	8.4	2	22.4	5.5
12	2.8	2	18.5	4.8
13	348	5.7	84.4	5.0
14	346.7	6.8	136.9	5.4
15	339.3	5	177.3	5.3
16	335.6	7.3	209.0	5.7
17	327.4	6.5	232.7	5.8
18	324.8	5.7	251.1	5.8
19	323.9	7.8	265.7	6.2
20	319	9.8	276.3	6.9
21	315.1	9.1	284.1	7.4
22	334.7	3.2	294.2	6.5
23	343.1	3	304.0	5.8
24	350.6	2	313.3	5.1
25	2.9	2	251.2	4.4
26	17.5	2.1	204.5	4.0
27	24	1.2	168.4	3.4
28	34.5	2.5	141.6	3.2
29	46.3	7.1	122.5	4.0
30	46.3	6.9	107.3	4.6

Table 4.7 Measured data of infinite impulse response filter process k=0.2 above show the data collected by using the infinite impulse response (IIR) filter. The mathematical formula must include in the excel to get the data, for this analysis there is 30 sampling time in 30 sec duration time. The k=0.2 filter effect value used for collecting the data.

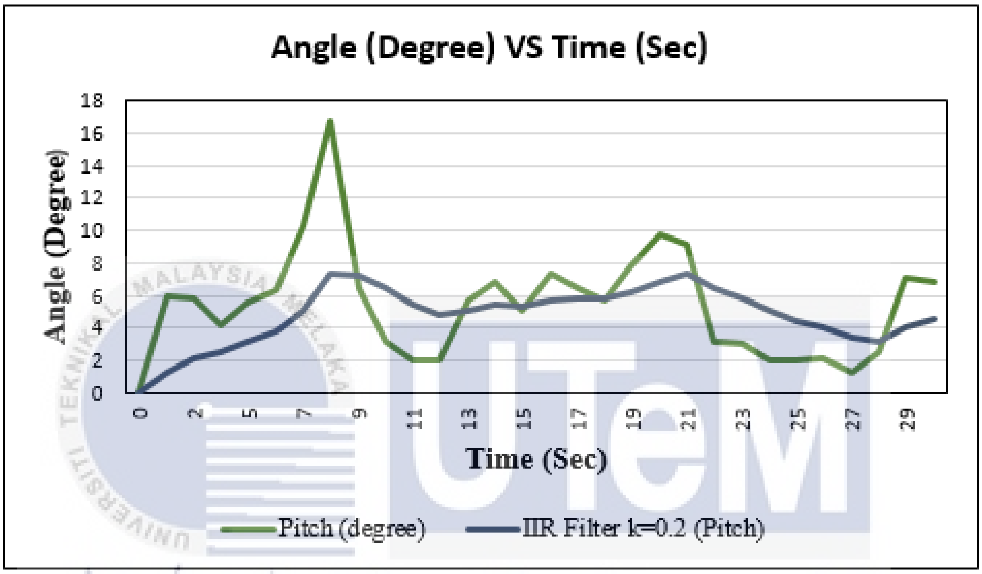


Figure 4.20 Angle (Degree) vs Time (Sec) the unwanted signal of data IIR filtered k=0.2

Figure 4.20 shows the effect of k = 0.2 the reducing of the unwanted signal. High "k" means a small filtering effect. The input signal is less filtered. The limit condition is $k=1$. In such condition, only the input signal is used, and the output old signal does not have any effect.

Table 4.8 Measured data of infinite impulse response filter process k=0.1

Time (sec)	Roll (degree)	Pitch (degree)	IIR Filter k= 0.1 (Roll)	IIR Filter k= 0.1 (Pitch)
0	4.9	0	0	0
1	2	5.9	0.2	0.6
2	2.9	5.8	0.5	1.1
4	15	4.2	1.9	1.4
5	27.4	5.6	4.5	1.8
6	37.3	6.3	7.8	2.3
7	50.9	10.3	12.1	3.1
8	59.5	16.8	16.8	4.5
9	21.3	6.4	17.3	4.7
10	19.3	3.1	17.5	4.5
11	8.4	2	16.6	4.2
12	2.8	2	15.2	4.0
13	348	5.7	48.5	4.2
14	346.7	6.8	78.3	4.5
15	339.3	5	104.4	4.5
16	335.6	7.3	127.5	4.8
17	327.4	6.5	147.5	5.0
18	324.8	5.7	165.2	5.0
19	323.9	7.8	181.1	5.3
20	319	9.8	194.9	5.8
21	315.1	9.1	206.9	6.1
22	334.7	3.2	219.7	5.8
23	343.1	3	232.0	5.5
24	350.6	2	243.9	5.2
25	2.9	2	219.8	4.9
26	17.5	2.1	199.6	4.6
27	24	1.2	182.0	4.2
28	34.5	2.5	167.3	4.1
29	46.3	7.1	155.2	4.4
30	46.3	6.9	144.3	4.6

Table 4.8 show the data collected by using the infinite impulse response filter. The mathematical formula must include in the excel to get the data, for this analysis there is 30 sampling time in 30 sec duration time. The k=0.1 filter effect value used for collecting the data.

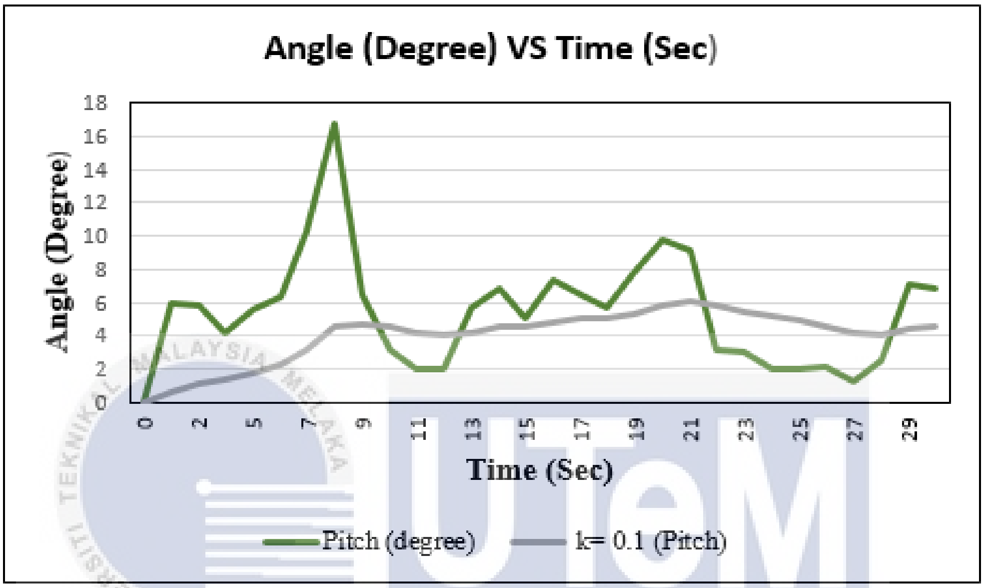


Figure 4.21 Angle (Degree) vs Time (Sec) the unwanted signal of data IIR filtered k=0.1

Figure 4.21 shows if the effect of k = 0.1 the reducing of the unwanted signal, Low "k" means high filtering effect. The input signal is filtered more and more depending on how you reduce "k". This is due to the fact that, reducing the value of "k", you reduce the influence of the input signal sampled at present time

4.4.2.8 Infinite impulse response (IIR) for pitch position

In order to eliminate the unwanted signal on the accelerometer sensor signal, the IIR filter is easy to implement in the Microsoft excel by using formula. The k stands a filter effect by using the three different values in the analysis of graph produced. The infinite impulse response filter is a numeric filter in which there is not the output value, it depends on the input signal values at the sampling time. The high k value means there will be very small signal reduced. As the k value is decreasing, the reducing of the signal will be high filtering effect. If the k=0 in that conditions, there do not have any changes with the input signals that means there is no any filtering effect occurs.

Table 4.9 Measured data of pitch position by infinite impulse response filter process k=0.5

Time (Sec)	Pitch(Degree)	Roll (Degree)	IIR filtered k=0.5 (Pitch)	IIR filtered k=0.5 (Roll)
0	358.2	0	0	0
1	356.2	0	178.1	0.0
2	352.6	0	265.4	0.0
3	349.7	0	307.5	0.0
4	339.9	1.2	323.7	0.6
5	336.9	1.1	330.3	0.9
6	321.1	0	325.7	0.4
7	333.1	2	329.4	1.2
8	344.6	2	337.0	1.6
9	350.6	0	343.8	0.8
10	358.1	0	351.0	0.4
11	1	3.8	176.0	2.1
12	2.9	2.9	89.4	2.5
13	3.9	2.9	46.7	2.7
14	6.8	3.9	26.7	3.3
15	10.8	5	18.8	4.2
16	13.2	5.7	16.0	4.9
17	21.2	8	18.6	6.5
18	26.2	6.3	22.4	6.4
19	31.2	5.4	26.8	5.9
20	32.9	7.8	29.8	6.8
21	37.1	10.4	33.5	8.6
22	19.1	7.9	26.3	8.3
23	28.7	7.5	27.5	7.9
24	10.6	4.9	19.0	6.4
25	0.1	4.8	9.6	5.6
26	356.3	3.8	182.9	4.7
27	354.4	2.9	268.7	3.8
28	350.6	2.9	309.6	3.3
29	348.8	2.9	329.2	3.1
30	357.9	2.9	343.6	3.0

The table above show the data collected by using the infinite impulse response filter. The mathematical formula must include in the excel to get the data, for this analysis there is 30 sampling time in 30 sec duration time. The k=0.5 filter effect value used for collecting the data.

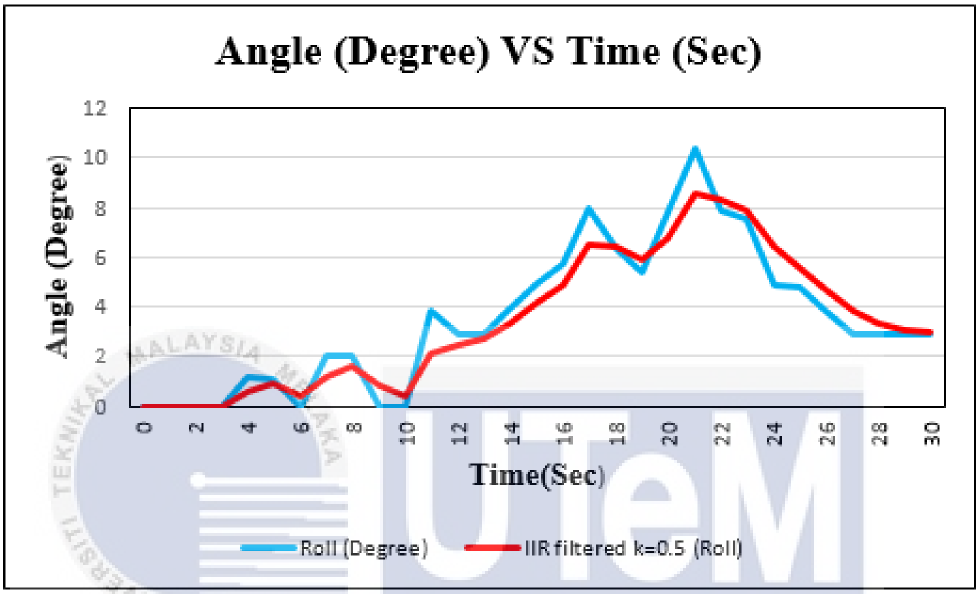


Figure 4.22 Angle (Degree) vs Time (Sec) the unwanted signal of data IIR filtered k=0.5

The graph shows the unwanted output signal which is when there is pitch movement by the hand vibration the sensor detects the angle and produce the value. In the graph above show if the effect of k = 0.5 the reducing of the unwanted signal.

Table 4.10 Measured data of pitch position by infinite impulse response filter process k=0.5

Time (Sec)	Pitch(Degree)	Roll (Degree)	IIR filtered k=0.2 (Pitch)	IIR filtered k=0.2 (Roll)
0	358.2	0	0	0
1	356.2	0	71.2	0.0
2	352.6	0	127.5	0.0
3	349.7	0	171.9	0.0
4	339.9	1.2	205.5	0.2
5	336.9	1.1	231.8	0.4
6	321.1	0	249.7	0.3
7	333.1	2	266.4	0.7
8	344.6	2	282.0	0.9
9	350.6	0	295.7	0.7
10	358.1	0	308.2	0.6
11	1	3.8	246.8	1.2
12	2.9	2.9	198.0	1.6
13	3.9	2.9	159.2	1.8
14	6.8	3.9	128.7	2.2
15	10.8	5	105.1	2.8
16	13.2	5.7	86.7	3.4
17	21.2	8	73.6	4.3
18	26.2	6.3	64.1	4.7
19	31.2	5.4	57.6	4.8
20	32.9	7.8	52.6	5.4
21	37.1	10.4	49.5	6.4
22	19.1	7.9	43.4	6.7
23	28.7	7.5	40.5	6.9
24	10.6	4.9	34.5	6.5
25	0.1	4.8	27.6	6.1
26	356.3	3.8	93.4	5.7
27	354.4	2.9	145.6	5.1
28	350.6	2.9	186.6	4.7
29	348.8	2.9	219.0	4.3
30	357.9	2.9	246.8	4.0

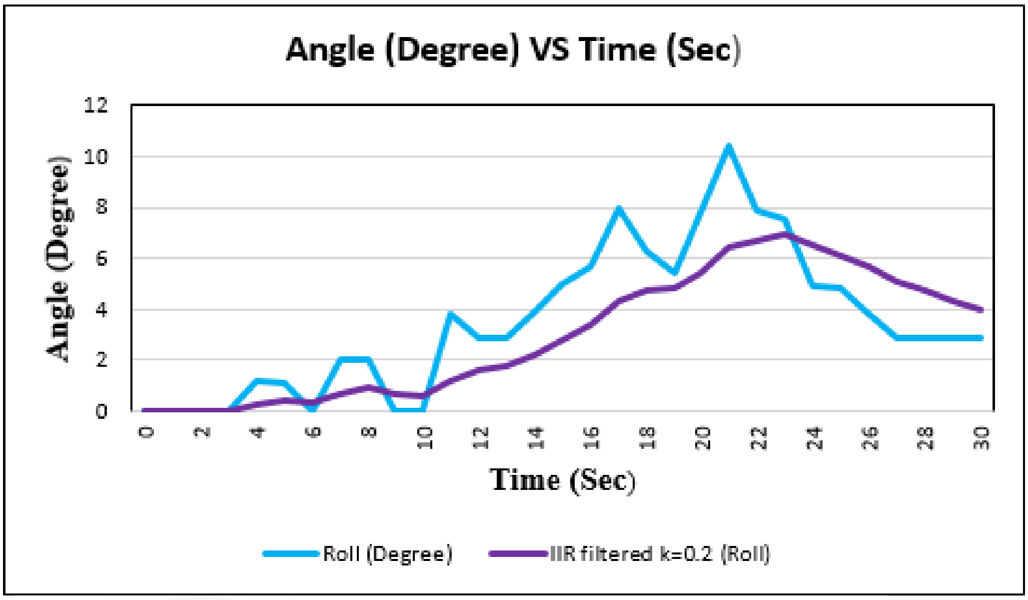


Figure 4.23 Angle (Degree) vs Time (Sec) the unwanted signal of data IIR filtered k=0.2

The graph shows the effect of k=0.2, the reducing of unwanted roll angle.

Table 4.11 Measured data of pitch position by infinite impulse response filter process k=0.1

Time (Sec)	Pitch(Degree)	Roll (Degree)	IIR filtered K=0.1 (Pitch)	IIR filtered K=0.1 (Roll)
0	358.2	0	0	0
1	356.2	0	35.6	0.9
2	352.6	0	67.3	0.9
3	349.7	0	95.6	0.9
4	339.9	1.2	120.0	1.0
5	336.9	1.1	141.7	1.0
6	321.1	0	159.6	0.9
7	333.1	2	177.0	1.1
8	344.6	2	193.7	1.1
9	350.6	0	209.4	0.9
10	358.1	0	224.3	0.9
11	1	3.8	202.0	1.3
12	2.9	2.9	182.1	1.2
13	3.9	2.9	164.2	1.2
14	6.8	3.9	148.5	1.3
15	10.8	5	134.7	1.4
16	13.2	5.7	122.6	1.5
17	21.2	8	112.4	1.7
18	26.2	6.3	103.8	1.5
19	31.2	5.4	96.6	1.4
20	32.9	7.8	90.2	1.7
21	37.1	10.4	84.9	1.9
22	19.1	7.9	78.3	1.7
23	28.7	7.5	73.3	1.7
24	10.6	4.9	67.1	1.4
25	0.1	4.8	60.4	1.4
26	356.3	3.8	90.0	1.3
27	354.4	2.9	116.4	1.2
28	350.6	2.9	139.8	1.2
29	348.8	2.9	160.7	1.2
30	357.9	2.9	180.4	1.2

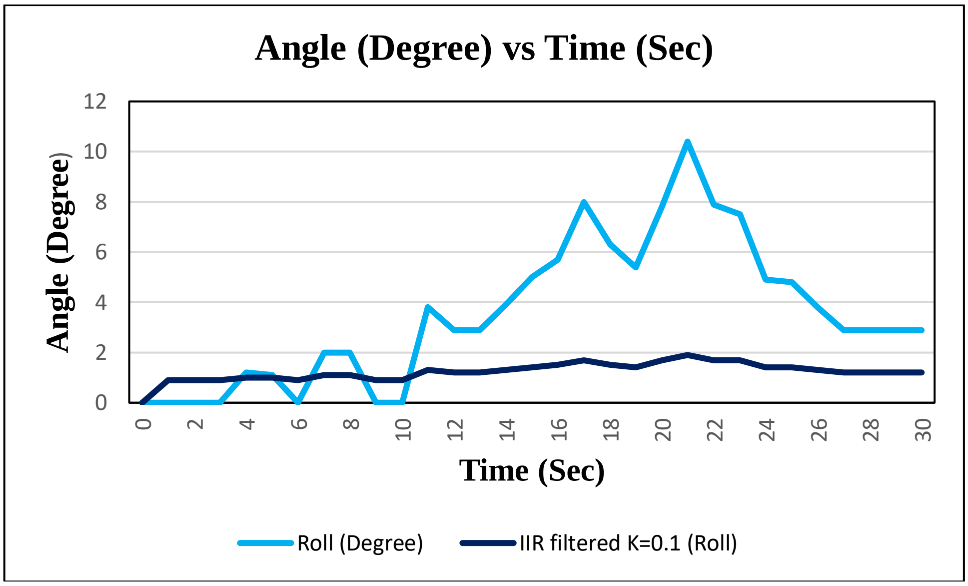


Figure 4.24 Angle (Degree) vs Time (Sec) the unwanted signal of data IIR filtered k=0.2

Low "k" means high filtering effect. The input signal is filtered more and more depending on how you reduce "k". This is due to the fact that, reducing the value of "k", you reduce the influence of the input signal sampled at present time as a Figure 4.24 show the high effect of signal reducing.

4.4.2.9 Summary of analysis on filtering process

The objective is to remove or eliminating the unwanted signal and to analysis the performance of the filters in collecting data by two type of filter such as, moving average and infinite impulse response. Moreover, the mathematic function implement in the excel. The unwanted signal is when there is roll position hand movement by the human hand vibration the pitch angle also calculates by the algorithm to reduce the signal. The aim is fulfilled by analysis the highest reducing signal as the figure below show for every filter process is can reduce the signal but the infinite impulse response filter (IIR) more effective processer to eliminating the signals. As mentioned before the k value is act as a filter constant as a theory of the IIR, if the k value is low there will be highly filter effect. As a conclusion of the summary of analysis the infinite impulse response filter of k=0.1 is the highly filtering effect.

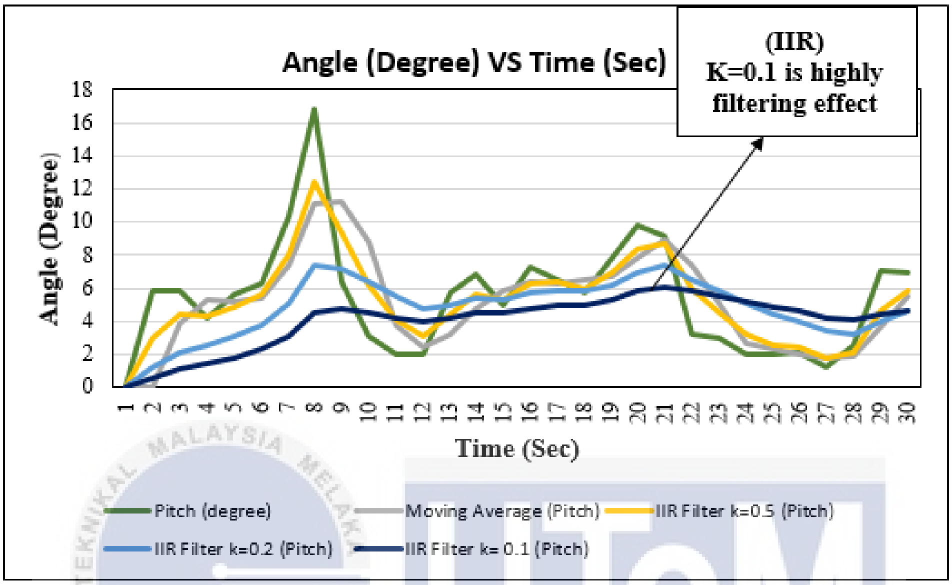


Figure 4.25 Analysis on unwanted signals

4.4.2.10 Discussion on filtering process

In this analysis filter process played a main role for eliminating or reducing the unwanted signal. The challenge faced to complete the analysis is choosing the accurate filter process as for example the articles mentioned for the moving average and the infinite impulse filter is most useful for reducing the digital signal. Beside that. For the infinite impulse response filter, the less k effects the signal high reducing filter, for that try almost 0 until 1 and choose the best three and produce a graph to show the effect of k values.

4.4.3 Analysis on the patient's hand motion capturing with the roll position

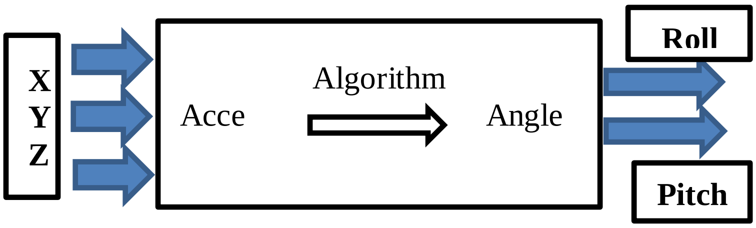
The stroke is the leading cause of the death, there some researchers' analysis for hand stroke patients which state that they can cure the disease by move hand daily. As a human being we can do the same work data by day for that in this project we introduce a new idea which is by the hand gesture movement interface with game. Instead of reducing the boredom this device helpful for stroke patients. In this particular part, the aim of analysis is to identify the hand motion of normal person and stroke patient. Besides that, I collected some data by hand movement of 2 different diseases, such as the major hand stroke patient who hand paralysis but there is some movement and Parkinson disease. Moreover, in this analysis the data is collected by roll position only.

4.4.3.1 Objective on the patient's hand motion capturing with the roll position

1) rehabilitation of patients with varied conditions include patient movement data to include patient motivation.

2) Capture the vibration of hand motion by patient.

4.4.3.2 Steps



Study about the cause of disease, the hand motion for the patients, talk with same patients, and get some knowledge from the YouTube videos, because there is not have any clinical test occurs to make a device more efficient.

1. Accelerometer measured the acceleration in unit of the (g), it is give a 3-axis value measurement from the ADXL 335 motion.
2. The value of 3-axis will give by the analog digital, microcontroller convert those value to digital value by using the signal conditioning of analog to digital.
3. Before calculate the roll and pitch three axis must convert 10-bit ADC value into g unit
4. Read accelerometer output voltages

```
valueADC_x = analogRead(x_input);
valueADC_y = analogRead(y_input);
valueADC_z = analogRead(z_input);
```

5. Acceleration in g units

```
xv = (valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;
yv = (valueADC_y / 1024.0 * ADC_ref - zero_y) / sensitivity_y;
zv = (valueADC_z / 1024.0 * ADC_ref - zero_z) / sensitivity_z;
```

6. Calculate the angle

Roll

```
angle_y = atan2(-xv, -zv) * 57.2957795 + 180;
```

Pitch

```
angle_x = atan2(-yv, -zv) * 57.2957795 + 180;
```

Yaw it is not will be appear because there is not get any accurate orientation angle for yaw, must use the gyro sensor to get the Yaw, at the same time this project limitation is roll and pitch only. The 180-degree addition process to make the degree in the range of 0 degree to 360 degrees.

```
angle_z = atan2(-yv, -xv) * 57.2957795 + 180;
```

7. APC 220 will transmit the data through the termite, it will convert the data files to Microsoft excel.

4.4.3.3 Normal human hand movement

Hands have an extremely sensitive and complex structure. This gives muscles and joints in the hand an extraordinary scope of development and exactness. The various powers are additionally disseminated in the most ideal manner. Because of this structure, you can complete a wide scope of things with your hands, for example, hold object tightly.

Hands are likewise very helpless, however: Tendons, nerve strands, veins and genuinely slim bones are altogether. The right and left hand are each constrained by the contrary side of the mind. Normally a normal human being hand is more sensitive and there is some vibration occur when we hold or doing some works.

Table 4.12 Measured data of stationary hand position

Time (Sec)	x (Acce), g	y (Acce), g	z (Acce), g	Roll (Degree)	Pitch (Degree)
1	0.05	0.1	1.14	2.5	5
2	0.05	0.1	1.13	2.6	5.1
3	0.07	0.1	1.13	3.4	5.1
4	0.07	0.1	1.13	3.4	5.1
5	0.07	0.1	1.13	3.4	5.1
6	0.08	0.1	1.13	4.2	5.1
7	0.12	0.1	1.11	6	5.2
8	0.13	0.1	1.11	6.8	5.2
9	0.13	0.1	1.13	6.7	5.1
10	0.15	0.1	1.13	7.6	5.1
11	0.17	0.1	1.13	8.4	5.1
12	0.18	0.1	1.13	9.2	5.1
13	0.18	0.1	1.09	9.5	5.3
14	0.2	0.1	1.09	10.3	5.3
15	0.22	0.08	1.09	11.2	4.4
16	0.23	0.08	1.09	12	4.4
17	0.25	0.08	1.11	12.6	4.3
18	0.27	0.08	1.09	13.6	4.4
19	0.27	0.07	1.11	13.4	3.5
20	0.28	0.08	1.09	14.5	4.4
21	0.28	0.08	1.09	14.5	4.4
22	0.28	0.12	1.08	14.7	6.2
23	0.3	0.15	1.06	15.7	8.1
24	0.32	0.12	1.04	16.8	6.4
25	0.3	0.12	1.08	15.5	6.2
26	0.33	0.12	1.06	17.4	6.3
27	0.37	0.1	1.04	19.3	5.5
28	0.37	0.1	1.04	19.3	5.5
29	0.38	0.1	1.03	20.4	5.6
30	0.38	0.1	1.06	19.8	5.4

The above table shows the collected data of roll hand movement for 30 data for 30 seconds.

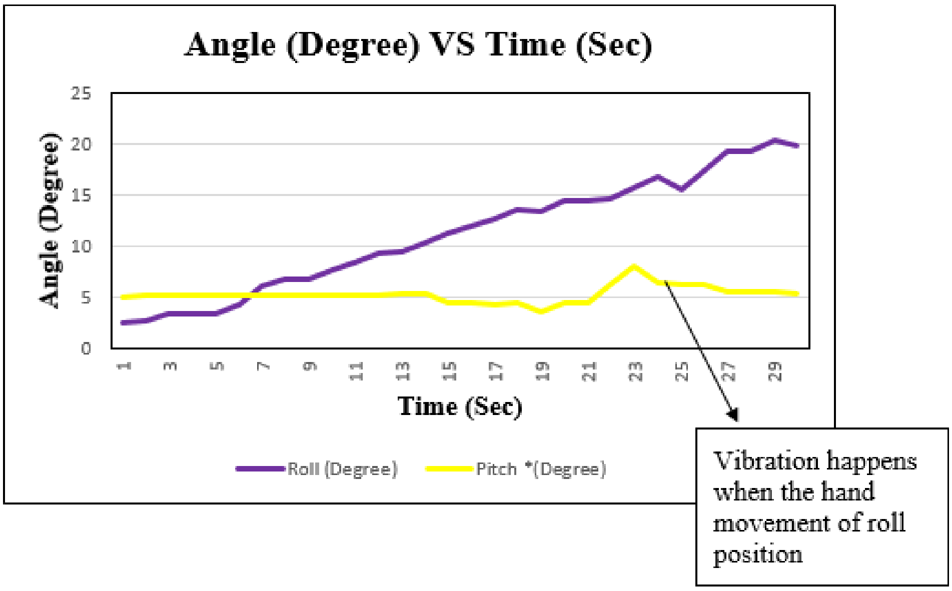


Figure 4.26 Angle (Degree) VS Time (Sec) by stationary movement with vibration signal

The graph shows the representation of collected data by the stationary hand motion. The pitch angle is detecting by the sensitivity level and the hand vibrations. The yellow line act as a pitch value which is unwanted signal.

4.4.3.4 Parkinson patients hand movement

Our brain has nerve cells and the nerve cells will produce dopamine which is hormone, to regulate our motor movement. Moreover, in long run the brain nerve cells is affected, so automatically it cannot produce sufficient dopamine. The symptoms of Parkinson disease are postural instability (balance impairment).

Table 4.13 Measured data of Parkinson hand position

Time (Sec)	X (acce),g	Y (acce),g	Z (acce),g	Roll (Degree)	Pitch (Degree)
0	0.03	0.03	1.06	1.9	1.8
1	0.17	0.07	0.96	4	9.8
2	0.2	0.1	0.98	5.9	11.5
3	0.23	0.05	1.01	2.9	12.9
4	0.33	0.05	0.91	3.2	20
5	0.28	0.05	0.83	3.5	18.8
6	0.32	0.05	0.95	3.1	18.4
7	0.43	0.07	0.83	4.7	27.5
8	0.23	-0.05	1	357.2	13.2
9	0.28	-0.06	1.01	356.3	15.6
10	0.43	0.07	0.81	4.8	28
11	0.53	0.02	0.85	1.2	32.1
12	0.63	0.02	0.81	1.3	37.8
13	0.58	0.05	0.76	3.8	37.3
14	0.63	0.02	0.76	1.4	39.5
15	0.58	0	0.78	0.1	36.7
16	0.63	0.02	0.73	1.4	40.8
17	0.53	-0.02	0.83	359	32.6
18	0.66	0.02	0.71	1.5	42.9
19	0.66	0	0.73	0.1	42.3
20	0.73	-0.02	0.75	358.8	44.3
21	0.56	-0.03	0.83	357.8	34.2
22	0.53	-0.06	0.85	355.6	32.1
23	0.7	0	0.7	0.1	45
24	0.68	0.02	0.7	1.5	44.3
25	0.12	0.3	0.96	17.3	6.9
26	0.1	0.4	0.9	24	6.4
27	0.7	0	0.7	0.1	45
28	0.68	0.02	0.7	1.5	44.3
29	0.71	0	0.66	0.1	47.1
30	0.28	-0.06	1.01	356.3	15.6

Table 4.13 shows the collecting data of hand movement of the Parkinson patients.

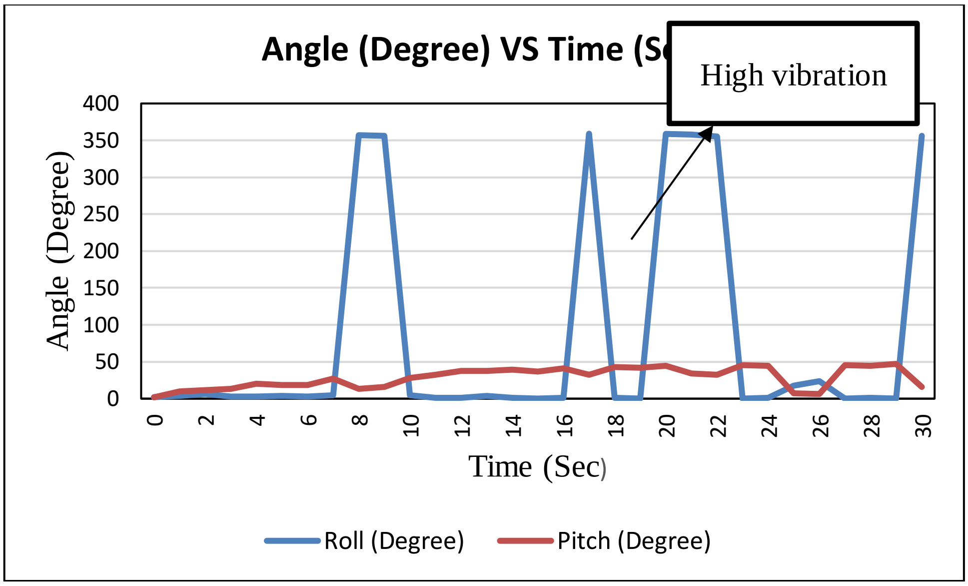


Figure 4.27 Angle (Degree) VS Time (Sec) by Parkinson hand position with vibration signal

The Parkinson patient is impairment of the patient's hand posture may have may become stooped and the patients will be facing the high hand balancing, at the same time they decreased to ability to perform unconscious movement, and also the patients has limited the hand range motion. Moreover, as the graph shows due to the impairment balance their hand motion has more vibration compare to the normal person.

4.4.3.5 Paralysis patient hand movement

Paralysis is loss of motion is the failure of a muscle or gathering of muscles to move voluntarily. Muscles are constrained by messages sent from the cerebrum that trigger development. At the point when some portion of the cerebrum is harmed after a stroke, informing between the mind and muscles may not work appropriately. This type of disease make the hand move very slowly, at the same time it cannot occur any fast movement.

Table 4.14 Measured data of Paralysis hand position

Time (Sec)	x (Acce), g	y (Acce), g	z (Acce), g	Roll (Degree)	Pitch (Degree)
0	0	0.02	1	0	1
1	0.03	0	0.98	1	0.1
2	0.02	0	1	1.5	0.1
3	0.05	0	1.01	2.8	0.1
4	0.05	0	1.01	2.8	0.1
5	0.05	-0.02	1.01	2.8	0.1
6	0.07	0	1	3.8	0.1
7	0.07	0	0.98	3.9	0.1
8	0.07	0	1	3.8	0.1
9	0.07	-0.02	1	3.8	0.2
10	0.08	-0.02	1.01	4.7	0.1
11	0.08	-0.02	1.01	4.7	0.1
12	0.08	-0.02	1	4.8	0.1
13	0.08	0	0.96	5	0.1
14	0.1	0	1	5.7	0.1
15	0.1	-0.03	1.01	5.6	0.1
16	0.12	-0.02	1	6.7	0.2
17	0.13	0	0.98	7.7	0.1
18	0.15	-0.02	1	8.6	0.1
19	0.17	-0.03	1.01	9.3	0.2
20	0.17	0	0.98	9.6	0.1
21	0.18	-0.03	1	10.4	0.1
22	0.2	-0.02	0.96	11.7	0.1
23	0.22	-0.03	1	12.2	0.3
24	0.23	-0.02	0.96	13.6	0.1
25	0.25	-0.03	0.98	14.3	0.2
26	0.27	-0.03	0.95	15.7	0.1
27	0.28	-0.03	0.96	16.3	0.1
28	0.3	-0.02	0.95	17.5	0.2
29	0.32	-0.02	0.95	18.4	0.1
30	0.33	-0.03	0.95	19.3	0.1

The Table 4.14 Measured data of Paralysis hand position the collected data of Paralysis patient and movement. The all collected data only in the roll position.

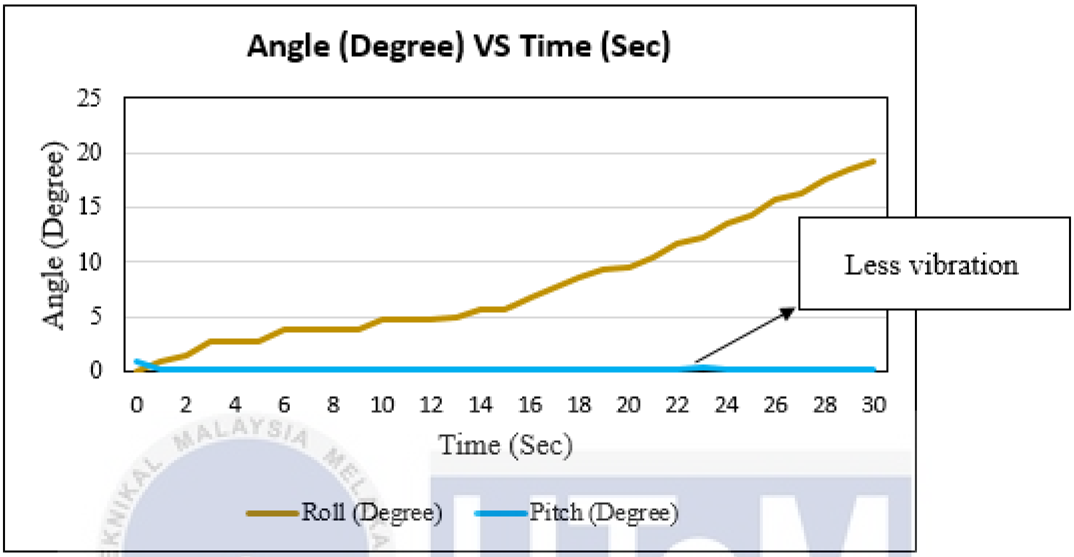


Figure 4.28 Angle (Degree) VS Time (Sec) by Paralysis hand position with vibration signal

4.4.3.6 Summary of the analysis on patient's hand motion

In the analysis there are three different hand motions captured for 30 secs, and produce the graph as well, the objective of the analysis is fulfilled, by the vibration of unwanted signal we can identify the type of patients who use the device, because for the three patient's movement we can understand the difference in vibration level.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This chapter contains a brief summary of the entire work, including methods, results and major conclusions and recommendations arising from the project. Human machine interaction is becoming widespread. So, with the introduction of new technologies the gap between the machine and human being reduced and ease the standard of living. This project describes the hand motion orientation measurement and the accelerometer ADXL335 which are used to measure the angle of the human hand motion. The aim of this project is to measure the performance in term of orientation and to achieve the objective of the project. At the end of the project, a rehabilitation device for stroke patient with integrated 2-dimensional board game that motivates hand muscles movement are developed. Moreover, an accelerometer based 2-dimensional hand orientation measure device for hand gesture detection has been designed and the performances in terms of orientation accuracy and precision has been measured. Besides that, the unwanted signal produces in this device, is eliminated or reduced the using two different filters. From the filtering process, the best filter is the IIR filter with the ‘K’ value effect of 0.1. Three different types of hand motion by patients are obtained. The analysis can be done by differentiating the vibration of patient’s hand movement from the vibration graph. We can identify the type of patients from the output. As conclusion, all the objectives were achieved successfully in this project.

5.2 Future Works

The gyro sensor can be attached together with ADXL 335 in the future researches and studies. It is because, in this project there is only 2-dimensional board game that motivates hand muscles movement is integrated. But through the gyro installation, the algorithms can detect yaw position. So, it is possible to play more games by using the hand gesture.

Furthermore, for future studies, researchers are recommended there will be clinical test conduct to measure the effectiveness of the project and may want to include integration with the board game, example stewart platform.

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APPENDICES

APPENDIX A ADXL335_PITCH_ROLL_HAND MOTION ORIENTATION

Table 5.1 Coding of hand motion orientation measurement

CODING	COMMENTS
#include <SoftwareSerial.h>	
SoftwareSerial APC_Serial(3, 2);	**// RX, TX for APC220 Serial interface**
#include <math.h>	**// Maths library for trig routines**
#include <U8x8lib.h>	**// SSD1306 OLED library**
#define ADC_ref 5.09	**// Analog to Digital Converter Reference voltage**
#define zero_x 1.67	**// X-axis Zero refence voltage, nom 1.65**
#define zero_y 1.62	**// y-axis Zero refence voltage**
#define zero_z 1.65	**// z-axis Zero refence voltage**
#define sensitivity_x 0.3	**// typical 300mV/g, max 330mV/g**
#define sensitivity_y 0.3	
#define sensitivity_z 0.3	
#define x_input A1	**// Accelerometer axis input pins**
#define y_input A2	
#define z_input A3	

objectU8X8_SSD1306_128X64_NONAME_HW_I2C u8x8(/* reset=*/ U8X8_PIN_NONE);	**// declare OLED**
unsigned int valueADC_x, valueADC_y, valueADC_z ;	**//ADC_Reading_from Accelerometer pins**
float xv, yv, zv;	**// Acceleration variables**
float angle_x, angle_y, angle_z;	**// Angle variables**
static char outstr_x[6];	**// Holds the string output of x value**
static char outstr_y[6];	**// Holds the string output of y value**
unsigned long now_time;	**// Current time in msec**
Unsigned long last_time;	**// Previous time in msec**
Const long interval = 1000;	**// 1 second interval**
unsigned int time_sec = 0;	**// Holds seconds data**
char timestr[10];	
char timestr[10];	
void setup() {	
APC_Serial.begin(9600)	**//Serial.begin(9600);** **// Initialise Serial com speed**
u8x8.begin();	**// Initialise OLED display**
u8x8.setPowerSave(0); }	
void loop() {	

`valueADC_x= analogRead(x_inputx` `valueADC_y = analogRead(y_input);` `valueADC_z = analogRead(z_input);`	**// Read accelerometer output voltages**
`xv =(valueADC_x / 1024.0 * ADC_ref - zero_x) / sensitivity_x;` `yv=(valueADC_y / 1024.0 * ADC_ref - zero_y) / sensitivity_y;` `zv=(valueADC_z / 1024.0 * ADC_ref - zero_z) / sensitivity_z;`	**// Acceleration in g units**
`angle_x = atan2(-yv, -zv) * 57.2957795 + 180;` `angle_y = atan2(-xv, -zv) * 57.2957795 + 180;` `angle_z = atan2(-yv, -xv) * 57.2957795 + 180;`	**// Convert to angles, 57.29 is radians to degree convert and add 180 degree offeset**
`delay(300);` `sendData();`	
`u8x8.setFont(u8x8_font_pressstart2p_u);`	**//Set display font for OLED**
`dtostrf(angle_y, 5, 1, outstr_y);` `u8x8.drawString(0, 0, "ROLL  : ");` `u8x8.drawString(8, 0, outstr_y);`	**// (var, noDigits, decplace,outputstr)** **// Y axis**
`dtostrf(angle_x, 5, 1, outstr_x);` `u8x8.drawString(0, 2, "PITCH : ");` `u8x8.drawString(8, 2, outstr_x);`	**// X axis**

`u8x8.drawString(0, 4, "TIME SEC:");` `now_time = millis();`	**// Elapsed time in secs**
`if (now_time - last_time >= interval) {` `last_time = now_time;` `time_sec++` `ltoa(time_sec, timestr, 10);` `u8x8.drawString(10, 4, timestr);`	**// update every 1000msec**
`}` `}` `void sendData()`	
`APC_Serial.print(",");` `APC_Serial.print(outstr_x);` `APC_Serial.print(",");` `APC_Serial.print(outstr_y);` `APC_Serial.print(",");` `APC_Serial.println(time_sec);` `APC_Serial.print(xv);` `APC_Serial.print(",");` `APC_Serial.print(yv);` `APC_Serial.print(",");` `APC_Serial.print(zv);`	**// Send data in comma delimited serial format**

APPENDIX B Measured data of roll movement and pitch movement

Table 5.2 Measured data of roll movement

X (acce),g	Y (acce),g	Z (acce),g	Time (Sec)	Roll (Degree)	Pitch (Degree)
0.03	-0.02	1.04	0	1.8	0.1
0.02	0.02	1	0	1	1
0.03	0.02	0.98	0	2	1.1
0	0	1.01	0	0	0.1
0.02	0	1	0	1	0.1
0	0.02	1	0	0	1
0	0	1.01	1	0	0.1
0	0	1.01	1	0	0.1
0.05	0	1	1	2.9	0.1
0.03	0	1	1	1.9	0.1
0.05	0.02	1	1	2.9	1
0.03	0	1.03	1	1.9	0.1
0.07	0.02	1	1	3.8	1
0.08	0	1.01	1	4.7	0.1
0.07	-0.02	1.03	1	3.7	1
0.1	0	1.01	1	5.6	0.1
0.1	0.02	1.03	2	5.6	1
0.13	0.02	1	2	7.6	1
0.1	0.03	0.98	2	5.8	2
0.13	0	1.01	2	7.5	0.1
0.13	0.02	1	2	7.6	1
0.17	0.03	0.98	2	9.6	2
0.15	0.02	0.98	2	8.7	1.1
0.15	0.03	0.95	2	9	2.1
0.18	0.02	0.96	2	10.8	1.1
0.18	0	1	2	10.4	0.1
0.18	0	0.98	3	10.6	0.1
0.2	0	0.96	3	11.7	0.1
0.2	0	0.96	3	11.7	0.1
0.22	0	0.98	3	12.4	0.1
0.22	-0.02	0.98	3	12.4	1
0.23	-0.02	0.98	3	13.4	0.1
0.23	-0.02	1	3	13.2	0.1
0.25	0	0.96	3	14.5	0.1
0.25	-0.03	1	3	14.1	1
0.23	-0.02	0.98	3	13.4	0.1
0.27	0	0.98	4	15.2	0.1
0.25	0	0.96	4	14.5	0.1
0.27	0	0.98	4	15.2	0.1
0.27	0	0.95	4	15.7	0.1

X (acce),g	Y (acce),g	Z (acce),g	Time (Sec)	Roll (Degree)	Pitch (Degree)
0.27	-0.02	0.96	4	15.4	0.1
0.28	-0.02	0.96	4	16.3	0.1
0.28	0	0.95	4	16.6	0.1
0.28	0	0.96	4	16.3	0.1
0.3	0	0.96	4	17.3	0.1
0.3	-0.02	0.96	4	17.3	0.1
0.3	0	0.93	5	17.8	0.1
0.32	0	0.96	5	18.2	0.1
0.3	0	0.95	5	17.5	0.1
0.3	0	0.95	5	17.5	0.1
0.33	0	0.93	5	19.7	0.1
0.35	-0.02	0.93	5	20.6	0.1
0.35	-0.02	0.95	5	20.2	0.1
0.33	-0.02	0.93	5	19.7	0.2
0.35	-0.02	0.93	5	20.6	0.1
0.33	-0.02	0.95	5	19.3	0.2
0.35	-0.02	0.95	6	20.2	0.1
0.35	-0.02	0.95	6	20.2	0.1
0.37	-0.02	0.93	6	21.5	0.2
0.35	0	0.91	6	20.9	0.1
0.37	-0.02	0.93	6	21.5	0.2
0.37	-0.02	0.95	6	21.1	0.1

X (acce),g	Y (acce),g	Z (acce),g	Time (Sec)	Roll (Degree)	Pitch (Degree)
0.37	-0.02	0.93	6	21.5	0.2
0.37	0	0.91	6	21.8	0.1
0.38	0	0.91	6	22.7	0.1
0.38	0	0.93	6	22.3	0.1
0.38	0	0.91	7	22.7	0.1
0.4	0	0.91	7	23.6	0.1
0.4	0	0.91	7	23.6	0.1
0.38	-0.02	0.95	7	22	0.1
0.4	0	0.91	7	23.6	0.1
0.41	0	0.91	7	24.4	0.1
0.41	-0.02	0.91	7	24.4	0.1
0.41	0	0.9	7	24.8	0.1
0.41	-0.02	0.91	7	24.4	0.2
0.41	-0.02	0.91	7	24.4	0.1
0.43	-0.02	0.93	8	24.9	0.1
0.43	-0.02	0.91	8	25.3	0.1
0.41	0	0.91	8	24.4	0.1
0.43	0	0.9	8	25.7	0.1
0.45	-0.02	0.9	8	26.6	0.1
0.43	0	0.86	8	26.6	0.1
0.43	0	0.86	8	26.6	0.1
0.45	0	0.88	8	27	0.1

X (acce),g	Y (acce),g	Z (acce),g	Time (Sec)	Roll (Degree)	Pitch (Degree)
0.45	0	0.88	8	27	0.1
0.46	-0.02	0.88	8	27.8	0.1
0.45	-0.02	0.88	9	27	0.2
0.45	0	0.86	9	27.4	0.1
0.46	0	0.86	9	28.3	0.1
0.48	0	0.85	9	29.6	0.1
0.48	-0.02	0.88	9	28.7	0.2
0.48	-0.02	0.86	9	29.1	0.3
0.46	-0.02	0.88	9	27.8	0.1
0.48	-0.02	0.88	9	28.7	0.1
0.5	-0.02	0.88	9	29.5	0.2
0.5	-0.02	0.85	9	30.5	0.2
0.48	0	0.86	10	29.1	0.1
0.5	-0.02	0.86	10	30	0.3
0.5	-0.02	0.86	10	30	0.1
0.5	-0.02	0.88	10	29.5	0.1
0.5	-0.03	0.86	10	30	0.2
0.51	-0.02	0.86	10	30.8	0.1
0.51	-0.02	0.86	10	30.8	0.1
0.5	0	0.83	10	31	0.1
0.51	0.02	0.81	10	32.3	1.3
0.51	-0.02	0.81	10	32.3	0.2

Table 5.3: Measured data of Pitch movement

X (acce),g	Y (acce),g	Z (acce),g	Time (Sec)	Pitch (Degree)	Roll (Degree)
0.07	0.2	1	0	11.4	3.8
0.07	0.18	0.98	0	10.6	3.9
0.07	0.17	0.98	0	9.7	3.9
0.07	0.18	0.96	0	10.8	4
0.05	0.18	1	0	10.5	2.9
0.05	0.18	0.98	0	10.6	2.9
0.05	0.17	0.98	1	9.7	2.9
0.03	0.18	1.01	1	10.3	1.9
0.07	0.17	1.01	1	9.4	3.8
0.03	0.18	1.01	1	10.3	1.9
0.05	0.2	1	1	11.4	2.9
0.07	0.22	0.98	1	12.5	3.9
0.05	0.22	0.98	1	12.5	2.9
0.07	0.22	0.98	1	12.5	3.9
0.05	0.22	0.98	1	12.5	2.9
0.07	0.22	0.98	1	12.5	3.9
0.05	0.22	1	2	12.3	2.9
0.05	0.22	0.98	2	12.5	2.9
0.05	0.22	1	2	12.3	2.9
0.07	0.22	1	2	12.3	3.8
0.08	0.22	0.98	2	12.5	4.9

X (acce),g	Y (acce),g	Z (acce),g	Time (Sec)	Pitch (Degree)	Roll (Degree)
0.07	0.23	0.98	2	13.4	3.9
0.07	0.23	0.98	2	13.4	3.9
0.07	0.23	0.98	2	13.4	3.9
0.08	0.25	0.96	2	14.6	5
0.08	0.25	0.98	2	14.3	4.9
0.07	0.25	1	3	14.1	3.8
0.08	0.25	0.98	3	14.3	4.9
0.08	0.27	0.98	3	15.2	4.9
0.08	0.25	0.98	3	14.3	4.9
0.08	0.25	1	3	14.1	4.8
0.08	0.27	0.98	3	15.2	4.9
0.07	0.28	0.96	3	16.4	4
0.07	0.28	0.98	3	16.1	3.9
0.07	0.28	0.96	3	16.4	4
0.07	0.27	1	3	15	3.8
0.08	0.3	0.98	4	17	4.9
0.1	0.3	0.96	4	17.3	5.9
0.08	0.32	0.96	4	18.2	5
0.08	0.32	0.95	4	18.5	5
0.08	0.32	0.96	4	18.2	5
0.08	0.32	0.96	4	18.2	5

X (acce),g	Y (acce),g	Z (acce),g	Time (Sec)	Pitch (Degree)	Roll (Degree)
0.08	0.33	0.95	4	19.4	5
0.07	0.33	0.96	4	19.1	4
0.08	0.35	0.95	4	20.3	5
0.08	0.35	0.96	4	20	5
0.08	0.35	0.96	5	20	5
0.08	0.35	0.95	5	20.3	5
0.08	0.37	0.95	5	21.2	5
0.1	0.37	0.93	5	21.5	6.1
0.13	0.35	0.96	5	20	7.9
0.12	0.37	0.96	5	20.8	6.9
0.12	0.37	0.93	5	21.5	7.1
0.1	0.38	0.95	5	22	6
0.1	0.38	0.93	5	22.4	6.1
0.1	0.42	0.95	5	23.7	6
0.1	0.42	0.91	6	24.5	6.3
0.1	0.42	0.93	6	24.1	6.1
0.1	0.42	0.95	6	23.7	6
0.08	0.4	0.93	6	23.3	5.1
0.08	0.4	0.95	6	22.9	5
0.1	0.42	0.93	6	24.1	6.1
0.07	0.43	0.93	6	25	4.1

X (acce),g	Y (acce),g	Z (acce),g	Time (Sec)	Pitch (Degree)	Roll (Degree)
0.1	0.42	0.9	6	24.9	6.4
0.12	0.43	0.9	6	25.8	7.4
0.07	0.43	0.93	6	25	4.1
0.08	0.43	0.91	7	25.4	5.2
0.12	0.52	0.88	7	30.4	7.5
0.08	0.47	0.91	7	27	5.2
0.1	0.47	0.9	7	27.5	6.4
0.12	0.47	0.9	7	27.5	7.4
0.1	0.48	0.88	7	28.7	6.5
0.1	0.48	0.88	7	28.7	6.5
0.1	0.5	0.88	7	29.6	6.5
0.1	0.52	0.91	7	29.5	6.3
0.1	0.52	0.88	7	30.4	6.5
0.1	0.55	0.88	8	32	6.5
0.12	0.53	0.88	8	31.2	7.5
0.13	0.6	0.81	8	36.3	9.3
0.13	0.56	0.85	8	33.7	8.9
0.13	0.58	0.85	8	34.5	8.9
0.12	0.58	0.86	8	34	7.7
0.13	0.6	0.83	8	35.8	9.1
0.13	0.61	0.83	8	36.5	9.1

X (acce),g	Y (acce),g	Z (acce),g	Time (Sec)	Pitch (Degree)	Roll (Degree)
0.13	0.6	0.83	8	35.8	9.1
0.13	0.61	0.8	8	37.7	9.5
0.13	0.63	0.83	9	37.3	9.1
0.13	0.61	0.8	9	37.7	9.5
0.13	0.63	0.81	9	37.8	9.3
0.15	0.65	0.8	9	39.1	10.6
0.15	0.65	0.78	9	39.7	10.9
0.13	0.63	0.81	9	37.8	9.3
0.13	0.63	0.81	9	37.8	9.3
0.13	0.65	0.8	9	39.1	9.5
0.12	0.65	0.81	9	38.6	8.2
0.15	0.65	0.78	9	39.7	10.9
0.13	0.66	0.8	10	39.8	9.5
0.12	0.65	0.8	10	39.1	8.3
0.13	0.66	0.78	10	40.4	9.7
0.12	0.66	0.81	10	39.3	8.2
0.13	0.66	0.78	10	40.4	9.7
0.12	0.66	0.8	10	39.8	8.3
0.12	0.66	0.78	10	40.4	8.5
0.12	0.68	0.8	10	40.5	8.3
0.12	0.68	0.76	10	41.7	8.7
0.12	0.7	0.76	10	42.4	8.7

APPENDIX C TURNITIN REPORT

PSM2

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