Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF IOT-BASED KIDS' SMART ACTIVITY TRACKER WITH SEIZURE DETECTION CAPABILITY

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Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

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A project report submitted
in partial fulfillment of the requirements for the degree of
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Faculty of Electrical and Electronic Engineering Technology
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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2023

DECLARATION

I declare that this project report entitled “Development of IoT-Based Kids’ Smart Activity Tracker with Seizure Detection Capability” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

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Date : 23/02/2023

APPROVAL

I approve that this Bachelor Degree Project 2 (PSM2) report entitled "Development of IoT-Based Kids' Smart Activity Tracker with Seizure Detection Capability" is sufficient for submission.

Signature : 

Supervisor Name : SITI NUR SUHAILA BINTI MIRIN

Date : 23/02/2023

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours.

Signature : 

Supervisor Name : SITI NUR SUHAILA BINTI MIRIN

Date : 23/02/2023

Signature :

Co-Supervisor :

Name (if any)

Date :

DEDICATION

To my beloved mother, Mrs. Lee Yoke Ting, and father, Mr. Lee Yim Nyen, for giving the greatest support in mentally and physically throughout my final year project.
To my brothers, mentor, friends and course mate who share their knowledge and advices to finish this project.

ABSTRACT

Seizure is a sickness that have be a part among human being for more than thousand years. A single event of seizure does not mean epilepsy as epilepsy is usually diagnosed when a person has at least two seizures that the cause is unknows and happen at least 24 hours apart. Febrile seizure is a special name for kids' seizure which their age is in between 6 months to 5 years old. Sudden Unexpected Death in Childhood (SUDC) states that 31.7% cases had a history of Febrile seizure. The main symptom of Febrile seizure is the children will have fever above 38ºC. In this era, parents have to work in order to provide daily expenses to the family and this means that children of them who have Febrile seizure will not have extra care and attention. To provide maximum protection for children with Febrile seizure in order to protect them from risk, danger and death from seizure, activity tracker with seizure capability will be designed and developed for the community. This device will be able to detect the temperature of the kids from their wrist and show in parents' smartphone through phone application. Once the device detected abnormal high temperature in children for several minutes, it will send notifications to through application to the parents' smartphone as they can take some precautions steps to reduce the risk and danger that might be happen to their children. ESP8266 will be used as a microcontroller as to send data to Blynk App, which is a smartphone application that can receive the information sent by microcontroller. DS18B20 digital temperature sensor will be used to sense the temperature near the wrist and transfer it to the microcontroller.

ABSTRAK

Sawan adalah penyakit yang telah menjadi sebahagian daripada manusia selama ribuan tahun dan lebih. Satu kejadian sawan tidak bermakna epilepsi sebab epilepsi biasanya diagnosis apabila seseorang mengalami sekurang-kurangnya dua sawan yang puncanya tidak diketahui dan berlaku sekurang-kurangnya 24 jam. Sawan Febrile (Deman) ialah nama khas untuk sawan kanak-kanak yang umurnya antara 6 bulan hingga 5 tahun Sudden Unexpented Death in Childhood (SUDC) menyatakan bahawa 31.7% kes mempunyai sejarah sawan Febrile. Gejala utama sawan Febrile ialah kanak-kanak akan mengalami deman melebihi 38ºC. Pada era ini, ibu bapa perlu bekerja untuk menyediakan perbelanjaan harian kepada keluarga dan ini bermakna anak-anak mereka yang mempunyai sawan Febrile tidak akan mendapat penjagaan dan perhatian yang lebih banyak. Untuk memberikan perlindungan maksimum kepada kanak-kanak yang mengalami sawan Febrile supaya dapat melindungi mereka daripada risiko, bahaya dan kematian akibat sawan ini, penjejak aktiviti dengan keupayaan sawan akan direka dan dimajukan untuk komuniti. Peranti ini akan mengesan suhu kanak-kanak dari pergelangan tangan meraka dan ditunjukkan dalam telefon pintar ibu bapa melalui aplikasi telefon. Sebaik sahaja peranti mengesan suhu tinggi yang tidak biasa pada kanak-kanak selama beberapa minit, ia akan menghantar pemberitahuan melalui aplikasi ke telefon pintar ibu bapa supaya mereka dapat mengambil langkah berwaspada untuk mengurangkan risiko dan bahaya yang mungkin berlaku kepada anak-anak mereka. NodeMCU akan digunakan sebagai alat mikrokontrol untuk menghantar data ke Blynk App, iaitu aplikasi telefon pintar yang boleh menerima maklumat yang dihantar oleh alat mikrokontrol. Meter suhu yg dinama DS18B20, dicategori sebagai meter suhu digital, akan digunakan untuk mengean suhu bahan berhampiran pergelangan tangan dan menghantar data ke alat mikrokontrol.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Mrs. Siti Nur Suhaila Binti Mirin for her precious guidance, words of wisdom and patient throughout this project.

My highest appreciation goes to my parent and family members for their love and prayer during the period of my study. Besides that, together with my course mates, friends who give their advice and help throughout this project. Lastly, thank you everyone who had been involved in this project, which is very meaningful to me.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

°	-	Degree
±	-	Plus minus

LIST OF ABBREVIATIONS

C - Celcius

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Seizure is an uncontrollable electrical disruption in the brain that occurs suddenly. It can alter a person's behaviour, motions, or sensations, as well as the person level of consciousness. Epilepsy is defined as having two or more seizures that occur at least 24 hours apart and are not caused by a known cause. Seizures come in a variety of forms, each with its own set of symptoms and intensity. The sort of seizure depends on where it starts in the brain and how far it spreads. The majority of seizures endure between 30 seconds and two minutes. A seizure lasting more than five minutes is considered a medical emergency.

When a child has a fever, he or she may experience febrile seizures (febrile convulsions). They are most common between the ages of six months and three years. Seeing your child have a seizure, especially if it's their first, can be frightening and distressing. These seizures, on the other hand, are usually innocuous, and almost all youngsters recover completely. Although febrile seizures are associated to the onset of a high temperature, the aetiology is uncertain (fever). There may also be a genetic relationship to febrile seizures, as having a seizure is more likely if a close relative has had one before. An infection is the most common cause of a child's elevated temperature. Chickenpox, the flu, a middle ear infection, or tonsillitis are all common examples.

One of the most distressing elements of childhood epilepsy for children and their families is not knowing when a seizure may occur. This unpredictability can pervade every facet of existence. Children are unable to swim in deep water or bathe alone. Teens are

frequently unable to drive for fear of having a seizure behind the wheel. Parents may sleep on their children's bedroom floors to keep an eye on any difficulties that arise throughout the night.

A smartwatch that has received FDA approval is part of an expanding group of gadgets targeted at detecting and even forecasting seizures. For many patients, the Embrace watch detects the movements and electrical pulses in the skin that are associated with seizures. When it detects a seizure, it sends a text message to a caregiver's phone, coupled with GPS coordinates so the user may be quickly located. It also saves and analyses data on sleep and activity patterns, which could help patients and their doctors better understand when and why seizures occur on any given day. The FDA approved the watch for adults early last year, and it has now been approved for youngsters.

1.2 Problem Statement

Seizure is dangerous without considering the age. An adult can suffer in seizure and sometimes will cause risks and danger because of it as seizure come in sudden without advanced notice. We can imagine that if an adult cannot take care of himself from seizure, how about a kid without life experience?

Kids should grow up in a happy and healthy surrounding. But if unluckily a kid was born with seizure, would it mean that he do not deserve a happy childhood?

In order to protect our kids from the sickness of seizure, together with the risk and danger from it, the problem that we got now is to investigate more about the kids seizure so that more studies and maybe more protection device, medication and additional concern can be provided to them to protect and secure them from danger.

An activity tracker, or more specifically a seizure tracker, can give additional monitor and protection to seizure patient. Seizure tracker do not meant to be an advanced technology device but it is used to detect the symptom of seizure attack such as convulsion, tremor and fever. Kids seizure, or called as Febrile seizure, the symptom is high fever, which body temperature is above 38ºC, the kid might have high possibility to trigger by seizure with the precondition that the kid have seizure before. Nowadays, seizure tracker is quite expensive which is cannot be afford by some families, but medication should be received by anyone without comparing the salary and family burden.

Besides that, to detect the kid's temperature is easy when their parents are along with them. But in this era, most of the families should have more than one salary, which means both of the parents should go to work in order to pay for household expenses. Who should they rely on to monitor their kids with seizure and what method should they use in order to have a peace of mind during their work?

Therefore, in order to let parents know more about what is kids seizure and the danger, sequela of kids seizure, more studies should be excavate. Other than that, in order to help parents which moderate or below average income to know the body temperature of their kids so that they can be aware of their kids trigger by seizure, a low cost and user friendly seizure tracker should be design for parents in order to detect their kids' temperature. Lastly, to let parents have a peace of mind during working hour or the time they are not with their kids, an application to monitor the kids' body temperature should be develop and the purpose of the phone application is not just monitor, and also give pop-up notifications to the parents so that they can take advanced precaution and be aware of it when anything trigger of seizure happen suddenly.

1.3 Project Objective

The main aim of this project is to propose a development of an activity tracker with IoT-based for kids with seizure detection and with reasonable accuracy. Specifically, the objectives are as follows:

a) To investigate triggering factors for seizure among kids.

b) To develop low cost and user-friendly kids seizure detector and monitoring for parents.

c) To analyze performance of kids seizure detector and monitoring system.

1.4 Scope of Project

To avoid any uncertainty of this project due to some limitations and constraints, the scope of the project are defined as follows:

1. The detection device just can detect temperature from 25ºC to 40ºC.
2. The detection device just can be wear in the wrist and detect the temperature near the wrist.
3. The detection device will only use digital temperature sensor as detection device.
4. The application which connected to detection device just can receive notification when device detected body temperature above 38ºC.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Nowadays, febrile seizure had become a common sickness among the kids. About 2-5% kids in the U.S.A have this seizure before age of 5. Febrile seizure can trigger a kid with several reccurence such as the kid have his first febrile seizure before 18 months old; family members of the kids have history of seizure or epilepsy; a kid had fever with temperature under 40ºC and lasted less than 1 hour; a kid had a complex febrile seizure previously; and lastly a kid developing common childhood infection for example chickenpox and flu.

In this topic, firstly will explain about what is seizure and mainly, what is kids seizure. To let the community have more knowledge about kids seizure, the symptoms of Febrile seizure, risks and danger of seizure, more studies and data will be showed up.

After introduced what is febrile seizure, in subtopic 2.3 will introduce the kids' seizure detection. The detection will included with internal and external body part detection. The technologies that are well-known in the community nowadays which help to detect seizure will also be introduced. The detection of body part will include brain, chest, wrist and so on.

Besides that, in subtopic 2.4 will introduce about activity tracker and IoT (Internet of Things). The activity tracker that are mainly used in the market and their functions, features and price will also included in it. After activity tracker, IoT will be included too inside this subtopic and the features that used IoT for example GPS, heart rate, detection of body temperature and so on.

After that, seizure tracker that are oftenly used by patients with seizure will be introduce in subtopic 2.5. Type of detection device and product will also introduce together with it.

After the previous subtopic, seizure tracker IoT will be continue in subtopic 2.6. In this subtopic, some research and questionnaire will show up which included with patient history, desired design characteristics and cost will be listed. Next, according to an survey article, the things that should be in a seizure tracker which filled by respondents will be introduced.

Moving on to the next subtopic which is the subtopic before summary, kids seizure tracker IoT will be introduced. The kids seizure tracker had shown up in previous subtopic but in this subtopic, the application that to detect and monitor kids will be introduced.

Lastly, the summary and conclusion for the whole chapter 2 will be written down in subtopic 2.8.

2.2 Kids Seizure

The According to [1], there are several types of seizure that has been discovered all over the world. Seizures are classified to 3 major groups which is:

1. Focal Onset Seizure
2. Generalized Onset Seizure
3. Unknown Onset Seizure

A seizure with generalised onset will affect both sides of the brain or cell clusters on both sides of the brain at the same time. This term has been used to describe a wide variety of seizure types, including tonic-clonic, absence, and atonic seizures, to mention a few.

Focal seizures begin in a specific area or cluster of cells on one side of the brain. When explaining where seizures begin, the term focal is used instead of partial to be more exact.

When a seizure starts with unknown reason, it is known as unknown onset seizure. It is referred to as having an unknown onset when a seizure takes place and no one is around to see or hear it, such as when it takes place at night or in a person who lives alone.

Table 2.1 shows the 3 major groups of seizures. More explanation about focal onset seizure and generalized onset seizure will included after table 2.1. There are no more information for unknown onset seizure as it would be categorized as a generalized or focal onset seizure when further information and medication becomes available. Table 2.1 will also list down motor and non-motor for each seizure and will be explained as well.

Table 2.1 Three Major Groups of Seizures

FOCAL ONSET SEIZURE	**GENERALIZED ONSET SEIZURE**	**UNKNOWN ONSET SEIZURE**
MOTOR - **NON-MOTOR** Focal to bilateral tonic-clonic	**MOTOR** Tonic-clonic Other motor **NON-MOTOR** Absence	**MOTOR** Tonic-clonic Other motor **NON-MOTOR** Absence

2.2.1 Generalized Onset Seizure

Most people hear the word tonic-clonic seizure, they will think of this sort of seizure, also known as a convulsion. “Grand mal” is an older name for this type of seizure. They mix the characteristics of tonic and clonic seizure. Tonic represent stiffnening while clonic indicates jerking motions in rhythm. Tonic-clonic seizure will appear in a few steps which tonic phase will comes first. After tonic phase comes, net will followed by clonic phase.

Figure 2.1 below shows the arrangement for tonic-clonic seizure and symptomes.

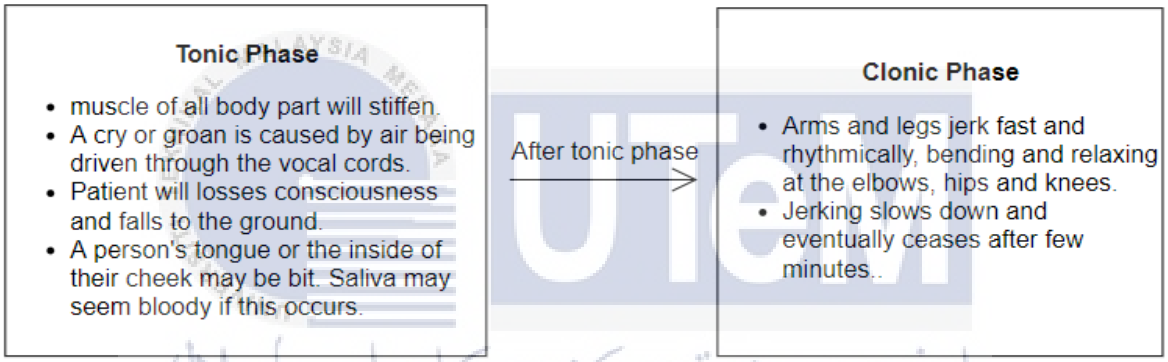

Figure 2.1 Arrangement for tonic-clonic seizure and symptoms

If the person is having respiratory problems or the seizure lasts for too long, their face may appear dark or blue. As the body relaxes, the person may lose control of their bladder or bowel. The recovery of consciousness or a person’s awareness is delayed. The convulsions normally last between 1 to 3 minutes. If a tonic-clonic seizure lasting longer than 5 minutes, quick medical intervention is essential as it could be classed as dangerous condition and it demands hospitalisation.

A generalised onset seizure, which is the type of seizure that affects both sides of the brain simultaneously, is the type of seizure that is known as an absence seizure. Absence seizures can manifest themselves in two different ways. Each characterised by its own

particular constellation of symptoms. In the beginning, the majority of people who experience any type of seizure do not have any idea what is happening to them. They can arrive out of nowhere and vanish just as quickly, making it impossible for anyone to notice anything amiss. Alternately, viewers may incorrectly interpret the symptoms as simple instances of daydreaming or a lack of concentration. Following is an explanation of the two kinds of absence seizures, which are known as conventional absence seizures and atypical absence seizures, as well as the symptoms associated with each.

1. Typical Absence Seizures
    - Most common seizures.
    - The individual instantly pauses all activity. He or she can appear to be staring off into space or merely blank.
    - Majority of seizures are short, lasting less than 10 seconds.
    - Eyelids may flap and eyes may turn upwards.
2. Atypical Absence Seizures
    - Atypical absence seizures are differentiated by their length, onset, and end times, as well as the presence of unique symptoms.
    - The seizure normally begins with a blank stare into space.
    - Muscle tone and mobility are usually compromised as a result of this condition. Blinking repeatedly can seem as fluttering of the eyelids, mouth smacking or chewing movements, and making various hand movements or rubbing fingers together, according to viewers.
    - Atypical absence seizures lasts for 20 seconds and more.

Atonic seizure is categorized in generalized onset seizures too. The typical tension of a muscle is called "tone." The word "atonic" (a-TON-ik) denotes "toneless." As a result, muscles become limp during an atonic seizure. The symptoms of atonic seizure are shown as below:

- It is possible for a part of the body or the complete body to become limp. Eyes may droop, the person's head may nod or sink forward, and objects may be dropped.
- Duration of these convulsions is usually less than 15 seconds.
- When atonic seizure happen to a person, he or she will falls on to the floor.
- People may sustain injuries if they fall. It's possible that a helmet or other head protection is required.
- “Drop attacks” or “Drop seizures” are often called by people, which are same with atonic seizure.

Sustained rhythmical jerking motions (clonic), muscles that become weak or limp (atonic), muscles that become tense or rigid (tonic), transient muscular twitching (myoclonus), or epileptic spasms are all motor symptoms of generalised onset seizures (body flexes and extends repeatedly).

Absence seizures are another name for non-motor symptoms. There are two types of absence seizures: typical and atypical (staring spells). Absence seizures can cause short twitches (myoclonus), which might affect a specific part of the body or just the eyelids.

2.2.2 Focal Onset Seizure

Focal seizures start in a specific area of the brain or a cluster of cells on one side. Focused onset seizures will be divided into two categories: focal onset conscious seizures and focal onset impaired awareness.

On one side of the brain, focal onset seizures will occur. They were previously referred to as partial seizures. Focused onset seizures are the most common form of seizure in epilepsy sufferers. In a pinch, the term concentrated seizure may be employed. When a seizure starts on one side of the brain but the person retains awareness of their surroundings, it is called a focal onset awareness seizure. This form of seizure was previously classified as a simple partial seizure. Focused conscious seizures occur when a person is fully awake, alert, and recalls events that transpired during the seizure. During seizures, some people become "frozen," and they may or may not be able to respond to others. These convulsions are usually only a couple of minutes long.

When a seizure originates on one side of the brain and the person's degree of consciousness changes for part or all of it, this is known as focal onset impaired awareness. It is not necessary to use the word "onset." This form of seizure was previously known as a complex partial seizure. Seizures that start in the temporal lobes of the brain are called temporal lobe seizures. The term "psychomotor seizure" is considerably older. Seizures usually start in a single area or group of brain cells, usually in the temporal or frontal lobes. They might also start in unexpected areas. Complex partial seizures (focal reduced consciousness) can affect both sides of the brain in some cases. This type of seizure is now referred to as focused to bilateral tonic-clonic seizures.

Focal seizures are seizures that occur only in one portion of the brain and are also known as partial seizures. There are three types of seizures that have been identified:

1) Simple focal seizures

-Affect only a small portion of the pain Twitching or a change in sensation, such as an unusual smell or flavour, will occur.

2) Complex focal seizures

-Make an epilepsy patient confused or bewildered. For up to a few minutes, the patient is unable to reply to questions or directives.

3) Secondary generalized seizures

-Begin in one section of the brain and gradually expand to both sides. A focal seizure will occur first, followed by a generalised seizure.

The seizures that normally happen in kids have a general name, called febrile seizure. Below will explain more about febrile seizure. Febrile seizure just contain two categories, not like normal generalized seizure, which is simple febrile seizure and complex febrile seizure.

2.2.3 Febrile Seizure

Fever is the most prevalent causes of seizure in children. This type of seizure is also called as febrile seizure. Febrile seizures have been categorized into focal seizures category. It is because this seizure only happened when a child is between 6 months to 5 years old, so the name Febrile seizure had been given. There are two types of febrile seizures which is simple febrile seizure and complex febrile seizure. According to [2], these two seizures have different symptom and different characteristic. Both simple can complex febrile seizures

caused by fever, but according to the lasting time of the seizures, they had been separated to different categories and according to the lasting time, the patient have different sequela.

Table 2.2 shows the symptoms of these two types of seizures, which is simple and complex febrile seizure.

Table 2.2 Symptoms of simple and complex febrile seizure

Simple Febrile Seizure	Complex Febrile Seizure
• Caused by fever • Last for a few seconds to 15 minutes • Do not reoccur within 24 hours • Not limited to a singly body part	• Caused by fever • Last for more than 15 minutes • Will happen more than once within 24 hours period • Limited to one side of a children's body

Infections, medicines, drug usage such as amphetamines or cocaine, low blood sodium, brain injury or tumour and genetic abnormalities are all possibilities causes of febrile seizure. Sometimes, the reason of a seizure will never be discovered (The Nemours Foundation, Kids Health, 2021).

The most common seizure seen in children is febrile seizure, which occurs when there is no illness of the central nervous system (CNS) or an electrolyte imbalance.. It is defined by episodes of convulsions that occur in combination with fever in children aged from 3 months to 6 years old. Febrile seizure is thought to be a benign seizure disease that is separate from other neurologic conditions [3] .

Family history is also one of the factors that causes febrile seizures. Some children inherit a family history of fever-induced seizures. In addition, some genes have been related to a risk of febrile seizures according to experts. The main symptoms of febrile seizures

include having a fever higher than 100.4F (38.0ºC), loss of consciousness (black out), breathing difficulty, eye rolling, frothing at the mouth, and jerking or twitching of arms and legs are all signs that your skin is turning pale or bluish. [4].

Except for status epilepticus, most seizures are harmless and do not require immediate medical intervention. It's a potentially lethal disorder in which a person has a prolonged or series of seizures before regaining consciousness.. Patients with epilepsy are more likely to develop epilepticus but roughly one-third of those who acquire the syndrome have never had a seizure before. The dangers of status epilepticus rise as the seizure lasts longer (Dan Brennan, MD, 2021). There are devices that can monitor kids with seizure in order to be alert when the symptom of febrile seizure occurs.

After discussed what is seizure, type of seizure and they type of kids seizure, the next subtopic will then discuss about the important of kids' seizure detection and detection type.

2.3 Kids' Seizure Detection

To provide maximum protection to the children with seizures all over the world, there is a must for parents to always get in detect with their children so that the danger that will happen on their children can be minimized. According to Market Research Blog, 2022, The business models, major strategies and respective market shares of some of the most notable players in this sector are all examined in depth in seizure detection devices market study. The comprehensive analysis includes market statistics in terms of revenue, segment-by-segment data, region-by-region data, and country-by-country data, as well as an in-depth commentary on the key affecting variables. In below, some of the types of devices will be discussed.

2.3.1 Type of Seizure Detection

Type of detection will be list and discuss in this subtopic. Segment of type of detection will show in figure below. Besides that, some of the technologies that used to detect seizure will also include in this topic.

There are a few of detection which is commonly used by patient with seizure or epilepsy. The type of detection is conventional type, wearable type and implanted type.

Figure 2.2 below shows the type of detection which are commonly used.

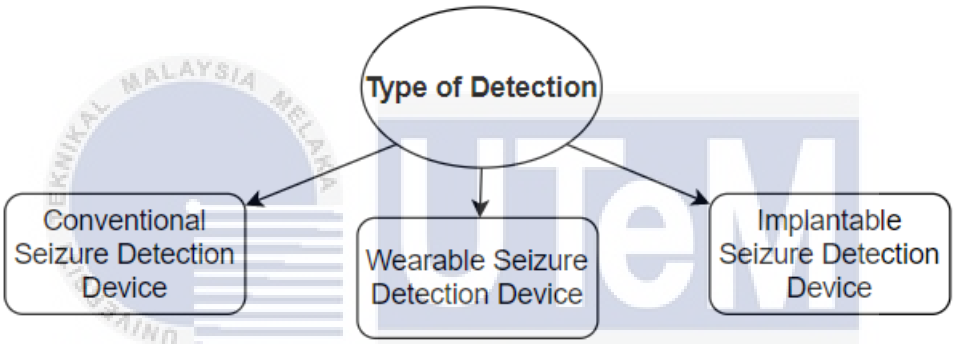

Figure 2.2 Type of detection which are commonly used

2.3.1.1 Conventional Seizure Detection Device

The conventional seizure detection device will firstly be introduced. Conventional detection is the most commonly type of detection in either kids or adults, simple or advance level. There will include 5 type of devices, which is mattress device, camera device, watch device, motion device and lastly anti-suffocation pillows.

Figure 2.3 below shows the type of conventional seizure detection devices.

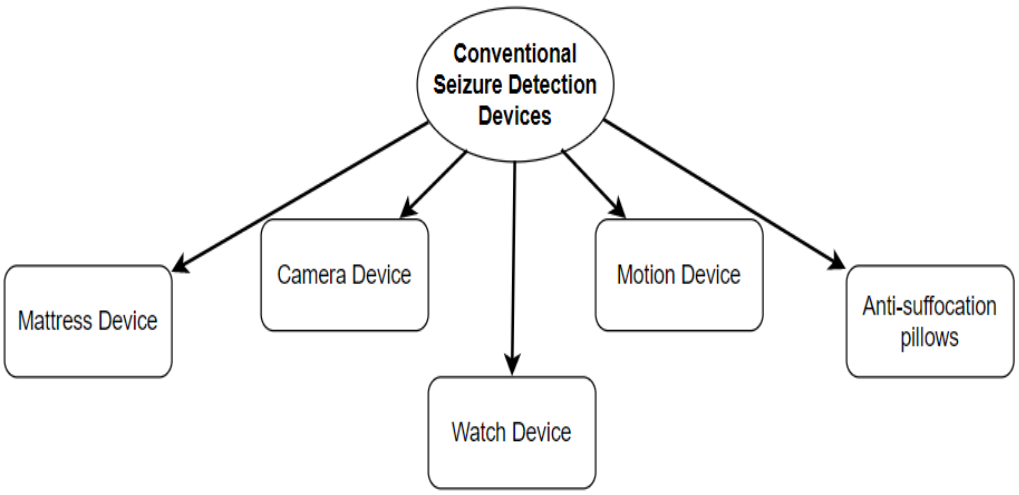

Figure 2.3 Type of Conventional Seizure Detection Devices

First is mattress device. Mattress devices are hidden under a person's bed. If the person who is sleeping on the bed have a sudden seizure, the vibrations from the shaking will set off an alarm and alert person who live with the person. Some of the examples for mattress devices is Emfit MM Sleep Monitor, or called as Emfit Epileptic Sensor Mat, and Medpage Movement Alarm. These accessible mattress gadgets can provide parents piece of mind if they worried about their child will have seizure trigger when their child is sleeping.

After mattress device is introduced, next camera device and its product will be introduce.

Camera devices is also a good choice to monitor patient with seizure. These devices use a remote infrared camera to detect movement. If a sleeping person makes unusual movements, such as shaking seizures, the camera will sound an alarm. The SAMi is an example of a seizure alert camera. This device will send an alert to the user's phone and record video of the seizure. This can aid clinicians in observing the seizure and providing more information regarding its type and behaviour.

Discussion of camera device will stop here, next is motion seizure detection device and its product.

People with seizure can use smart watches to detect their motion too. These timepieces can come with a range of characteristics. Some people sound an alarm to summon assistance. Others send a message with a person's GPS location to a caretaker or guardians if for children. For example, Embrace Smart Watch can be worn on a person's body part such as wrist or ankle. With that, the watch will detects involuntary movements, it will warns or give notifications to guardians or caregivers to the possibility of trigger by seizure. Besides that, the SmartMonitor Smart Watch is another good choice. With the present of GPS tracking technology used by this watch, it can send seizure alarms to caretakers or guardians.

Motion devices is almost same as wearable device. After wearable device had been introduce, motion detection will be the next.

Motion detection devices will monitor bodily movement such as strong shaking in arm muscles. Some devices can capture audio and provide notification to guardians or caretakers [5]. For person with seizure, wearing a MedicAlert bracelet will benefits. This helps emergency medical personnel to immediately recognise someone who has seizure and contact their emergency contacts. There are variety seizure alert gadgets on the market. Traditional metal bands with soft silicon bracelets are all available. Some people also wear epilepsy necklaces in the style of dog tags so emergency personnel can be directed to a wallet card with a person's medication list using these attachments.

Suffocation is a contributing factor in SUDEP (Sudden Unexpected Death in Epilepsy). According to [6], SUDEP is a common cause of mortality in epilepsy patients. Children have an average incidence of 0.2 per 1000 people per year while adults have an average of 1.0 per 1000 people per year. Anti-suffocation pillows are provided for patients

with epilepsy to prevent suffocation. Sleep-Safe pillow is an example. This pillow is made to prevent airflow from being blocked around a person's nose and mouth. This product do not detect seizures.

2.3.1.2 Wearable Seizure Detection Device

Wearable seizure detection devices is included inside conventional seizure detection devices. It is separated out to become one category its because now mainly in market, wearable seizure detection devices are more preferable by patient with seizure. According to Bruno et al, over 70% of persons with epilepsy accepted smartphone and watch-based devices but only 50% accepted leg, upper-arm, chest and head-based system. Over 60% people approved the ring-style wearable device[7].

2.3.1.3 Implantation Seizure Detection Device

Implatation seizure detection device is created to help adults with refractory focal seizures forecast and quantify their episodes. Two silicon leads, each with eight connections, were put over the quadrant suspected to contain the epileptoenic zone. During the data collecting phase, a hand-help device processed the collected EEG using a patient-specific algorithm. This device sent audio and visual indications minutes to hours before a seizure occurred. Indicating the likelihood of one occuring. After four months of implantation, the average sensitivity was 66% (data collected from 10 patients). The effectiveness of seizure prediction was unclear and variations in warning times and difficulty adapting to the system appeard to play a role. The main drawback of this technology is that it necessitates an intrusive treatment with the potential for consequences. 4 paients (27%) experienced major

side effects one year after implantation, including device movement and infection. This study demonstrated for the first time that a seizure detection device predicted seizures better than change.[8].

2.3.2 Type of Technology Used for Detection Device

According to [7], there are some technologies that are commonly use in market. These technologis some are commonly used in medical field but not in seizure, and some are commonly used for detection device in seizure.

The tyoe of technologies that will be introduce will include Electroencephalogram (EEG), Electromyography (EMG), Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Electrocardiography (EKG/ECG, in this report the term EKG will be used), Electrodermal Activity (EDA), Accelerometry (ACC) and lastly is Photoplethysmographic (PPG).

Figure 2.4 will show the type of technologies that are commonly used in type of detection.

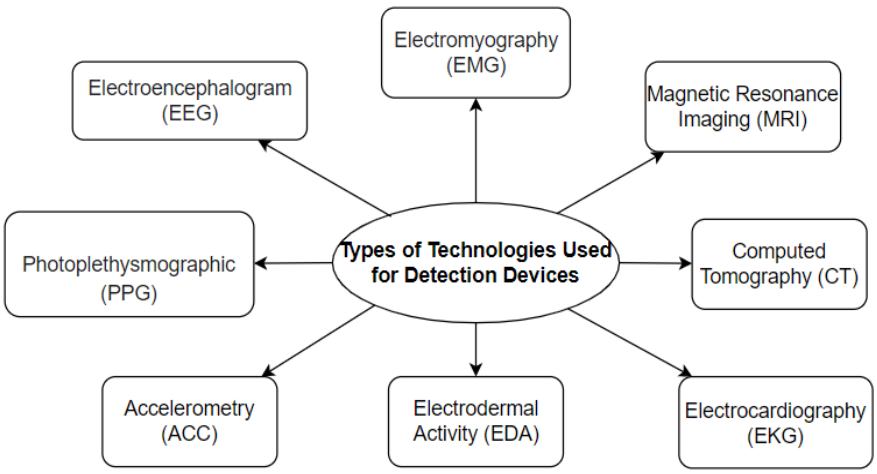

Figure 2.4 Type of technologies for detection

2.3.2.1 Electroencephalogram (EEG)

A graph of the voltage difference between two different brain sites over time is called an electroencephalogram (EEG). The scalp is affected by the electrical conductive characteristics of the tissues between the electrical source and the recording electrode on the scalp, the conductive properties of the electrode itself, and the orientation of the cortical generator to the recording electrode. Cerebral neurons produce an EEG signal.. Volume conduction, which involves current travelling through tissues between the electrical generator and the recording electrode, is used to get the EEG. Because EEG is a two-dimensional projection of three-dimensional reality, pinpointing the location of the EEG generator simply only on scalp-recorded EEG data is theoretically impossible. [9]. Video Electroencephalography (vEEG) is a more specialised type of EEG test in which the patient's brain activity is continuously monitored on a video screen. This permits doctors to monitor brainwave activity while a seizure is taking place [10]. Routine EEG had a sensitivity and specificity (95% confidence interval of 17.3% and 94.7% in adult trials respectively. The pooled sensitivity and specificity for kids studies were 57.8% and 69.6% respectively [11]. Figure 2.5 shows the example of electroencephalogram (EEG).

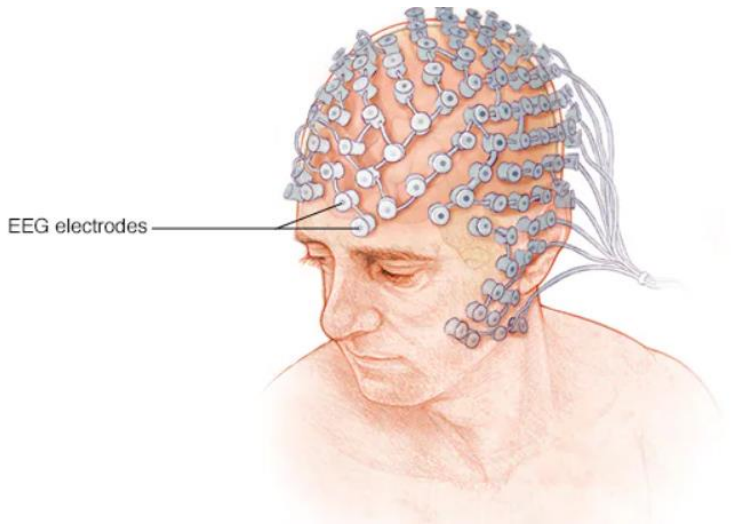

Figure 2.5 Electroencephalogram (EEG)

During the EEG test, there will be a little discomfort. The electrodes purpose is to record the brain waves of the patient and will not transmit any sensations. The procedure of EEG will explain below.

Firstly, a technician will measure the patient's head and mark the scalp with a special pencil to show where the electrodes should be placed. The patient's scalp will be scraped with some grainy cream to boost the recording quality. The discs (electrodes) will next be attached to the patient's scalp using a specific glue. In rare cases, an elastic headgear containing electrodes is utilised instead. The electrodes are connected to a gadget that amplifies and records brain waves on a computer.In rare cases, an elastic headgear containing electrodes is utilised instead. The electrodes are connected to a gadget that amplifies and records brain waves on a computer. Once the electrodes are in place, an EEG normally takes 20 to 40 minutes.Once the electrodes are in place, an EEG normally takes 20 to 40 minutes. Certain circumstances entail napping for the duration of the exam. In this case, the test can be prolonged. The patient will lie down in a comfortable position with his or her eyes closed during the examination. At different intervals, the technician may ask the patient to open and close their eyes, perform a few easy computations, read a paragraph, gaze at a picture, take a few deep breathes, or look at a flashing light. Video is generally recorded during the test. The patient's bodily movement will be recorded with a video camera, and the patient's brain waves will be recorded using an EEG. The combination of the two recording is to diagnose and give the next treatment [12].

2.3.2.2 Electromyography (EMG)

The electrical activity response or muscle response to nerve stimulation of the muscle will be measured using electromyography (EMG). The electrical activity response or muscle response to nerve stimulation of the muscle will be measured using electromyography

(EMG). When patients are unattended, bilateral tonic-clonic seizures (TCS) increase the rish of sudden unexpected death in SUDEP studies. TCS typically goes unnoticed during sleeping, resulting in unsatisfactory treatment recommendations. Wearable devices should be used to identify these large epileptic episodes automatically. TCS is characterised by a dynamic evolution of low-frequency and high-frequency signal components in quantitative surface electromyography (EMG) changes. TCS biomarkers are algorithms that target increases in high-frequency EMG signals and can be used to detect seizures as well as distinguish TCS from convulsive nonepileptic seizures. Wearable EMG sensors were shown to be accurate in identifying TCS with great sensitivity in two large-scale, blinded prospective investigation (76%-100%). The false alarm rate (0.7-2.5/24 hour) has to be reduced further[13].

Figure 2.6 will show the example of electromyography (EMG).

Figure 2.6 Electromyography (EMG)

EMG testing can be performed either as an outpatient procedure or as part of a patient's stay in the hospital. The patient's condition and the practises of the treating physician might both have an impact on the procedures that are performed. A neurologist

who is specialises in nerve and brain problems performs the EMG, while some of the test parts will be handle by a technologist. Immediately following a nerve conduction study, an electromyography (EMG) is typically carried out (a test that, rather than measuring the response of the muscle itself, assesses the passage of electricity through a nerve before it reaches the muscle itself). The cloting of the patient will asked to remove any or metal objects because it will interfere the procedure. Gown will be given to patient after their clothes have been remove. Next, neurologist will request that the patient take a seat or lying position and will identify the muscle in question to be studied. In order to disinfect the skin, an antibacterial solution will be used. After that, a fine needle that has been sterilised will be used to inject the muscle. A ground electrode will be implanted under the patient's limb or arm.. After that, the test may require five or more needle insertions. The insertion of the electrode may cause some discomfort, but it is normally painless. Any discomfort in patient will immediately stop the examiner because it will interfece the results of the test. On the oscilloscope, the electrical activity of patient's working muscle will be measured and shown. The appearance and sound of electrical potentials can be investigated using an audio amplifier. When patient contract their muscle and the patient may hear a sound that is comparable to hail falling on a metal roof since the recorder is attached to an audio amplifier. [14].

2.3.2.3 Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging, or MRI for short, is a kind of imaging that does not involve the use of any intrusive procedures and provides images of the patient's anatomy in three dimensions. It is commonly employed in the detection and diagnosis of disorders, as well as the monitoring of their progression. Innovative technology that excites and detects changes in the rotational axis of protons in the water that makes up biological tissues is the

foundation of this method [15]. MRI scans examine a person's brain structure and function and how their brain is made up and how it works. It can be used to see if there is an obvious cause for seizures in persons with epilepsy. This could be a scar or lesion on their brain shown in the photo. Because the ultimate goal of treatment, whether medicinal or surgical, is relief from symptoms and, in the latter instance, prevention of severe postresection sequelae such as speech and memory loss, MR techniques are critical for a thorough workup of a patient with seizures [16].

Figure 2.7 below will show an example of MRI machine and the body position of patient during the test.

Figure 2.7 Magnetic Resonance Imaging (MRI)

A MRI test can be tested on mainly brain and spinal cord. In here will explain the procedure for a head MRI.

To get the sharpest images throughout the exam, patient must remain still. Children who have trouble sitting still for extended periods of time may require sedation, which can be administered intravenously or orally. Sedation could be helpful for adults who experience

feelings of claustrophobia. Within the MRI machine, the patient will be positioned to sit on a table that moves back and forth. The table moves through a big tube-shaped magnetIt is possible to wrap a plastic coil around the patient's head. After the table is slid into the machine, a technician will take a number of images of the patient's brain, and each of these photographs will take a few minutes to take. Patient will be able to communicate with the personnel via a microphone that will be included within the machine. The test can often be finished in anywhere between 30 and 60 minutes. It is possible to use an IV to deliver a contrast solution, which is typically gadolinium, to the patient in order to assist the MRI machine in more clearly displaying various parts of the patient's brain, particularly their blood vessels. The MRI scanner will make a lot of hammering noises while the procedure is being performed on you. Earplugs or headphones can be provided to the patient so that they can tune out the sounds produced by the MRI scanner; alternatively, the patient may opt to listen to music during the treatment. There are no risks involved in using an MRI machine. A very small fraction of individuals could have an allergic reaction when exposed to a contrast solution. Inform the doctor immediately if the patient's renal function has significantly deteriorated. In this scenario, the use of contrast solution might not be considered safe [17].

2.3.2.4 Computed Tomography (CT)

In year of 1972, computed tomography (CT) was first publicly announced. CT has evolved into a strong and frequently utilised diagnostic imaging technique since then. With about 70 million exams performed in the United State alone in 2007. While the bulk of CT scans are sought for "normal" head and body applications, the less common and more technically challenging examinations garner the greatest interest in scientific publications and at trade fairs [18]. On 256 children with seizure disorders, CT was conducted and in the

entire group, anomalies were found in 33% of the time. An abnormal neurologic examination resulted in a 64% increase in abnormal CT scans. Although 65 percent of the children had abnormal EEGs, only localised slowing caused a substantial increase in the number of abnormal CT scans. Seven of the youngsters (2.7%) had intracranial abnormalities that need surgery. The yield of aberrant CT scans was only 5% of the total if the neurologic examination and EEG were normal [19]. Despite the fact that both types of scans have the same goal, the images they create are not the same. A magnetic resonance imaging (MRI) scan employs strong magnetic fields and radio waves, whereas a CT scan uses X-rays. CT scans are less expensive and more common, although MRI scans are more comprehensive. A CT scan entails lying down in a large X-ray machine called a CT scanner. The scanner transmits images to a computer. An MRI scan entails lying down in an MRI scanner, which is a machine that creates a continuous magnetic field by bouncing radio waves off water molecules and fat cells in the body. Images from the MRI scanner will be transferred to a computer in the same way that CT scan images are [20].

Figure 2.8 below shows the example of the CT machine and the position of the patient during test.

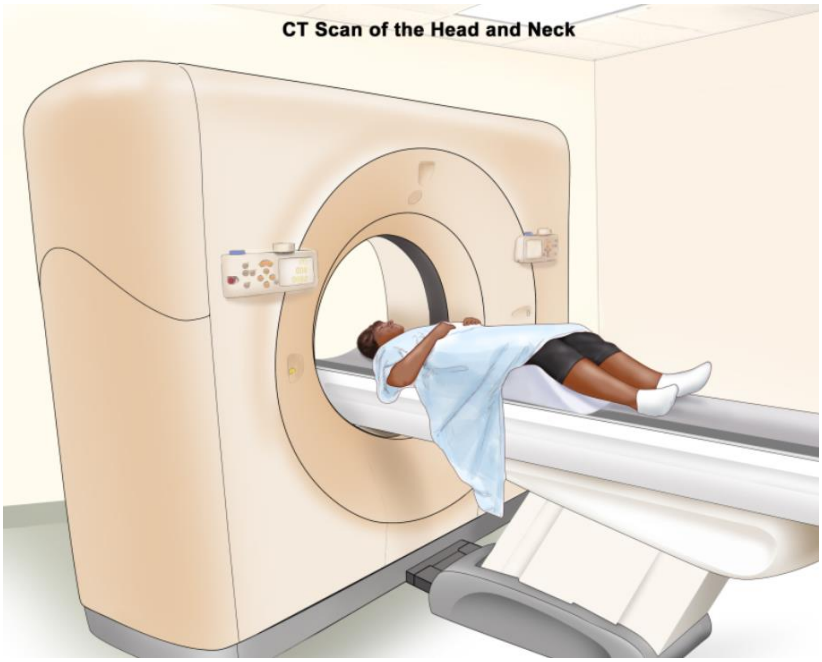

Figure 2.8 Computed Tomography (CT)

Here is the procedure of CT scan. Patient will be asked to change into a hospital gown when patient arrive for his/her CT scan. Patient's scan technician may place an IV catheter in their arm or leg and inquire if they have removed any metal gadgets or medication patches before coming in. Doctors may also go over the reason for the scan, any allergies that the patient have, and any other particular instructions he/she have. When it's time to start the scan, patient be seated on a long, narrow table with velcro straps or other safety mechanisms to keep them in place. Depending on which portions of their body need to be visualised, the table will slide in and out of the circular scanner. Before running the scanner, the technician will leave the room and may give the patient instructions through an intercom. The machine will circle around patient as the table travels in and out of the scanner, generating a loud noise. It's possible that patient will be instructed to hold their breath or hold particular positions. Otherwise, be as steady as possible to avoid blurry photos being captured by the scanner. Time duration is about 20 minutes to 1 hour [21].

2.3.2.5 Electrocardiogram (EKG/ECG)

An electrocardiogram, also known as an EKG or ECG, is commonly performed in hospital, ward and also clinic. In operation rooms and ambulances, EKG, machines are commonplace. EKG monitoring is available on some personal gadgets such as smartwatches. In all patients with seizures or suspected seizures, an EKG is advised as a test. The prevalence of aberrant EKGs in patients presenting to the initial seizure clinic. On the other hand, remains unknows. According to one research in 2009, this approach has an 85.7% sensitivity and 84.6 percent specificity [22]. In year of 2014 employed EKG signals to achieve a positive predictive value (PPV) of 86.2% for partial seizures and a sensitivity of 100% for generalised seizures. Professionals have recently proposed a multivariate statistical technique for epileptic seizure prediction that has a sensitivity of 91% and a false positive rate of 0.7 h1 (Koichi Fujiwara et al., 2016).

Figure 2.9 show the modle of EKG and the body position of patient while the test is going on.

Figure 2.9 Electrocardiogram (EKG/ECG)

An EKG is a rapid, painless and completely safe procedure. A technician applies roughly 10 soft electrodes (about the size of a quarter) to the patient's chest, arms and legs after they change into a gown. These electrodes are connected to wires and connected to the EKF machine. The technician may shave these places where the electrodes are attached if they are not completely shaven. Patient will lie still on the table and breath regularly during the test. When the test is going, patient cannot talk. The equipment will capture the electrical activity of patient's heart and display the results on a graph. The electrodes are removed and disposed after the test is completed. It should take roughly 10 minutes to complete the procedure [24].

2.3.2.6 Electrodermal Activity (EDA)

Electrodermal activity (EDA) is a metric for neurally mediated effects on sweat gland permeability, as measure by changes in skin resistance to a tiny electrical current or electrical potential differences between different areas of the skin. The activity of sympathetic nerve traffic on eccrine sweat glands is refected in the EDA signal [25].

Figure 2.10 will show the example of a product that have EDA on it.

Figure 2.10 Electrodermal Activity (EDA)

Figure 2.11 below shows a result that taken from different research. For two research from (Poh 2012) and (onorati 2017) which have the data for EDA, it shows that the type of seizure that can be detected by EDA is tonic-clonic (TC) seizure and clonic seizure (C). The percentage of sensitivity is all 90% and above and the false detection during the night (FDR/night) in 8 hours is below 0.3.

	Modality						n	Seizure type	%sens	FDR/night (8 h)	Algorithm	Inclusion bias
	ACC	EMG	HR	EDA	Oximetry	Remote						
Conradsen 2010[15]	x	x					5	TC, C, M	91-100	0.64	ML	y
Milosevic 2016[16]	x	x					56	TC	91	0.33	ML	y
Poh 2012[17]	x			x			80	TC	94	0.25	ML	Some
Onorati 2017[18]	x			x			69	TC, C	95	0.07	ML	y
Van de Vel 2014[19]	x					Video/radar	1	TC, C, T	56	20	ML?	n
Van Andel 2017[20]	x		x				43	TC, C, T, H, M	71-87	2.3-5.7	Physiol	n
Goldenholz 2017[21]			x		x		45	TC	81	9.6	Physiol	y
Fulton 2012[22]						Mov/sound	27	All	4.3	?	?	n

Figure 2.11 Results for Accuracy of EDA[26]

2.3.2.7 Accelerometry (ACM)

Accelerometry, ACM has been use to treat motor seizures because it able to detects varations in direction and velocity. A three-axis motion or accelerometer sensor, a microprocessor and a small rechargeable battery will commonly placed on a limb and record the signal. Some systems offer a cancel button that can be used to indicate that a movement was a false alarm to prevent the caregiver from receiving a false-positive alert [27]. GTCS, secondarily generalised seizures, myoclonic, clonic, tonic and hypermotoer seizures, were all detected using this technique. Clonic seizures have a burst-like pattern that is easier to spot and distinguish from other movements. Because the acceleration is nearly constant, tonic seizures are block-shaped. They resemble gradual, natural movements, making them difficult to spot. Absence seizures and focal dyscognitive seizures without motor symptoms were not found [28]. The sensitivity ranges from 16 to 100 percent with an FDR of 0.2 per day in one research. Seizures were detected from 9 to 60 seconds after they began. The similar level of accuracy was attained for both nocturnal and day-time seizures [27]. In one trial, the system was found to detect 78.5% of the seizures reported by parents in a home setting with only 0.6 false alarm every night [29].

Figure 2.12 shows the example of an accelerometry, which is normally wear by patient in their wrist part.

Figure 2.12 Accelerometry(ACC)

2.3.2.8 Photoplethysmography (PPG)

Photoplethysmography (PPG) is a simple and inexpensive optical measurement technique that is commonly used to monitor heart rate. PPG is a non-invasive device that measures the volumetric fluctuations of blood circulation using a light source and a photodetector at the skin's surface. Many academics around the world have recently expressed an interest in extracting more useful information from the PPG signal in addition to heart rate estimation and pulse oxymetry values. The second derivative wave of the PPG signal contains vital health data. As a result, researchers and physicians can use this waveform to assess various cardiovascular illnesses like atherosclerosis and arterial stiffness. Furthermore, studying the second derivative wave of the PPG signal can aid in the early detection and diagnosis of a variety of diseases. Furthermore, examining the second derivative wave of the PPG signal can aid in the early detection and diagnosis of a variety of cardiovascular diseases that may manifest later in life. Continuous and real-time

monitoring, enabled by recent technological developments in sensor technology and wireless communications, is an important technique for early detection and analysis of such disorders.

Figure 2.13 shows the example of a PPG. PPG will normally be placed on human's finger to get data.

Figure 2.13 Photolethysmography(PPG)

For benchtop level, which are innovative sensors under development and not available commercially. Test will normally take from saliva or from metabolites, which put a sensor infront of the patient's chest and take data.

Moving on to approved level, which include sensor systems CE Marked or FDA approved for seizure and epilepsy. EMG, which will put on the forearm part and ACC which is put at the wrist part. Both of these sensors will put on the patient's body part and test will go on to getht the results which the doctor wish to get.

Research grade devices are commercially available and provide high-quality and accurate data. These devices are EEG, ACC, PPG, EKG, EMG and EDA. EEG will be placed on the head. On the chest part, devices will included ACC, PPG, EMG, EKG and EDA. Data can also get by placing these devices, ACC, PPG and EDA on the forearm of the patient.

Wrist will be the last body part for research grade devices to get their data. In wrist part will contains ACC and PPG.

Consumer grade devices will be the last categories among these four. Consumer grade sensors are commercially accessible sensors designed for situations where data accuracy is not critical, and may deliver information to the user via interpolation or estimation methods. Four body parts, which are head, chest, wrist and finger are the common part for these devices to take data from a patient's body. EEG will normally put on the head. For the chest part will include with ACC, PPG and EKG. Wrist part will include ACC, PPG EDA and lastly for finger, the devices are ACC and PPG.

Figure 2.14 below shows the technology of detection that works well in each body part. Inside it contains level from fundamental to advanced, which is benchtop, approved, consumer grade and research grade.

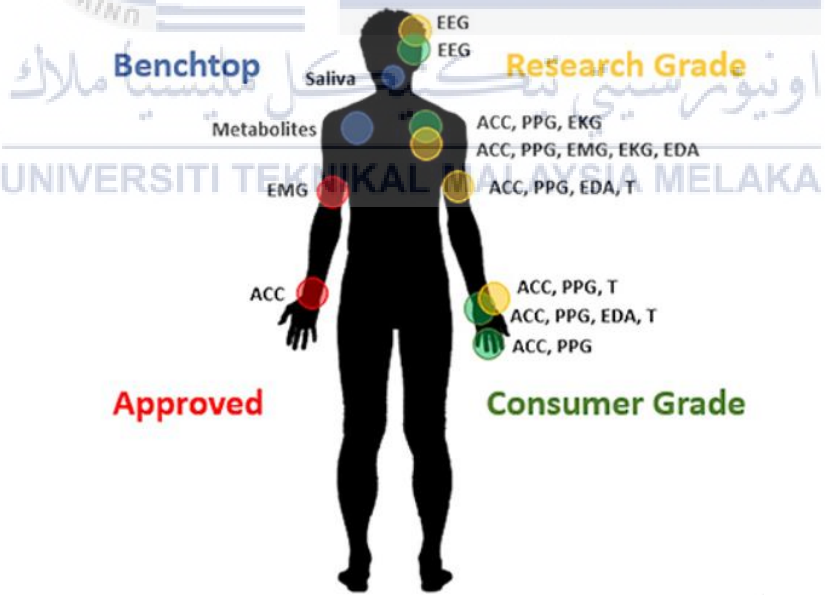

Figure 2.14 Technology of Detection that Works Well in Each Body Part

The type of detection for seizure still had been discussed. The next subtopic will discuss about Internet of Thing (IoT) and activity tracker.

2.4 Activity Tracker IoT (Internet of Things)

In this topic, activity tracker IoT will be discussed. At first, activity tracker and IoT (Interner of Things) will be introduce and explain briefly.

Activity tracker is a wearable technologies which is now well-known in the market that mainly to monitor energy expenditure and heart health. Personal fitness indicators such as the amount of steps taken, heart rate and sleep quality can all be measured using activity trackers. Activity tracker can be in many ways but the most popular in the market will be in type of wristbands and smartwatches. Examples of wristbands are Fitbit, Mio and for smartwatches are Apple Watch, Samsung Galaxy Gear [30].

Table 2.3 shows the price and example for these wearable technologies which are well-known and mostly used in the market.

Table 2.3 Price and examplf of wearable technologies

Fitbit Flex	**Mio Link**	**Apple Watch**	**Samsung Galaxy Gear**
RM 126.91	RM 412.50	RM 3399.00	RM 999.00 – 1399.00 (according to watch surface diameter)

Follow by table of pricing, the features inside each activity tracker will slightly be introduced.

The first activity tracker that will be introduce in Fitbit Flex. The features of Fitbit Flex have alot but the main 6 features are all-day activity, progess display, auto sleep tracking and silent alarms, interchangeable accessories, long battery life and lastly wireless syncing. Figure 2.15 shows the physical product image of Fitbit Flex.

Figure 2.15 Fitbit Flex Product

For the first feature, all-day activity, is mainly keep track of user's steps, distance traveled, calories burned, active minutes, hourly activity and time spent stationary. For second feature which is progress display, it is used when user get closer to their daily goal, the LED will light up. The third feature, auto sleep tracking and silent alarms, will track user's sleep quality automatically and wake up calmly with a silent alarm. Fourth feature, interchangeable accessories, is to flex user's style with Fitbit and Tory Burch accessories. Fifth feature, long battery life, allow up to 5 days of battery life means user can monitor all day and night without needing to charge. The final feature, wireless syncing, will sync metrics to desktops and 200+ popular iOS, Android, and Windows devices wirelessly and automatically.

Figure 2.16 below shows the feature of Fitbit Flex in summary.

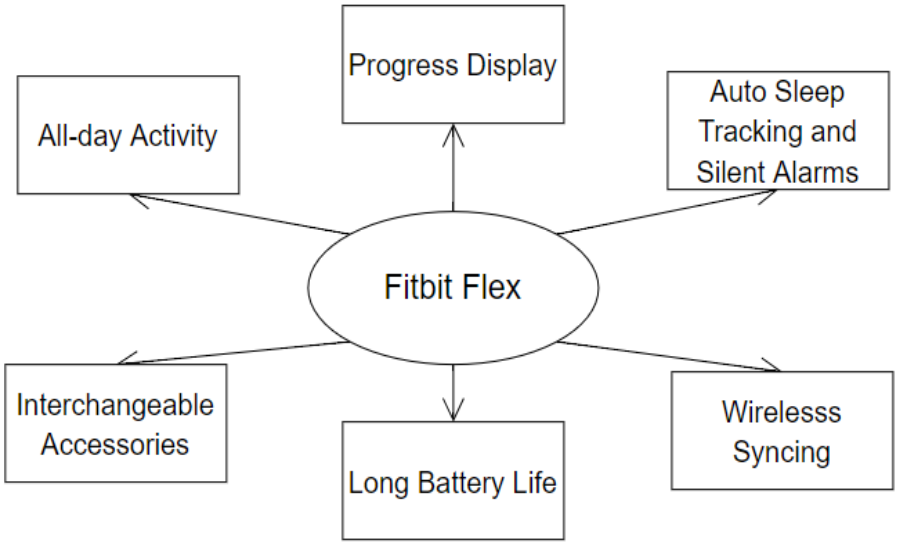

Figure 2.16 Features of Fitbit Flex

The next activity product that will be disccussed is Mio Link. There are alot of advantages in Mio Link, and the following paragraph will explain the advantages of having a Mio Link acitivity tracker.

Advantage will come first, The first advantage is Mio Link is very comfortable when wearing it on the wrist with heart rate monitor, Secondly, it can act as an agent tracker and can able to work with many smartphone applications. The indicator light will change it colour with heart rate zone is also one of the advantage of this activity tracker as it can notify user about their heart rate. Besides that, it also design in a way of button-less so that it is more ideal for runners, cyclists and sports enthusiast. Lastly, it is water resistant and has both Bluetooth Smart and ANT+ [31].

Figure 2.17 shows the physical product of Mio Link.

Figure 2.17 Mio Link

After Mio Link, the next product will followed by Apple Watch. The Apple Watch Series 7, which debuted in 2015 and succeeded the Series 6, was announced in September 2021 as the current edition of the Apple Watch. The Apple Watch Series 7 includes a more rounded look than prior Apple Watch models and some important new features such as larger displays, greater durability, and faster charging. Apple Watch Series 7 comes in new 41 and 45mm sizes, which are 1mm larger than prior generations' 40mm and 44mm sizes, and the casings have been improved with softer, more rounded edges. The Apple Watch Series 7 has a black ceramic and sapphire crystal backing, as well as a Digital Crown with haptic feedback, similar to the Apple Watch Series 6. A built-in ECG sensor is included with the Digital Crown [32].

Figure 2.18 shows the physical product of Apple Watch, in this case we use Apple Watch Series 7.

Figure 2.18 Apple Watch

The last product that will be introduce is Samsung Galaxy Gear. The features that are present in Samsung Galaxy Gear is it possesses a 800MHz Exynos processor which give it a high speed. It has a 315mAh battery and a 1.63-inch 320x320 resolution Super AMOLED display. The Samsung Galaxy Gear features a 1.9MP camera with BSI sensor technology. Samsung Galaxy Gear comes with Samsung Apps and the ChatON messaging service pre-installed. There are two microphones and one speaker on the device. It is equipped with Bluetooth 4.0 technology and lastly it contains 4GB of internal storage and 512MB of RAM. Figure 2.19 shows the physical product of Samsung Galaxy Gear.

Figure 2.19 Samsung Galaxy Gear

2.4.1 Internet of Things (IoT)

IoT (Internet of Things), also knows as Internet of Everything or Industrial Internet. This is a new technology paradigm that envisions a global network of machines and objects that can communicate with one another. The IoT is widely considered as one of the most essential areas of future technology and it is attracting significant interest from a variety of businesses. When linked devices can communicate with one another and integrate with vendor-managed inventory systems, customer support systems, business intelligence tools and business analytics, the true potential of the IoT for businesses may be completely realised [33]. In short, IoT have the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

According to [34], children who have an activity tracker on their body with access to IO monitoring and GSM (Global System for Mobile) technologies are constantly monitored. The system includes sensors that are connected to the processor and continuously monitor important data such as heart rate, temperature, and so on. As a result, anytime potentially dangerous situations emerge, parents may be alerted. The parent can set a safety distance for each child, and the system will alert both the parent and the youngster if it is exceeded. When a child crosses a zone (for example, a school zone) due to harassment, the system instantly transmits information to the parents and the local police station, notifying them of the problem's status.

2.4.2 Method that an Activity Tracker IoT Used to Track Data

For a variety of reasons, activity monitors are beneficial nowadays. They assist you in becoming more conscious of your current exercising, sleeping, and eating habits. You can detect behaviour patterns if you are more mindful of your tendencies. It's a lot easier to set

health objectives now that you know this. Furthermore, activity trackers give enjoyable social avenues for you to discuss your accomplishments and challenge your peers. Physical inactivity among individuals in general, especially children and teenagers, is becoming a global public health issue. More than 80% of the world's adolescent population is insufficiently physically active, according to the World Health Organization. Obesity is a result of inactivity, and it is developing at alarming rates among youngsters. So, most of the medical specialist would hope that by wearing an activity tracker can reverse this trend. Children and teenagers can use an activity tracker to become more conscious of how active or inactive they are. Gentle reminders to get up and walk about for a few minutes, or to go outside and play with a ball or the dog, can help youngsters maintain a healthy lifestyle from a young age [35].

There are a few features that should be included inside an activity tracker and which are normally and commonly needed by people who living in this era which we rely on advanced technology alot. The features will include location, heart rate, Calories logging and calories burning, blood pressure, body temperature and sleep tracker. Different features will accompany with different type of technology used. Table 2.9 will discussed the function that normally appear in an activity tracker IoT and its method that used to measure the data from each angle.

Table 2.4 shows the functions and method used for activity tracker.

Table 2.4 Function and method used for activity tracker

Function	Method used
Location	1. Geographic Information Systems (GIS) - Capturing and storing geographic data for large-scale location-tracking systems.

	- Capable of capturing, storing, analysing and reporting geographic data. 2. Global Positioning System (GPS) - Able to locate or more of these satellites to figure out distance through trilateration.
Heart Rate	1. Photoplethysmography (PPG) - Blood will absorb green light, so green light underside the tracker combine with light sensor will measure heart rate in different light absorption.
Calories logging and calories burning	1. Basal metabolic rate (BMR) - Activity tracker IoT will get basic information from user such as height, weight, age, gender and more. - BMR will be calculated automatically, this rate will use together with algorithm to calculate number of calories burned. 2. Activity level - By using accelerometer, the tracker will track the activity level of user each day. - Data collected will used by algorithm to calculate calories burned. 3. Manual entries

	- Information such as food consumed and activity that user had participated will be ask and record by tracker. ∴With measurement from accelerometer and BMR inserted by user, activity tracker IoT can calculate calories burned in a day by using algorithm. Additional information will make the calculation more accurate.
Blood pressure	1. Photoplethysmography (PPG) - Detect heart rate. 2. Electrocardiogram (EKG/ECG) - Track blood flow.
Body temperature	1. Electrodermal activity - Sensor will able to sense when user skin feels hot, chilled and clammy.
Sleep	1. Accelerometer - Detect when a person have be lying still for a period of time and it begins to start counting that as sleep. 2. Heart rate monitor - Suggested that various stages of sleep correspond to various heart rate patterns.

Activity tracker IoT is an amazing innovation in this era. After this subtopic, the next will goes to seizure tracker that are used among the patients with seizure and epilepsy. There are alot of amazing technologies that can help the patient with seizure.

2.5 Seizure Tracker

A seizure tracker is also known as a seizure alert device which mainly give alert and monitor for patients with seizures. If a patient have epilepsy or seizure, they were recommended to use this electrical device because it can warn patients themselves and their caregivers if they having a seizure or have some symptoms of might having a seizure. This device would not be able to stop seizure from happening but at least some precautions can be take in advanced.

Seizures are a type of aberrant brain activity that can result in stiffness, jerking motions, convulsions or limping. They also will change the a patient in state of consciousness, behavior and sensations for a short period of time. To prevent risk of seizures such as falling down to ground with seizures happen, drowning while a patient have seizures while in swimming pool or getting car accident when seizure trigger, it is an ideal choice for patient to get their own seizure tracker.

Some patients with epilepsy may not be able to use seizure tracker. Detecting aberrant movement is how the seizure tracker function. If a patient's seizures do not accompanied with shaking, twitching and cramp, this electrical device might not fit well in that patient. On the other hand, doctors are conducting more research in order to advance these devices and provide additional possibilities. Amount of hundred dollars can be spent on this seizure tracker therefore some people cannot afford it ([36].

2.5.1 Type of Seizure Tracker

The majority of seizure tracker use non-invasive wearable or non-wearable technologies to track patients' movement and send data to a smartphone applications. A lot of non-invasive methods are available for parents which their children with epilepsy who want to monitor their children at night.

The type of non-invasiveseizure tracker are made in different ways, which included pad-type sensor, camera, pulse oximeter, smartwatches and non-invasive monitoring device. Table 2.5 are types of non-invasive seizure tracker include.

Table 2.5 Types of non-invasive seizure tracker

Type of non-invasive seizure tracker	Function
Pad-type sensor	- Put under the bed/mattress to detect strange movements while sleeping. - An alarm will sound if unexpected movement is detected.
Camera	- Transmit video through phone applications and analyses it for any strange motions while patient is sleeping. - Will automatically records any unexpected movement and send an alert to phone if it detected.

Pulse Oximeter	- Devices that can measure heart rate and blood oxygen levels and can be worn on a finger to send an alarm through smartphone applications if significant changes are detected. - Could happen during a seizure.
Smartwatches	- Typically movement is recorded and relayed to a smartphone application.
Non-invasive monitoring device	- Worn on the bottom half of bicep to continually monitor the are of brain that governs voluntary motions in the body.

2.5.2 Product of Seizure Tracker in Marker

In this section, some product in each category for example mattress device, camera device, wearable device, motion device which is widely used and still using in market will introduced.

First, the products for mattress devices will be introduced, which is Emfit MM Sleep Monitor and Medpage Movement Alarm.

2.5.2.1 Emfit MM Sleep Monitor (Emfit Epileptic Sensor Mat)

The Emfit MM Sleep Monitor is also a tonic-clonic monitor. It can detect seizures that occur while a person is sleeping and send an alert. The device is capable of detecting even the tiniest movements while intelligently distinguishing between normal sleeping behaviour, making it ideal for usage by everyone which including small children and the elderly.

Bed sensor mat and a control device make up the seizure monitor. The sensor pad is placed beneath the mattress and detects the movements of the person sleeping on top of it, including micro-movements generated by heartbeat and breathing. The control unit begins to sound alarm when the system detects a seizure. The design of putting the sensor underneath the mattress is not to affect the normal sleeping patterns of users. Using the provided brackets, the control unit can be put next to the bed, mounted on the wall or clipped on the bed frame.

Figure 2.20 shows the physical product of Emfit MM Sleep Monitor.

Figure 2.20 Emfit MM Sleep Monitor

In this study shows that it was a very effective meeting in this objective of Emfit monitor. The sensor caught 84.6% of generalised tonic-clonic seizures that occurred while children were sleeping and 75% of these events that occurred while they were awake in bed. The alarm was less sensitive to seizures that did not entail rhythmic movement, although it was still able to identify them in some situation. The monitor is effective in identifying generalised tonic-clonic seizures, which have been related to an increased risk of sudden unexplained death in epilepsy (SUDEP). The Emfit movement monitor was used in this investigation to detect a significant percentage of tonic-clonic seizures in sleeping patients. It could also be used to detect children with epilepsy and nocturnal generalized tonic-clonic seizures [37]. Figure 2.21 below shows an experimental data by [37] about the accuracy of Emfit monitor sensor.

Seizure type	Seizures captured	Seizures causing alarm activation	Seizures in sleep	Seizures in sleep causing alarm activation
Generalized tonic-clonic	16	12 (75%)	13	11 (84.6%)
Simple motor	7	4 (57%)	4	2 (50%)
Complex partial with motor involvement	12	3 (25%)	2	2 (100%)
Tonic	11	3 (27%)	2	0
Myoclonic-tonic	12	1 (8.3%)	2	0
Complex partial without motor involvement	9	0	1	0
Myoclonic	11	0	4	0
Total	78	23 (29.5%)	28	15 (53.6%)

Figure 2.21 Emfit monitor sensor experimental data

2.5.2.2 Medpage Movement Alarm (MP5)

The Medpage MP5 is an under-the-mattress microphone system designed to capture the sound of seizures during the night. It does not have medical device approcal or clearance. 64 participants were investigated in the EMU for a total of 1528 hours in one study, with eight GTCSs detected during that period. With a false-alarm rate of 4.2 per day, five of the eight

were discovered, equals with 63% of sensitivity [38]. Only one convulsive seizure was detected by the MP5 device in a paudiatric study in the EMU, out of 23 seizures was recorded The rate of false alarm was not disclosed [39].

Figure 2.22 shows the physical product of Medpage Movement Alarm (MP5).

Figure 2.22 Medpage Movement Alarm (MP5)

Emfit MM Sleep Monitor and Medpage Movement Alarm are both mattress devices. The price of Emfit product is about $594 and Medpage product is $403. Although the price of Emfit product is slightly higher than Medpage product, its sensitivity on detecting seizure in also much higher than Medpage product. The sensivity of Emfit MM Sleep Monitor can reach 89% but Medpage Movement Alarm jsut only 62.5%. Both of the products used vEEG technology and their targeted community are both young children and adults.

Table 2.6 below shows a comparison data for Emfit MM Sleep monitor and Medpage Movement Alarm (MP5) from [40].

Table 2.6 Comparison data from Emfit MM Sleep Monitor and Medpage Movement Alarm (MP5)

	Emfit MM Sleep Monitor	Medpage Movement Alarm (MP5)
Cost (in USD)	$594.00	$403.00
Sensitivity	21%-89%	11.1%-62.5%
Technology used	vEEG	vEEG
Age range	- Young children - Elderly	- Older children (body weight above 25kg) - Adults
Do product clinically proven?	No	No
Warranty	2 years	3 years
Size	53.0cm x 40.0cm x 0.1cm	15cm x 10.5cm x 4.5cm
Installation	- Easy to setup - No engineer or training required.	-

In this paragraph, camera device will be introduced and discussed.

2.5.2.3 SAMi-3

SAMi-3 is a sleep activity monitor designed for guardians and those who need to keep an eye out for unexpected movements during the night. Audio-video data from a remote infrared video camera is delivered to an iOS app that runs on an iPHone or iPod Touch while the user is sleeping. The SAMi app captures video and analyses it for any strange acivities. It raises an alarm and records live audio and video from the SAMi network camera when an unexpected event is detected. Any necessary action can be taken by the individual or caregiver in a matter of seconds [41].

The price of a SAMi-3 is $650. It contains of 32GB and 128GB storage. This product was recommanded for parents who wants to monitor their kids with seizures. SAMi will give out a loud alarm when children have abnormal movements while sleeping. This alarm do not easily sound when a children is trying to tossing and turning during sleep. Besides that, it

also make recording job so parents can show their doctors about the behaviour os their children while they was sleeping. SAMi is able to work without a WIFI . SAMi-3 camera device should be used together with a phone application [42].

Figure 2.23 shows the physical product of SAMi-3 camera device.

Figure 2.23 SAMi-3

Next, wearable device will be introduced and the features will be discussed. Wearable device to detect seizure will include Embrace Smart Watch and SmartMonitor Smart Watch.

2.5.2.4 Embrace Smart Watch (Embrace 2)

Embrace 2 is the only FDA-approved wrist-worn epilepsy wearable device. FDA represents Food and Drug Administration. FRA-approved means that the “benefits of the product outweigh the recognised hazards for the intended usage”. To obtain approval, manufactureres must submit a premarket approval (PMA) application along with the

findings of clinical testing [43]. It identifies the possibility of convulsive seizures and warns the guardians immediately. Whethre they are sleeping next door or thousand of kilometres away. Designed to provide 24 hours safety and comfort to person with epilepsy so they can obtain help when they need it the most [44].

Figure 2.24 shows the physical product of Embrace Smart Watch (Embrace 2).

Figure 2.24 Embrace Smart Watch (Embrace 2)

The Embrace 2 product had been seperated from parts to parts and explanation will be given about the technology used in Embrace 2.

1. **Top cover**

- Anodized metal is used to keep water out and boost durability.

2. **Electronics Board**

- CPU, RAM, Bluetooth antenna, LEDs, touch sensor, accelerometer and gyroscope are among the components. Gyroscpes are intriguing object that move in strange ways and even appear to defy gravity [45].

3. Lithium Polymer Battery

- Extremely small and light, with a long battery life.

4. Bottom Cover

- Vibration motor and exposed electrodermal activity (EDA) electrodes.

Figure 2.25 shows the design of Embrace 2. Materials and features will be explained below according to ascending order[44].

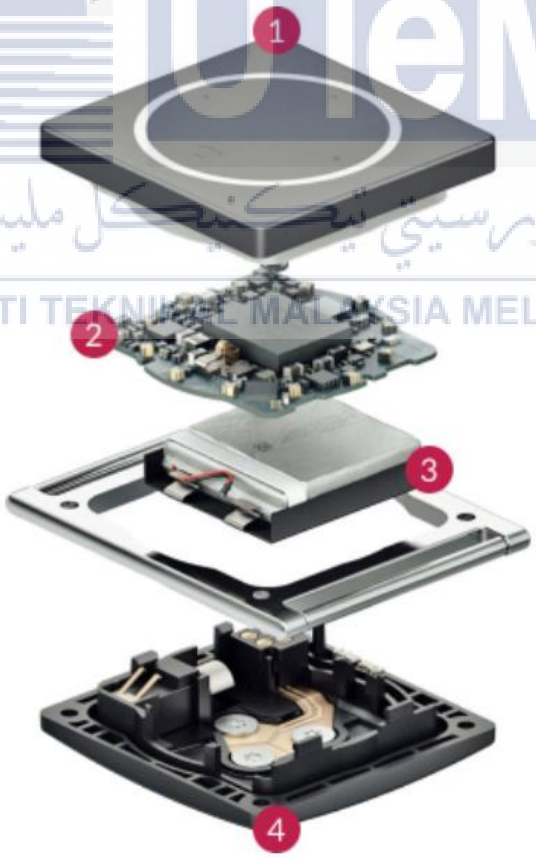

Figure 2.25 Design of Embrace 2

This device has Class IIA clearance in the European Union, which means it can monitor physiological processes without causing immediate harm. It's worth nothing however this level of approval specifically excluds monitoring physiological processes where deviations could cause immediate harm [40].

A number of papers have described the performance features of Embrace and other Empatica devices. A prototype device measuring EDA (Electrodermal Activity) and ACM (Accelerometry) was utilised in 80 patients in the EMU (Epilepsy Monitoring Unit) in a single-center trial with a total of 4213 hours (127 days) of recorded time. Wtih a false-alarm rate of 0.74 per day, a semi-patient-specific algorithm (trained on recording data from the seven patients with GTCSs (Generalized Tonic-Clonic Seizure) using leave-one-serizure-out cross-validation) reached 94% sensitivity (detecting 15/16 GTC) [26].

For an average of 3.5 days, each patient was monitored. During this time, the patients' seizure diaries were recorded a total of 111 GTCSs, which is a very high rate of seizures. Multiple detection algorithms were tested and modified offline in this study:

1. Top performing algorithm had a sensitivity of 93% (103 of 111 seizures were correctly detected). The sensitivity of detection was lower for evernts that occurred during exercise.
2. 40 of 46 events during actiovity were accurately detected (87%), compared to 63 of 65 events during rest (97%).

The average number of false alarms per day was 0.58/ Data from three patients who had gathered Embrace data for more that one year were provided in another conference presentation [40]. According to a poster report from [46]. Three patients data were collected over 1609 days and had 330GTCSs in total, indication a significant seizure rate. Two patients' sensitivity was 100%, while the third patient was 97%, with a false-alarm rate

ranging from 0.1 to 0.32 per day. Only one nocturnal event was missed in the entire datat collection, and all false alarms occurred during the day. A case of likely SUDEP (Sudden Unexpected Death in Epilepsy) in a 20 year-old patient while wearing the Embrace had been described, despite the device's alarm (Picard et al., 2017).

2.5.2.5 SmartMonitor SmartWatch

SmartWatch is a product from Smart Monitor, which is a proprietary, inteliggnet and non-invasive wristwatch that continuously monitors the used and warns family members and caregivers when abnormal movement patterns resembling those caused by generalised tonic-clonic (GTC) seizures occur. Whent the SmartWatch detects repetitive shaking action, it send SMS and phone call alerts from the user's Bluetooth-connected Andriod phone to preset alert recipients. Family members reveice SmartWatch alerts in seconds which contain the event's data, time, GPS location and duration.

SmartWatch is a totally portable device that may be worn in and out of bed, during sleep and waking hours. As users go about their daily lives in homes, schools, offices and other locations. SmartWatch gives caregivers piece of mind y ensuring that they will be notified if their loved one exhibits excessive movements which could indicate a seizure. SmartWatch also provides wearers with independence, allowing them to go about their daily routines without worrying about getting aid if they experience a seizure.

Figure 2.26 shows the physical product of SmartMonitor Smart Watch.

Figure 2.26 SmartMonitor Smart Watch

There is a study on SmartMonitor Smart Watch. From this study, there are review from University of California, Stanford University Medical Center and St. Jude's Le Bonheur Children's Hospital. The study in this SmartMonitor Smart Watch is very new.

Table 2.7 shows the clinical studies of detection accuracy of SmartWatch according to [48].

Table 2.7 Clinical studies for detection accuracy of SmartWatch

Medical Institutions	Date	Cases
Stanford University Medical Center	Jan 2009-June 2010	The SmartWatch was able to detect all but one generalised tonic-clonic seizure in this research, which lasted over a year and involved adult patients.

University of California, San Francisco Pediatric Epilepsy Center	July 2011-Jan 213	Patients as young as three years old wore the SmartWatch. The SmartWatch did not miss a single seizure in over 500hours of testing. During the entire testing period, there was only one false positive. Based on algorithm enhancements made following the Stanford studies, this shows a significant increase in accuracy.
St. Jude's Le Bonheur Children's Hospital	Jan 2013-Present	The research is centred on the SmartWatch's data reporting and aggregation capabilities. The research began in January 2013 and is expexted to finished soon. So no accurate report will be shown.

The product that will going to introduce and discuss is MedicAlert, which will be catogorized inside motion detection.

2.5.2.6 MedicAlert Medical ID Bracelets

There are alot of design for MedicAlert Medical ID Bracelets. The price range for the bracelet is from $24.99 to $1449.00 depends on the material used and design.

To be able to use MedicAlert product, a fee should be paid and the range is between $20 to $60 per month depending on the requested features and functions. The plans offer some of the best value in the market. Annual plan also would be able to cancel anytime and it is refundable. A qualified emergency despatcher will come over the two-way speaker and inquire if the user is okay when an alarm is transmitted to the Command Center. The Command Center will contact the user's Circle of Care (pre-designated contacts), emergency services or both based on the user's reaction. If user become unresponsive, Command Cneter will immediately contact emergency services, followed by the user's Circle of Care. Figure 2.27 shows the physical product of MedicAlert Medical Bracelets (Alert1).

Figure 2.27 MedicAlert Medical Bracelets

To function MedicAlert Medical Bracelets smoothly, there are a few steps that need to follow. Below are some few simple steps to work the MedicAlert Medical Bracelets (Alert1)

1. Wear the bracelets on user's wrist comfortably. Wear the alert bracelet at all times to ensure that user are ready for anything. After all, it has a 600-foot range around the base unit, ensuring user safety bothe inside and outside their house. When user wearing the bracelet, safety is always a click of a button away.
2. In an emergency, press the alert bracelet button to summon assistance. Wheatevery emergency such as slipped and fallen in bathroom, tripped over a stair, by simply push the help button, the aid will be provided as soon as possible. The bracelet is waterproof.
3. Speak with a member of Command Center's qualified staff. The staff with TMA 5 Diamond Certified operators will assess the issue and call the appropriate emergency services. Even when user is unable to communicate, the operators will follow nonverbal protocols to guarantee that user reecive assistance.

MedicAlert Medical Bracelets have alot of benefits. The first benefit that user can get is the system are designed for senior and their family members. Secondly, users can enjoy the best is class customer support. MedicAlert Medical Bracelets also offer users to be able to get in touch with their Command Center 24 hours a day for a whole year. Besides that, user can also pay and cancel anytime with no penalty and question asked. Lastly, user will enjoy supper-fast shipping which powered by FedEx. Figure 2.28 shows the advantages of MedicAlert Medical Bracelets.

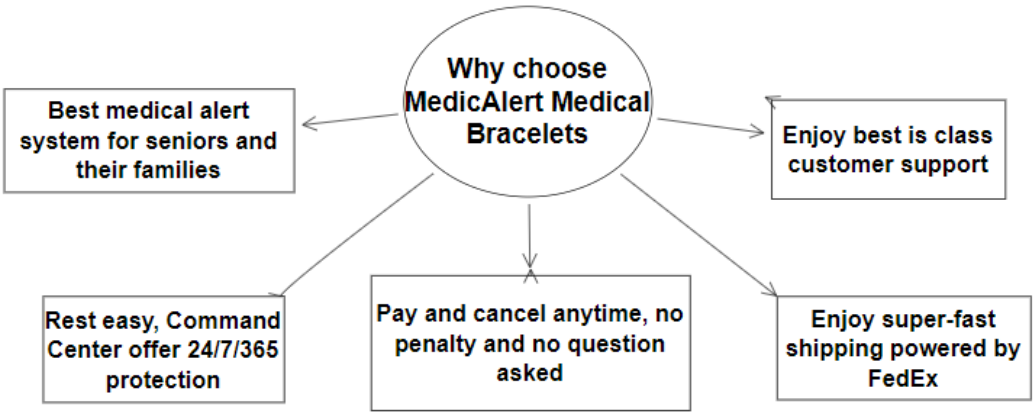

Figure 2.28 Advantages of MedicAlert medical bracelets

MedicAlert Medical Bracelets, with a concept of Command Center connected with user all the time. There are also alot of product such as Life Alert, Bey Alarm Medical and other more, in the market too which have the same concept.

Table 2.8 shows the comparison between MedicAlert Medical Bracelets (Alert1) with some other medical alert system alternatives. Reasons of why choosing a MedicAlert Medical Bracelets (Alert 1) will be listed down too.

Table 2.8 Comparison between MedicAlert Bracelets (Alert1) with other medical alert system

Brands of medical alert system			**Reasons**
		Life Alert	The cost of a Life Alert system can be on the high end of what medical alert systems can cost. MedicAlert monthly fee starting fee: $19.95 Life Alert monthly fee starting at: $69.90

MedicAlert Medical Bracelets (Alert 1)	vs	Bay Alarm Medical	Medical alert system reviews are mixed. Alert1 provide excellent medical alarm systes, flexible payment plans and world-class emergency responce service.
		Medical Guardian	Get a medical alert system that is simple to use and provides excellent service.
		GreatCall	Pay solety for what the user need. Do not pay for services that the user does not require.
		MobileHelp	Alowing the user to be held back by limited options or excessive fees is not a good idea.
		ADT Health	An alarm company versus a dedicated medical alert system for elderly.

After introducing IoT and seizure tracker, the following subtopic will combine the both technology together and will discussed about seizure tracker IoT

2.6 Seizure Tracker IoT

According to one research from [49], a survey was carried out with the help of a population of patient with epilepsy and guardians or caregivers to learn about the design criteria that patients with epilepsy most wish in wearable device. The survey included 11 questions that covered a wide range of topics and ideas. The questions were divided into 3 main groups which is patient history, desired design characteristics and costs. Figure 2.29 shows the three main groups in the questionaire.

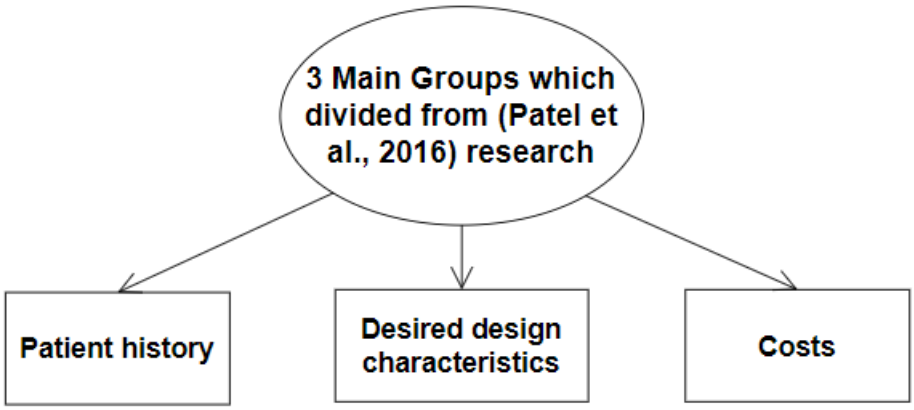

Figure 2.29 Three main groups in questionaire

In this survey, respondent stated whether or not they would find each of nice sensor kinds useful by answering Yes or No. The nine sensors will be stated below:

- Muscle signal
- Heart rate
- Pulse oximeter (to measure oxygen level in the blood)
- Accelerometer (to detect motion)
- GPS
- Body Temperature
- Microphone
- Galvanic skin (to detect sweat)
- Barometer (to measure air pressure)

2.6.1 Type fo Features in Seizure Tracker IoT

The results of this research showed that there are a lot of people knew and realised the importance of seizure tracker especially for patient with epilepsy or caregivers. From a rating scale of 1 to 5 and the rating of 5 will be the most important, overall mean which collected from 904 respondent. From the results, most of the respondent will buy a seizure tracker product depends on features such as detecting all seizures, text/email alerts, comfort and battery life. Table 2.9 shows the results of the survey.

Table 2.9 Results of survey

Type of Feature	**Rating mean from 904 respondating with scale 1 to 5 (5 being the most important)**
Detecting all seizures	4.73
Text/email alerts	4.53
Comfort	4.46
Battery Life	4.43
Not knowing device is for seizures	2.60
Multiple Uses	2.57

2.6.2 Price Range of Seizure Tracker IoT

Moving on to cost which consider as one of the most important part, the range of price and percentage of respondents vote will be listed in table below.

Table 2.10 shows the percentage of respondents consider a reasonable price range for a seizure tracker. From the results of the survey, the pricing range that most of the respondents think it is reasonable for a seizure tracker is between $101-$300. More on

choosing the range from $101-$200, which is 39.68% and the percentage which choosing $201-$300 is 21.78%.

Table 2.10 Percentage of respondents considering in price range

Price range that respondents think that its reasonable for a seizure tracker	**Percentage of respondents (%)**
<$100	17.52%
$101-$200	39.68%
$201-$300	21.78%
$301-$400	9.66%
$401-$500	5.11%
$501-$600	3.41%
$601-$700	0.57%
$701-$800	0.47%
>$800	1.80%

Table 2.11 shows the price that respondents willing to pay for a seizure tracker. (Currency in USD will be used in this research). In the results, the pricing that respondents willing to pay is also between price range of $101-$300. There are about 29.84% of people choose to pay for a seizure tracker in price of $101-$200 and 22.69% of respondents choose to pay for a seizure tracker with price of $201-$300.

Table 2.11 Percentage of respondents willing to pay price range

Price range that respondents willing to pay for a seizure tracker	**Percentage of respondents (%)**
<$100	17.45%
$101-$200	29.84%
$201-$300	22.69%
$301-$400	11.73%
$401-$500	7.63%
$501-$600	4.39%
$601-$700	0.38%
$701-$800	1.24%
>$800	17.45%

Observation from table above can show clearly that total of 57.20% of respondents think that a seizure tracker for price below $200 is reasonable. Besides that, 69.98% of respondents willing to pay less than $300 for a seizure tracker. From the research, it also shows that 84.45% of respondents willing to pay more for a seizure tracker.

2.6.3 Battery Life of Seizure Tracker IoT

Moving to minimum battery life, the respondents is targeted from below 11 years old to above 30 years old. Total of the age range is divided into 4 groups. From the results , respondents would wish to have minimum battery life more than 6 days are normally the respondents with age range about 19-30 years old and above 30 years old. This is because most of these youngsters and adults, they have study and work to do in day time and it is

quite difficult for them to charge the seizure tracker everyday. Without considering the battery life of their seizure tracker, it will decrease their worries when they are outstation.

Table 2.12 shows the percentage of respondents that would wish to have more than 6 days minimum battery life.

Table 2.12 Percentage of respondent considering in battery life

Age range	**Percentage of respondents would wish to have more that 6 days minimum battery life.**
<11	15.90%
12-18	15.4 %
19-30	26.6%
>30	30.50%

2.6.4 Monthly Fee of Seizure Tracker

Normally, the seizure tracker will connect to the user's smartphone so that notification can pop up at first when the symptom of seizure happen to user. Some of the phone application needs monthly fees and some not.

The final data in this research is monthlyfees for applications. Normally seizure tracker will connect to a smartphone in order to calculateand give notifications to patient or their caregiver to prevent any incident happe. According to reseearch, 39.98% from these respondents would not willing to pay for monthly fees.

After discussed about seizure tracker IoT and its feature, pricing range, battery life and monthly fees, the subtopic of kids seizure tracker IoT will be discuss next.

2.7 Kids Seizure Tracker IoT

Kids are not like adults. Normally, adults can have their own awareness and they can sense danger when the times come. But this thing does not happen ini kids. They would not have slef awareness and they do not sense danger. We can imagine that the kids with symptom of seizures such as they are jerking and fall on the ground, but the minute before they are playing joyfully.

So, in order to protect our kids with seizures, an tracker which can tracker the kid's temperature, heart rate, pulse and something else is a must. Besides that, applications to receive the data that recorded from the tracker so the applications will able to record data, predict symptom and give awareness to caregiver in advance in order to protect the kids the most.

2.7.1 Applications that can Receive Notification from Kids Seizure Tracker IoT

Knowing the seizure types of the kids, the proper medicine and dose are parts which cannot be neglected for patient who living with seizures. Apps meant to help people with seizure or epilepsy adopt a practical approach to their seizures and manage how the illness impacts their social, emotional and physical well-being are available.

Repeated seizures are the most common sign of epilepsy and they will affect people differently depending on which portion of the brain is affected. Some people suffer seizures in which their bodies jerk and shake, while others have strange sensations or lose consciousness. Seizures are most commonly triggered by stress, sleep deprivation, alcohol, certain drugs, specific foods and flashing bright lights. A patient could notice their seizure have a pattern or they happen more frequently in specific

conditions. Recording the symptoms and seizures in an epilepsy monitoring applications and share the information with a healthcare professional or epilepsy specialist can be beneficial to kids. This could prevent the kids from suffering the sequela by seizure.

There are a lot of application in the market and most of them have their own features and advantage. The applications that have are such as HealthUnlocked, Seizure Tracker, Seizure First Aide and many more. These applications will be introduced in table 2.13

Table 2.13 shows some of the applications that are commonly used by patients with seizure.

Table 2.13 Applications that commonly used by seizure patients

Application	**Supported Device**	**Charging Fees**	**Features**
HealthUnlocked 	iOS	Free	-Match people with similar health-related topics -A community member can post question, learn experience and receive emotional support from others.
Seizure Tracker 	Android iOS	Free	-Created to aid in the management of epilepsy by recording seizures and keeping track of their length, type, potential triggers and symptoms. -Quick Capture feature of the progran allow user to time and record seizures as they occur then submit to YouTube for private sharing.
Seizure First Aide	Android iOS	Free	-The First Aid indicator on the dashboard displays the four critical

EPILEPSY FOUNDATION Minnesota			steps to take if user have a seizure. The Timer icon can also be sued to record the duration of the seizure.
Snug Safety 	iOS	Free	-If someone does not check in at their regulat time, emergency contacts will be notified and a upgrade to a dispatch plan is offered in which a personal dispatcher will phone or coordinate a wellness check to the individual's last known location.
ICE Medical Standard 	Android iOS	Free	-Able to add phone numbers of user's emergency conteacts, information about medical conditions and other essential information that would save time in an emergency situation. -The program walks user through entering emergency information and saves it as a lock screen image so a first responder only needs to turn on user's phone to see everything they need to know.
Epilepsy Journal 	Android	Free	-Able to keep track of user rescue medication, triggers, what user was doing at the time of seizure and user's location. User may make reports, view trends and email to their doctor using these entries.
myChildren's	Android iOS	Free	-Have specialized built-in epilepsy toolkit although the app allows for tracking a wide range of healthcare needs.

			-Can choose to add the Epilepsy Toolkit after inputting the kid's information which will send to caregiver's phone to a customised add-on. Add-on will allow caregivers to keep track of the kind, description, likely causes, date and time of seizures.
Epilepsy Health Storylines 	Android iOS	Free	-Recording symptoms, seizures, moods and setting medicine reminders. -Symptom tracker is well-designed with a loopup search that allows user to enter common symptoms, these will be saved to user's home screen, enabling for quick entry fof the intensity of the ailment, its impact on user's day and current mood.
SeizAlarm 	iOS	Free trial for 2 weeks	-When the app detects abnormal repeated movements or a high heart rate, it alers your emergency contacts. User can turn off this option if they plan on doing somethings that might cause false seizure detection. -SeizAlarm offers a help request opetion that user can activate and logs of their requests are saved for own records. When user send an assistance request, their location is recorded and forwarded to their emergency contacts so they can find the user quickly.

After discussed the application which have in the market to track seizure, next will introduce the example of kids seizure tracker IoT.

2.7.2 Example of Kids Seizure Tracker IoT

The Embrace is one of an increasing number of wearables that can detect seizures and send notifications to caretakers.

One of the most distressing elements of childhood epilepsy for children and their families is not knowing when a seizure may occur. This unpredictability can pervade every facet of existence. Children are unable to swim in deep water or bath alone. Teens are frequently unable to drive for fear of having a seizure behind the wheel. Parents may sleep on their children's bedroom floors to keep an eye on any difficulties that arise throughout the night.

A smartwatch that has received FDA approval is part of an expanding field of gadgets aimed at detecting and even forecasting seizures. For any patients, the Embrace watch detects the movements and electrical pulses in the skin that are associated with seizures. When it detects a seizure, it sends a text message to a caregiver's phone coupled with GPD coordinated so the user may be quickly located. It also saves and analyses data on sleep and activity patterns which could help patients and their doctors better understand when and why seizures occur on any given day. The FDA approved the watch for adults early last year and it has now been approved for youngsters.

The Embrace watch can only identify generalised tonic-clonic seizures, which is the most severe type of seizures. The business is working on developing an algorithm to detect other types of seizures [50].

To transmit warnings, Embrace 2 watch must be connected to a smartphone. This smartphone should be owned by the person wearing Embrace and kept close to them at all the times. The Alert App, which comes with Embrace, is used to transmit alerts. Those receiving warnings can be anywhere. Even landlines can receive alerts from Embrace. If a kid uses Embrace for example, his parents could be a co-worker because they are close by and can help. Either in working place or at home, parents may also be on the list since they wish to be contacted in the event of a seizure.

Embrace works with any iOS device running iOS 10 or higher, as well as any Android device running Android 5.0 (Lollipop) or higher and supporting Bluetooth Smart/Low Energy. The iPod Touch 6th generation and all iPad devices released since 2013 are also compatible [51].

Figure 2.30 shows the Alert App that are in iOS device and figure 2.31 shows the application that are in Android device.

Alert App

Figure 2.30 Alert App in iOS

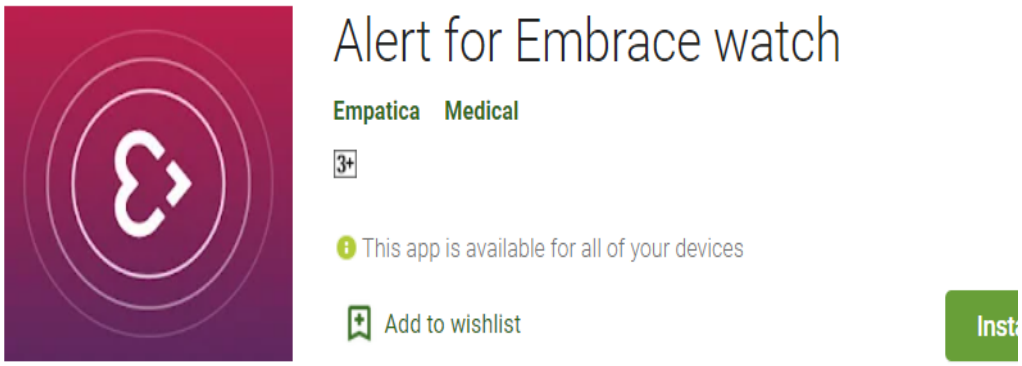

Figure 2.31 Alert App in Android

When Embrace product detects a typical pattern that could be associated with a generalised tonic-clonic seizure, the Alert App pairs with Embrace and delivers an automated SMS and phone call to user's designated caregivers.

There are many functions in Alert App. The Alert App will work when on these activities such as event detection, alert dispatching and caregiver alert. Figure 2.32 shows the summarize of how the Alert App works. After the diagram, the explanation of each works will be listed.

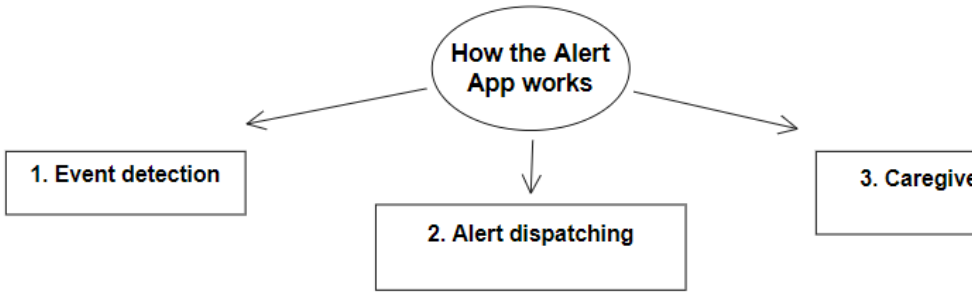

Figure 2.32 Summarize of how Alert App works

1. Event detection

- Embrace's sensors continuously capture physiological data. The data is evaluated in real time to spot anomalous movement and skin conductance patterns.

2. Alert dispatching

- The Alert App uses Bluetooth to connect to user's Embrace. When Embrace identifies strange patterns that could indicate a convulsive seizure, the Alert App uses the smartphone's cellular data or Wi-Fi connection to deliver an automated call and SMS to user's designated caregivers.

3. Caregiver Alert

- Caregivers will be notified at the same time via the Embrace Alert System. To receive these notifications, caregivers only need a phone with a cellular signal. No smartphone is required.

It is a must that to send notifications, Alert App requires Bluetooth as well as an internet or cellular data connection.

Although the application and tracker combination is to monitor the patient in anytime and anywhere, but there is some situation that patients should have their private and personal time. Alert App also provide these functions such as rest mode, alert with location and manage caregivers.

Figure 2.33 shows the functions to get the most out of the Alert App in mind mapping form. After the diagram, the details of each function will be explained.

Figure 2.33 Functions to get the mostout of Alert App

1. Rest Mode

- Rest mode will monitor the user's signals as he/she is sleeping, reading a book or watching TV and will promptly inform user when they have a tonic-clonic seizure.

2. Alert with Location

- To help user get help faster, add accurate GPS location to their notifications.

3. Manage Caregivers

- Make sure that user have someone ready to assist them at all times. As user go about their day, activate and deactivate caregivers.

2.8 Summary Topic

From the journal and article studies above, the risk and danger of Febrile seizure had already know. The studies above shows that how dangerous is Febrile seizure is if parents did not take care of their children well at the beginning of the age. It might also causes death if parents have any mistake in taking care of their kids. Next, from the journal studies above, the by putting the detection device on the wrist is approved by all studies.

Moving on to the next subtopic, the price range of detection device that can be afford is about RM400 and below. The objective of the project is to make a low-cost and user friendly seizure tracker so the aim is below RM400. Lastly is the application. Most of the apps need monthly fee and this might be critical to the poor family. Therefore, an free app will also be design in the next chapter.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the method of conducting and overall strategy of the project will be listed down in this chapter. To develop this project the sequence from designing and developing of IoT-based kids' smart activity tracker with seizure detection capability will be shown step-by-step.

In this chapter, the software and hardware which have related to the design and development of IoT-based kids' smart activity tracker with seizure capability will be stated out too. The design and construction of this kids' activity tracker with seizure detection capability and mainly on detection body temperature of a human on the wrist part, which this product is wearable and it will send notification to smartphone through phone application.

3.2 Project Flowchart

It is very important that to make sure the progress of this project is followed step-by-step and complete the tasks that arranged in schedule. Therefore, a flowchart will be drew. A workflow or process can be graphically represented using something called a flowchart. It involves carrying out a series of distinct steps in a predetermined order. In most cases, a flowchart will display the steps as a series of boxes of varying types. Steps are linked so that anyone can examine the flowchart and follow its directions in the appropriate order from the very beginning to the very end. This is accomplished by connecting lines and

directed arrows. It is also useful for a variety of other objectives, including as documenting, studying, planning, refining, and describing complicated processes in a style that is easy to understand, straightforward, and straightforward. Utilizing a flowchart allows for the development of an understanding of how a process is carried out.

Figure 3.1 shows the flowchart of this project which included with design and development.

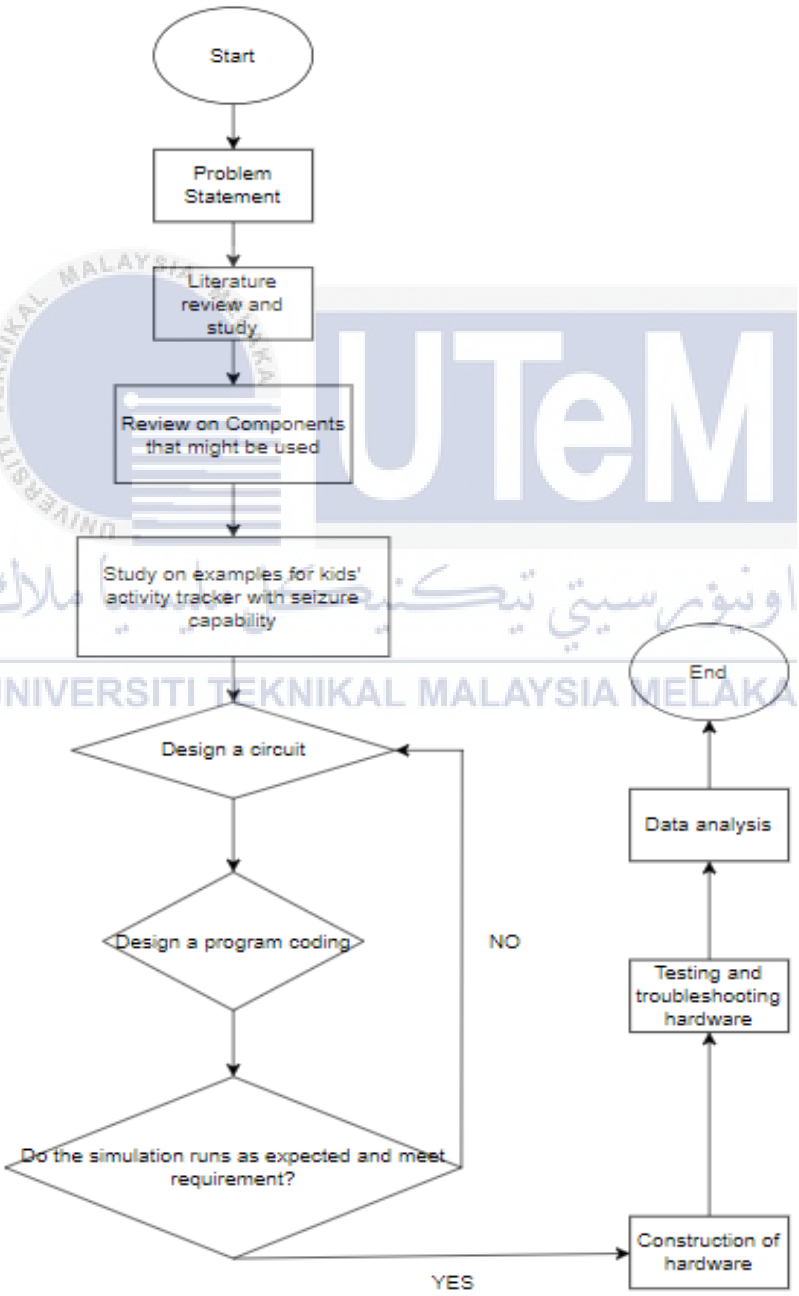

Figure 3.1 Flowchart of project

3.3 Design Prototype of Activity Tracker

By design and developing a prototype, a physical product may be examine a version of the prosposed product to decide which features are effective and which need to be refined. This will be the opportunity to collect more precise needs and market input. For the subtopic next part will include with the physical appearance of the activity tracker, electrical circuit connection diagram, setting up Blynk Application and lastly program code. The circuit connection which include NodeMCU (ESP8266), Temperature Sensor (DS18B20), connecting Wires/Jumper, breadboard and lastly battery. Besides that, the application that will connected to the NodeMCU is Blynk Apps.

The main component of this project prototype is NodeMCU, which acts as a microcontoller to receive and send data from sensor to phone and the next component which is also important in this project prototype is DS18B20.

DS18B20 is a 9-bit to 12-bit Celsius temperature measureming digital thermomter include an alert function with nonvolatile user-programmable upper and lower trigger points. It communicates with a central microprocessor via a 1-Wire bus.

The reason of choosing DS18B20 as the final sensing componet is because:

- Contactable
- Measures temperature from -55˚C to +125˚C
- The accuracy of ±0.5˚C from the temperature range -10˚C to +85˚C
- Simplifies Distributed Temperature-Sensing
- Only 2 pins are required for operation in parasitic power mode, which is pin DQ and GND.

3.3.1 Circuit Diagram of Component

The interface of DS18B20 (digital temperature sensor), NodeMCU ESP8266 and will be connected.

In the connection, the D2 pin of NodeMCU (GPIO 4) will be connected to the DQ pin of DS18B20. The reason of connecting to D2 pin of ESP8266 its because this is the most suitable pin for ESP8266 to read the data. If other microcontroller such as ESP01, it will be more suitable to connect with GPIO 2 of the microcontroller. Any changes of the microcontroller need to refer back to the datasheet of microcontroller itself.

Besides that, the VDD of DS18B20 will connect to the ESP8266 pin 3.3V as to give power supply for the ESP8266 to work. The GND of DS18B20 will connect to the pin GND in ESP8266. Lastly, the circuit will also include a suitable resistor as to makes the DS18B20 functions well. This is because the sensor operates in between 3.0V to 5.0V. Too hight of power supply will burned out the sensor.

Figure 3.2 shows the circuit diagram of component connection by Fritzing.

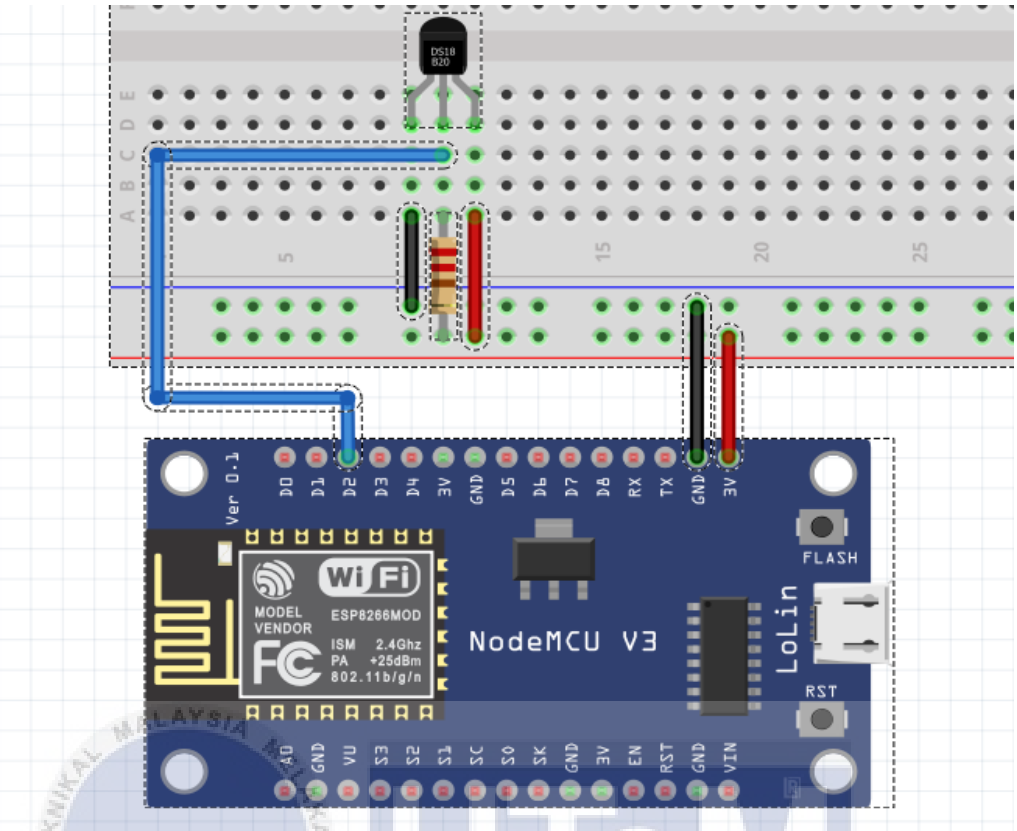

Figure 3.2 Circuit diagram of components connection by Fritzing

3.3.2 Development of IoT-Based Cloud Platform

In order to perform an IoT development, a cloud platform should have in this project. The activity tracker will be connected to smartphone in this project. So the Blynk Application had be chosen as the cloud platform. The purpose of choosing Blynk as the IoT-Based Cloud Platform is because Blynk has its own coding method in Arduino IDE software. Besides that, Blynk is used worldwide and lastly, it can monitor the temperature of the user which in every places that have WiFi connection. Using Blynk Apps and Web, caregivers can monitor their son with seizure using phone application and also from Blynk web browser.

In coding, the WiFi name and password will be inserted so that Blynk will authorize and connect to WiFi. Besides that, the setting of sending pop-up notification when the body

temperature hits 38˚C also included in Blynk App. The receiver can increases for if lets say, the patient user have more than one parent, of their parents have emergency cases to settle, so the notification may send to the kid's daycarer, kindergarden teacher and more.

3.3.3 Development of Program Code

The program code of NoceMCU ESP8266, together with DS18B20 and also Blynk App will be written using Arduino IDE software. In order to do compilation, there is some libraries should be downloaded and insert inside Arduino IDE library folder. The library that will be needed is:

- OneWire
- DallasTemperature
- Blynk

All the required library will be downloaded and import at the the first of the program. This is to make sure that the coding inside Arduino IDE will runs without any hesitation. Besides that, as the project used NodeMCU ESP8266, the board manager of ESP8266 will also be included before the program run. Figure 3.3 shows the import libraries that needed in Arduino IDE software.


```
#include <OneWire.h>
#include <DallasTemperature.h>
#define BLYNK_PRINT Serial
#include <Blynk.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
```

Figure 3.3 Imported libraries

After included the libraries for the program coding, next thing that need to do insert the command of the pin connection for DS18B20 and ESP8266. After that, the program should be setup a oneWire instance to communicate with any OneWIre device. Lastly, the pass of oneWire reference will be go through Dallas Temperature sensor. This is the created instances that needed for the temperature sensor. The temperature sensor will be connected to GPIO 4.

Figure 3.4 below shows the instances created for temperature sensor.

```
const int oneWireBus = 4;
OneWire oneWire(oneWireBus);
DallasTemperature sensors(&oneWire);
```

Figure 3.4 Instances created for temperature sensor

Next step in moving on to the setup. For the first line “Serial.begin(115200)” is initializing the Serial Monitor at a baud rate of 115200. Moving on to the second line “sensors.begin()”, is initializing the DS18B20 digital temperature sensor. Third line with “sensors.requestTemperatures()” is the first call of requested temperature method in order to obtain the temperature. Fourth line “float temperatureC” is get the temperature in Celcuis by using the getTempCByIndex() method. In the Arduino IDE, all these setup in below “void setup”.

Figure 3.5 below shows the setup for serial monitoring.

```
Serial.begin(115200);
sensors.begin();
sensors.requestTemperatures();
float temperatureC = sensors.getTempCByIndex(0);
```

Figure 3.5 Setup for serial monitoring

After setting up the Serial Monitor, the basic of the program coding has almost finished. Lastly, the program coding will be looped and print it out in the Serial Monitor. The temperature data will be shown in ˚C. The following command will be inserted in Arduino IDE in "void loop", which represents looping of the whole process. Figure 3.6 below shows the Looping of Serial Monitor.

```
Serial.print(temperatureC);
Serial.println("ºC");
```

Figure 3.6 Looping of serial monitoring

3.3.4 Flowchart for Overal System Operation

In this subtopic, the overall system operation flowchart will be shown here. The purpose of this flowchart was made is for the understanding of this project.

When the system starts, power from battery will be supplied in. Then the digital temperature sensor DS18B20 will be activated. Then the temperature sensor will be touched the object that need to be detect, which is body temperature in this project. After that, the transmitted temperature sensed will be send back to microcontroller, which is NodeMCU ESP8266. Then the NodeMCU ESP8266 will transfer the data signal to IoT-based Cloud

Platform. In this project, Blynk App will be used. In Blynk App, there will be a gauge showing the current temperature of the object (body temperature on the wrist part) as been listed down in the project objective which is monitoring the body temperature of kids. As to let the project have improvement, the project will then let the microcontroller determine whether the object temperature trigger 38.0ºC or not. If yes, it will send notification to the Blynk App. If no, the looping process will be operate again from activate the digital temperature sensor.

Figure 3.7 below shows the flowchart of overall system operation.

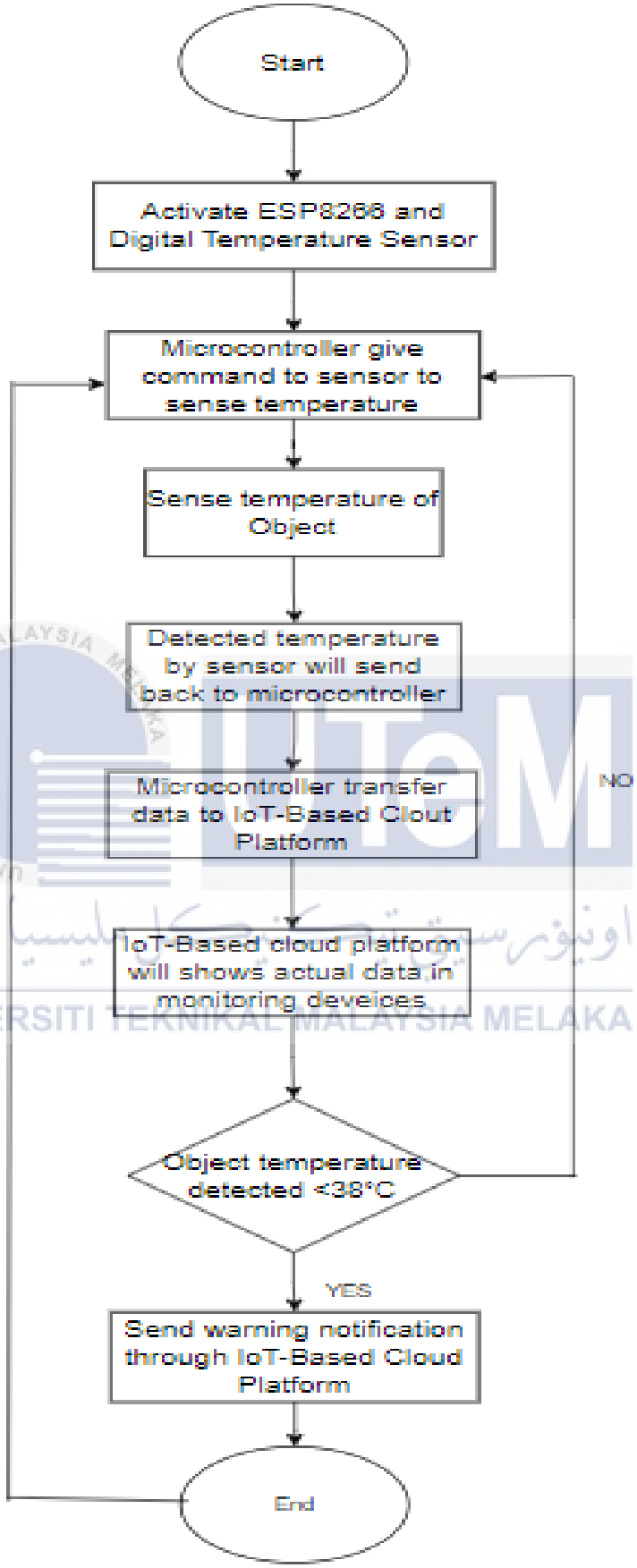

Figure 3.7 Flowchart for overall system operation

3.4 Project Prototype Design

In this subtopic, the project prototype design will be discussed. First will show the components that will be used and the prototype on the breadboard. The prototype on the breadboard will be consider as primary prototype. After that the soldering work will be do and attach all the components on a band which can be wear on the wrist. This prototype will be consider as the final prototype. As to ensure that the data can be collected nicely to do analysis for the next chapter, the data will be collected using the primary prototype. This is to prevent any errors that occur after all the components had been soldered up on a PCB donut and stick it on the wristband.

3.4.1 Primary Prototype Design

In this subtopic, the primary prototype of design will be discussed. The prototype will be conducted with several components which will be listed down below:

- NodeMCU ESP8266 (as microcontroller)
- DS18B20 (as digital temperature sensor)
- 4.7k Ohm resistor

Besides that, the components such as battery charger and 3.7V lithium polymer battery will be included in the final prototype.

Figure 3.8 below shows the components that will be used in this project.

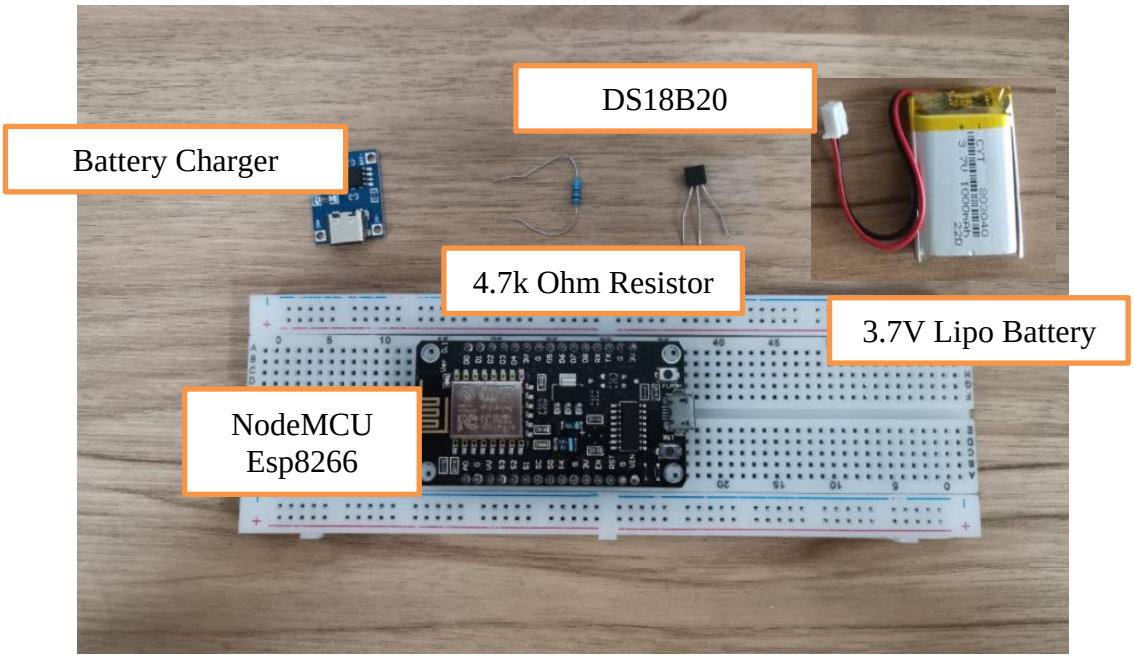

Figure 3.8 Components of project

The component that will listed above will be connected by refering the circuit diagram on the subtopic above. Figure 3.9 shows the primary prototype of project.

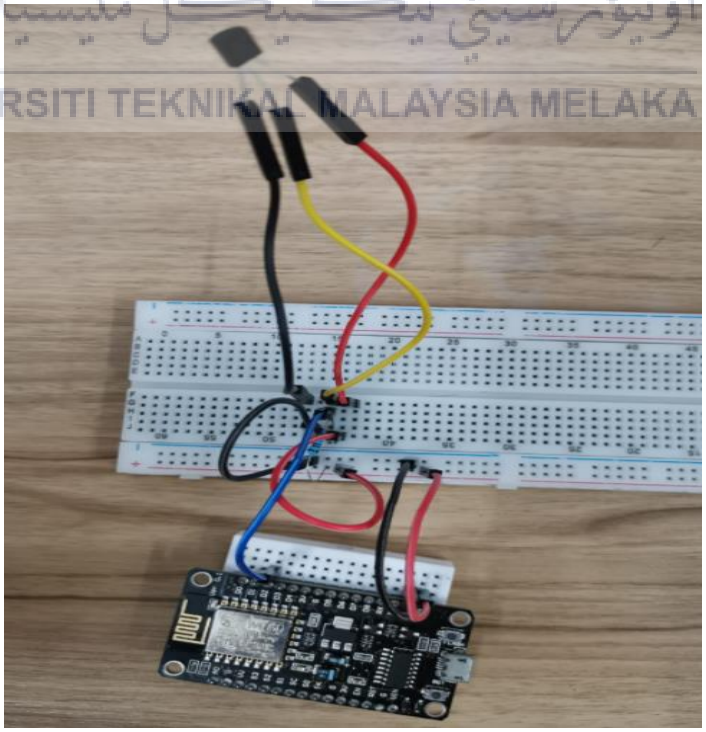

Figure 3.9 Primary prototype of project

3.4.2 Final Prototype of Project

In this subtopic, the final prototype of Project will be shown in the way of software and hardware.

The purpose of having software design first than hardware is to make sure that there will be nearly zero error in the soldering process. Besides that, the hardware of the final prototype will be soldered up in a sports wristband as to act like wearing a real activity tracker on the wrist.

Figure 3.10 below shows the software design of the final prototype without putting on the wristband.

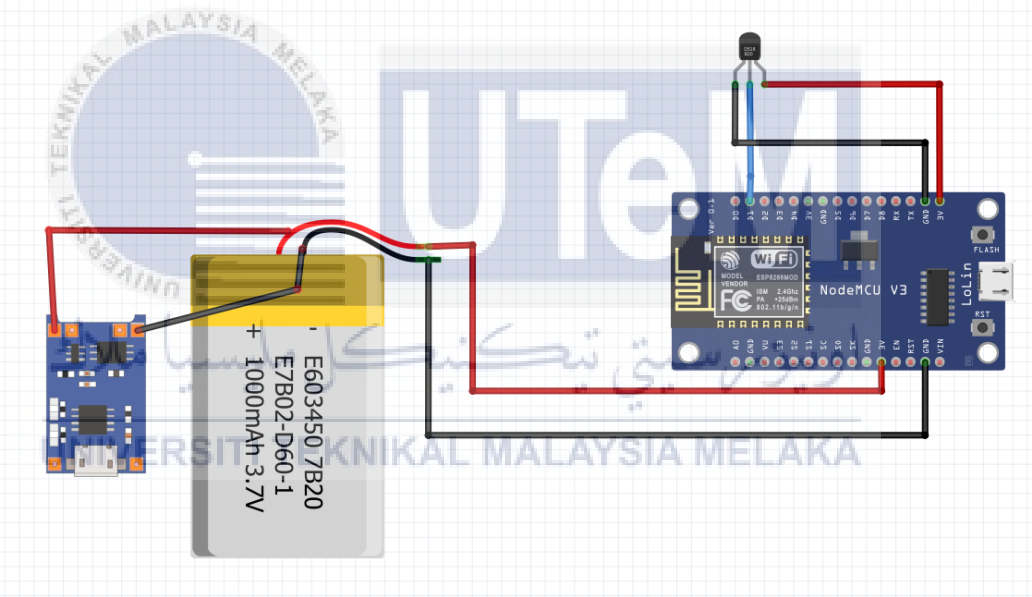

Figure 3.10 Software design for final prototype

From the software design above it shows that the battery charger will connect to the 3.7V LiPo battery at first. The aim of having a battery charger, TP4054 with the 3.7V LiPo battery is to charge up the LiPo battery whenever the battery drained, or whenever the user did not use the wristband when they are in a safe place which their parents are on their sides.

After that, the positive side of the LiPo battery will connect to the pin 3.3V of ESP8266. The aim of connecting the positive terminal of LiPo battery to pin 3.3V of ESP2866 is to give up power supply to activate ESP8266 whenever the USB port did not connect to ESP8266. Then, the -ve terminal of the LiPo battery will connect to the GND of ESP2866.

Moving on, the digital temperature sensor, DS18B20 will connect with the ESP2866 as to let the detected temperature send to ESP8266 and let the WiFi module of ESP8266 send the data to IoT-Based cloud platform for the monitoring, in this project Blynk App is used. The VDD of DS18B20 will connect to pin 3.3V of ESP8266 and the GND of DS18B20 will connect to the pin GND of ESP2866 as well. Lastly, the pin DQ of DS18B20, which is the middle pin in the sensor will connect to the pin D2 of ESP8266. The D2 pin of ESP8266 is GPIO 4.

For the final prototype, the ESP8266, 3.7V LiPo Batttery battery charger, a suitable resistor and a additional ON/OFF switch is added on the top view of PCB donut. On the other side of the PCB donut, the digital sensor DS18B20 is attached to it.

Figure 3.11 below shows the final prototype is hardware style (top view), figure 3.12 below shows the back view, figure 3.13 shows the final prototype stewed on a sports strap and figure 3.14 shows the final prototype wore on a human wrist part.

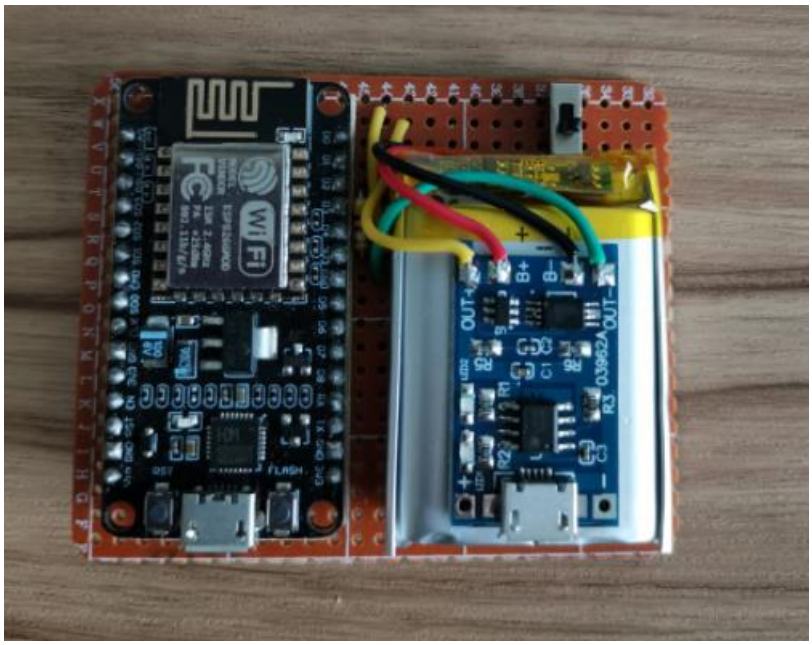

Figure 3.11 Final prototype hardware top view

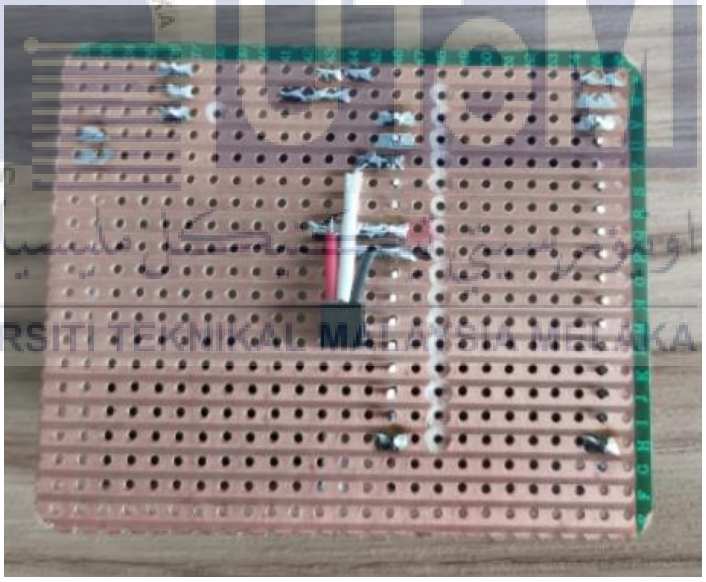

Figure 3.12 Final prototype hardware back view

Figure 3.13 Final prototype on wrist strap

Figure 3.14 Final protytpe on human's wrist

3.5 Summary Topic

This chapter presents the overall progress of activity tracker with seizure capability. From design of circuit, development of circuit and lastly the design of the product appearance. A simple and safe design creates a activity tracker that can be wear by kids from age 3 month to 6 years old. Besides that, with the program code designed, the information that sense by the digital temperature sensor will be sent to the Blynk App and this can let parents monitor their children in anytime and anywhere.

In this topic, the basic components is introduced and discussed. Besides that, the basic project coding that will be transfer to ESP8266 has been mentioned. Moving on to the design of the prototype, the data that get from the prototype will be discuss in the next chapter. The data will be taken from the prototype that DS18B20 and ESP8266 is placed on the breadboard. This is to ensure that the digital temperature sensor can work at its best and the offset that should be included in the coding will also be determined.

Furthermore, this topic had also discussed about the primary prototype and final prototype of project. The primary prototype is created using Fritzing software as to make sure that the idea of design works in hardware too. Finally, the designing idea of primary prototype will then been soldered up on a PCB donut with a fit and nice measurement which can wear on wrist, and a sports wrap is used as a band to wrap over the wrist and also to let the PCB donut stick on the wrap.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The results and analyses of development of kids' activity tracker with seizure detection capability will be discussed in this chapter. First of all, the circuit will be designed using computer software as to ensure that it will be run. Secondly, will be going to the program code. Lastly the hardware design part which need to place all the component in a suitable material as can let kids wear it comfortably. After that, data will be taken from the prototype and graph analysis will be made to check the accuracy of prototype.

4.2 Results and Analysis

In this subtopic, there are a few sets of data and graphs will be shown to prove that the prototype of this project is functioning well. The results will be given full in Appendix A and inside this topic, the average value of data will be listed out. Besides that, graph will be followed after the average data and analysis will be given.

4.2.1 Average data from Prototype Project

As been mentioned above, the data of the project will first be taken from the prototype. Besides that, as to have comparison that the temperature data of the project does not run so far from the actual temperature, an Infrared Thermometer will be used to take temperature from the surrounding and also from the object, which is the human's wrist part.

Figure 4.1 below shows the Infrared Thermometer that used in this project.

Figure 4.1 Infrared thermometer

In this part will be showing the data that had been collected for 7 days using the prototype of the project. The aim of of collecting the data from prototype is to ensure that the idea and design of this project can be run because there might be some accident happen during the soldering of all components include the battery, battery charger and so on.

Instead, the data of the project will be firstly collected by the prototype which connected to Blynk and the data will be collected using Arduino IDE serial monitor function. The data will be recorded in a table and put into appendix of the report.

The data will be collected into two ways, which is:

- IR Thermometer
- Seizure Tracker (DS18B20 Digital Temperature Sensor) Prototype

Besides that, to ensure the accuracy of the product, the data will be collected for 7 days and separate it into indoor and outdoor to ensure the project prototype can function no matter in which situation. Lastly, in these 7 days, the data will be collected 3 times a day which is:

- Morning (0900 hour)
- Afternoon (1200 hour)
- Evening (1800 hour)

The project prototype will only collect data from this 3 timing as considering the timing for a kid to moving from a place to a place, with different kind of weather.

To get the accuracy of the project prototype, at least 5 readings will be taken using the seizure tracker prototype. Data will be collected using the format below.

Table 4.1 shows the table of data recorded.

Table 4.1 Table of data recorded

Day # - Indoor/Outdoor (Date)				
	IR Thermometer (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	(Temperature from IR Thermometer)	(Temperature from Seizure Tracker (DS18B20 Digital Temperature Sensor) prototype) x5	(Temperature from IR Thermometer)	(Temperature from Seizure Tracker (DS18B20 Digital Temperature Sensor) prototype) x5

Before the analysis starts, it is very important to list down the weather in these 7 days. This is because the temperature of IR thermometer and seizure tracker prototype will

be affected by the surrounding weather temperature. The 7 days of experiment are from 27 November 2022 to 3 December 2022.

Table 4.2 below shows the weather observed for the 7 days of experiment from 27 November 2022 to 3 December 2022.

Table 4.2 Weather observed for the 7 days of experiment

	Morning	Afternoon	Evening
Day 1 (27 November 2022)	Cloudy without sun	Thunderstorm	Fog with moon
Day 2 (28 November 2022)	Fog with sun	Cloudy without sun	Cloudy without moon
Day 3 (29 November 2022)	Cloudy without sun	Thunderstorm	Light rain
Day 4 (30 November 2022)	Fog with sun	Cloudy without sun	Cloudy without moon
Day 5 (1 December 2022)	Fog with sun	Cloudy without sun	Cloudy without moon
Day 6 (2 December 2022)	Cloudy without sun	Cloudy without sun	Thunderstorm
Day 7 (3 December 2022)	Fog with sun	Cloudy without sun	Cloudy without moon

4.2.2 Average data and Graph Analysis by Session

The data of Seizure Tracker Prototype will be collected 5 times in order to get the average temperature when the prototype sensor is already stable. Therefore, the average temperature of these 5 data will be taken out and compare with other day's temperature.

After calculating the average data of Seizure Tracker prototype, the data will be shown below. These data will show the overall temperature taken by IR Thermometer and Seizure Tracker prototype in the morning session, indoor temperature. Table 4.3 below shows the average data with situation of indoor, in the morning.

Table 4.3 Average data for morning, indoor

Morning—Indoor				
	IR Thermometer (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Day 1	26.2	26.42	36.2	36.65
Day 2	25.8	25.95	35.8	36.02
Day 3	25.3	25.38	35.8	35.84
Day 4	24.8	24.89	35.7	35.46
Day 5	25.4	25.36	35.3	35.41
Day 6	25.1	25.05	35.0	35.02
Day 7	25.6	25.67	35.5	35.46

Graph will be shown for body temperature only because the accuracy of detecting body temperature is the aim of this project. The graph will be represented by two lines, which is red line for seizure tracker (using DS18B20 Digital Temperature Sensor) prototype data, and blue line is for IR thermometer that we can get in any shopping mall. The aim of including the blue line (IR thermometer) inside is to ensure that the seizure tracker prototype works well. The cross-section of the point for total of 7 (7 days) will be taken and determined the accuracy of the seizure tracker prototype.

Besides that, analysis of timing that seizure tracker prototype working (morning, afternoon, evening) and the place of seizure tracker detecting temperature (indoor and outdoor) will also be analysed.

The graph will only show the body temperature (object) detected by IR thermometer and seizure tracker prototype. The data that collected by ambient will be forfeit in this report because that data is just to determine the functional of seizure tracker prototype.

The first graph shows the body temperature detected in indoor situation, morning. As can see from the graph, there is 4 out of 7 cross-section inside it.

Figure 4.2 below shows graph analysis of the data at indoor in the morning.

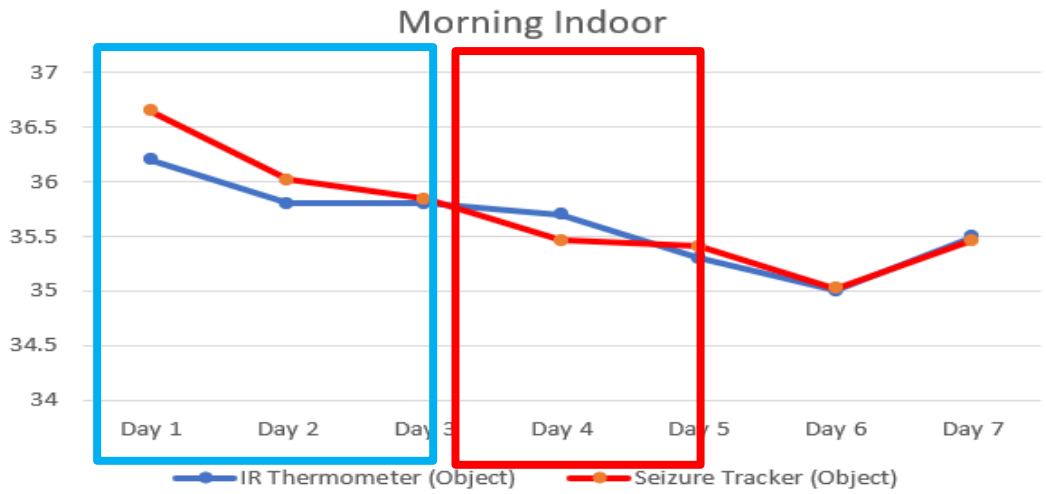

Figure 4.2 Graph analysis of morning, indoor

From graph figure 4.2 above, by referring the blue box, the temperature for seizure tracker and IR thermometer go down together. It means that the comparision between two temperature detector act the same thing. For day 1, which is 36.2˚C for IR thermometer and 36.65˚C for seizure tracker, which is still in the range of accuracy for DS18B20. Difference between day 2 getting smaller and day 3 the two graphs have a cross-sectional point on it.

Moving on to the red box, there is a little difference in the reading and the pathway of the graph. The blue line graph is mainly on a stable condition with day 2 but the red line graph moves downwards. Although it moves downwards, the range of accuracy still in the range of DS18B20. The graph is moving downward for the first 6 days and slightly upwards on the seventh day and this might be the causes of the weather, which weather in morning indoor is quite cold day by day.

Table 4.4 below shows the average data taken for morning session, indoor temperature.

Table 4.4 Average data for morning, outdoor

Morning—Outdoor				
	IR Thermometer (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Day 1	31.0	30.85	36.5	36.73
Day 2	31.2	31.52	36.1	36.39
Day 3	29.6	29.74	36.5	36.52
Day 4	30.6	30.23	36.5	36.29
Day 5	29.6	29.61	36.5	36.36
Day 6	28.6	28.60	36.5	36.46
Day 7	28.5	28.69	36.4	36.51

The graph below shows the analysis of the data above which is outdoor situation, in the morning.

As can see from the graph, when the blue line dropped from day 1 to day 2, the red line will also drop, this means that the temperature of both sensor are equivalent. Besides that, the cross-section point of this graph is 2 out of 7.

Figure 4.3 below shows the graph analysis of data for morning ourdoor.

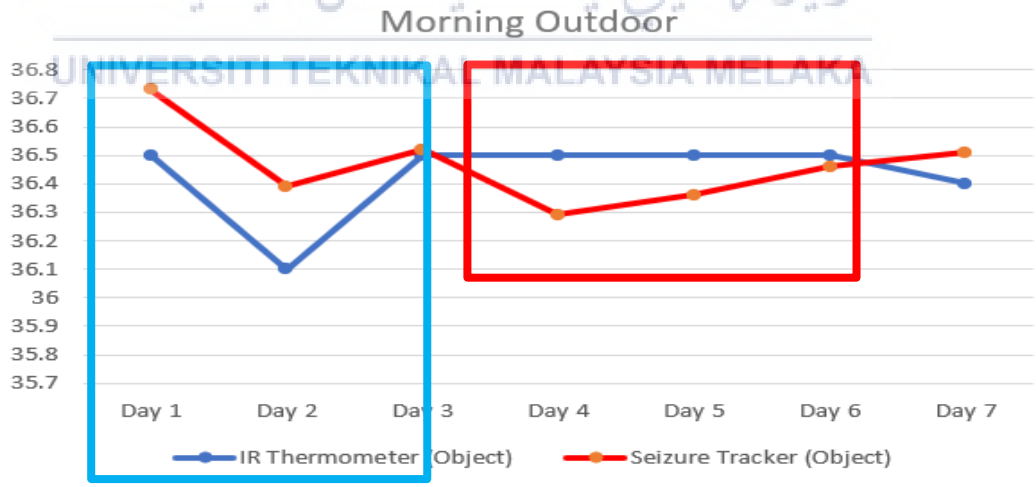

Figure 4.3 Graph analysis for morning outdoor

From the graph figure 4.3 above, by referring from the blue box, for day 1 to day 3 the graph pattern for both red and blue lines are equivalent. The temperature for both lines

are still in the range ±0.5˚C. Moving on to the red box, there is a downwards action for seizure tracker but the blue line still continue stable. This is because the seizure tracker have quite a big movement in detecting the temperature of body, and its a outdoor situation. There will be a effect in outdoor situation because human might sweat, and this will make the skin temperature get either hotter or colder.

The next average data is for afternoon indoor. Table 4.5 below shows the average data taken for afternoon session, indoor temperature.

Table 4.5 Average data for afternoon, indoor

Afternoon—Indoor				
	IR Thermometer (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Day 1	26.9	26.78	36.9	36.56
Day 2	26.6	26.72	36.5	36.76
Day 3	25.4	25.47	36.4	36.60
Day 4	26.2	26.21	36.1	36.41
Day 5	29.3	29.30	36.2	36.57
Day 6	28.7	28.81	36.6	36.68
Day 7	29.4	29.31	36.3	36.58

Figure 4.4 below shows the graph analysis of indoor situation, in the afternoon. As can see from the graph, although there is only 1 cross-sectional point between day 1 and day 2, the uprise and downhill of the graph is actually equivalent. This means that the seizure tracker prototype with sensor DS18B20 works well by reading the body temperature of the user.

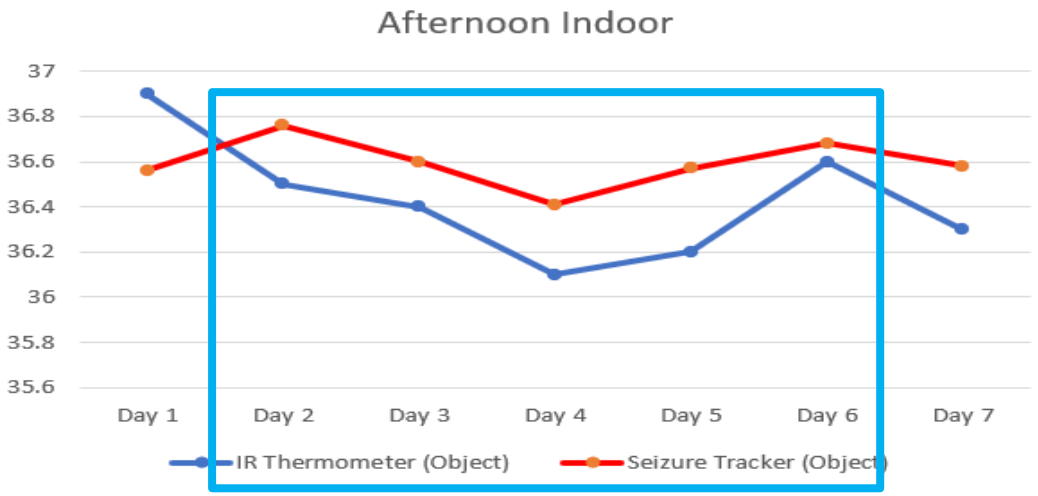

Figure 4.4 Graph analysis for afternoon, indoor

From the graph figure 4.4 above, by referring to the blue box, it shows that the red line graph and blue line graph have the equal pathway. Which is when the blue line go downwards, red line will also go downward. Same with the upward direction.

The next data and graph will be discussing on afternoon outdoor. Table 4.6 below shows the average data taken for afternoon session, outdoor temperature.

Table 4.6 Average data for afternoon, outdoor

Afternoon—Outdoor				
	IR Thermometer (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Day 1	31.5	31.84	37.3	36.85
Day 2	32.1	32.41	37.0	37.03
Day 3	25.8	26.00	36.7	36.54
Day 4	31.2	31.41	37.1	36.73
Day 5	32.0	31.78	36.9	36.56
Day 6	31.9	31.70	36.8	36.71
Day 7	30.7	30.64	37.2	37.07

From the graph below, it show that only 1 out of 7 cross-sectional point. Except for day 1, which the temperature of both lines are abit further, the lines for other days work well as they have the same uprise and downhill inside the graph. Although for day 4 the lines are abit further too, the error did not exit ± 1˚C.

Figure 4.5 below shows a graph analysis of outdoor situation in the afternoon.

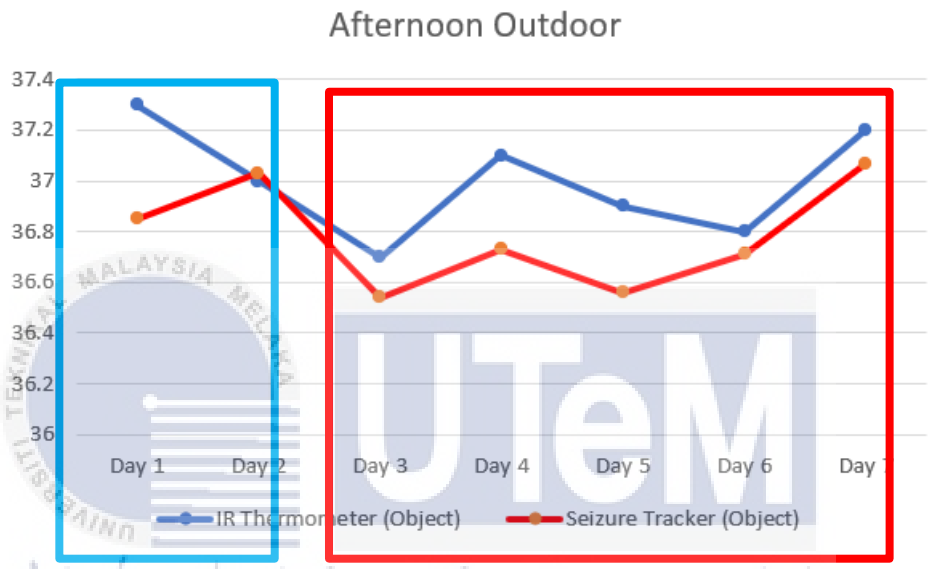

Figure 4.5 Graph analysis for morning, outdoor

From the graph figure 4.5 above. By referrring to the blue box, there is a slightly difference for blue line and red line. This might due to the weather because the weatehr in day 1 afternoonis a thunderstorm. Thunderstorm makes the surrounding temperature get cooler and this might affect the temperature sensed by IR thermometer because IR thermometer's temperature is almost 37.3˚C which is quite high compare to other graphs and data. By referring to the red box, the graph for both lines run in the same pathway. Just there is a quite big difference in day 4 but the range of accuracy is still inside ±0.5˚C.

The next set of data and garph will be discussing on evening indoor. Table 4.7 below shows the average data taken for evening session, indoor temperature.

Table 4.7 Average data for evening, indoor

Evening—Indoor				
	IR Thermometer (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Day 1	25.8	25.91	36.4	36.52
Day 2	26.1	26.16	36.0	36.17
Day 3	24.2	24.28	36.0	36.05
Day 4	25.4	25.41	35.3	35.30
Day 5	25.7	25.74	35.6	35.71
Day 6	24.3	26.29	35.2	35.25
Day 7	26.4	26.39	36.0	35.99

From the graph below, it shows how the seizure tracker prototype works well. The accuracy of the seizure tracker prototype is nearly perfect with the IR thermometer which is a guideline in this project. There is 4 out of 7 cross-sectional parts and both of the lines and nearly attached to each other.

Figure 4.6 below shows the graph analysis of indoor situation in the evening.

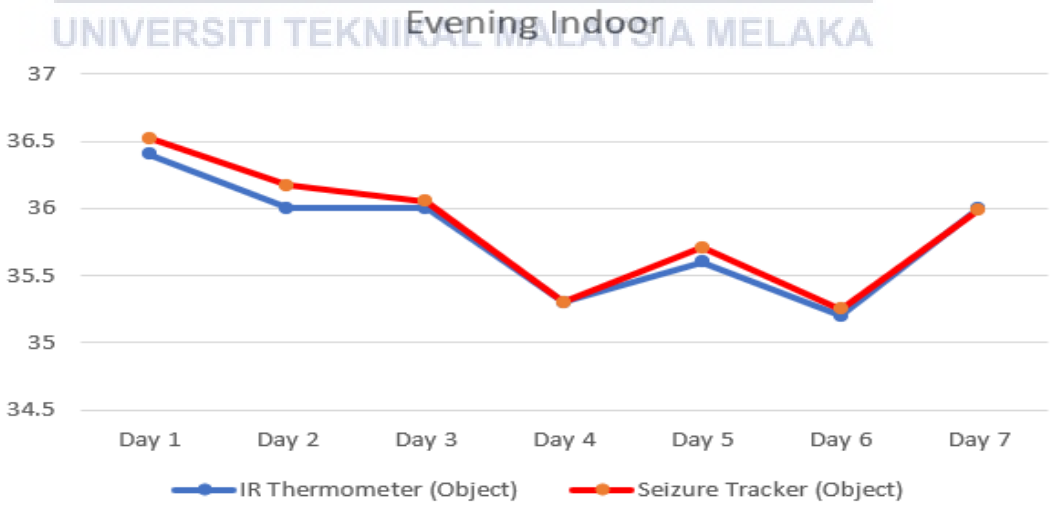

Figure 4.6 Graph analysis for evening, indoor

For the overall of graph figure 4.6, the graph runs smoothly for the both lines. Same as the graph for morning indoor at figure 4.2, the graph go in a downwards direction and slightly upward in day 7 because of the weather affecting the temperature of human's body.

The last set of data graph in this subtopic will be discussing about evening outdoot. Table 4.8 below shows the average data taken for EVENING session, OUTDOOR temperature.

Table 4.8 Average data for evening, outdoor

Evening--Outdoor				
	IR Thermometer (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Day 1	26.7	26.94	36.4	36.90
Day 2	27.9	28.06	36.8	36.83
Day 3	25.1	25.33	36.0	36.43
Day 4	25.9	25.77	36.8	36.91
Day 5	27.3	27.27	36.2	36.40
Day 6	26.5	26.38	36.8	36.68
Day 7	27.9	27.73	36.8	36.56

From the graph below, there is 2 cross-sectional parts which is in day 2 and in between day 5 and 6. Although the cross-sectional parts are not as much as the graph above, but obviously the both lines are equivalent from day 2 to 5, which is a big "W" word in the middle of the graph. Figure 4.7 below shows the graph analysis of outdoor situation in the evening. From the graph belows, by referring the blue box, there is a difference for red line and blue line. As this is for day 1, which mentioned before, it is due to the weather affecting the garph. For the remaining days, the graph that includes both lines go in the same way.

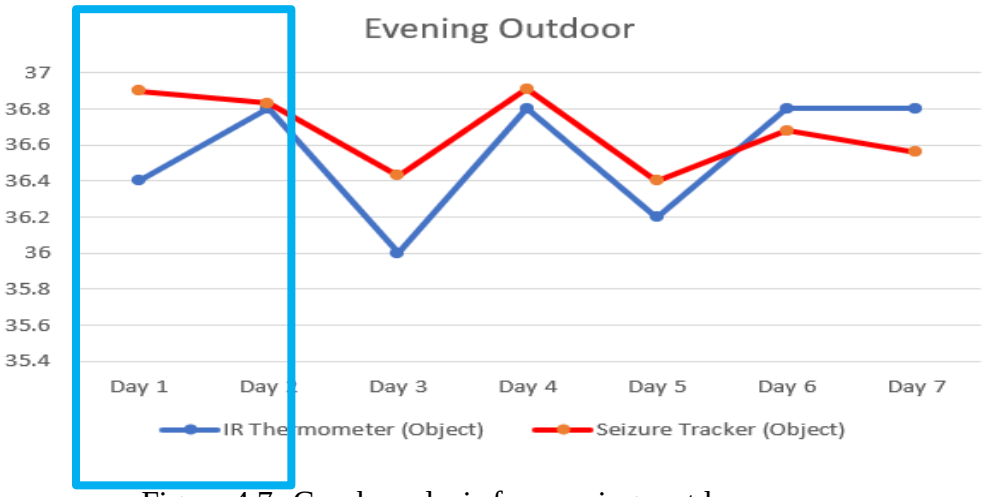

Figure 4.7 Graph analysis for evening, outdoor

4.2.3 Settling Time for Prototype

DS18B20 is a digital temperature sensor. When the switch is on and the project prototype is placed on the user's wrist and WiFi connection is all set, the temperature sensor needs a settling time to get itself set up.

In this case, normal body temperature of a human being is used, which is around 36˚C and this temperature will become the set point temperature in this topic. When DS18B20 is placed on the wrist, the temperature that shown in Blynk App will not directly turns 36˚C, or the person's body temperature. It will start from around 32˚C to 34˚C and slowly raises its temperature until the set point temperature that this project wanted, which is around 36˚C.

From the graph below, it shows the settling time which the digital temperature sensor needs. For the settling time of this temperature sensor, it also depends on the weather and situation too. For example, when the weather is cold and the body temperature is abit low, it will takes about 20 to 30 seconds of the temperature to reach the set point. If the weather is normal, or hot, the temperature rises to the set point temperature will be slightly

faster than the one before. It takes about 10 to 15 seconds for the temperature to reach its set point.

Figure 4.8 shows the settling time of DS18B20 to reach set point.

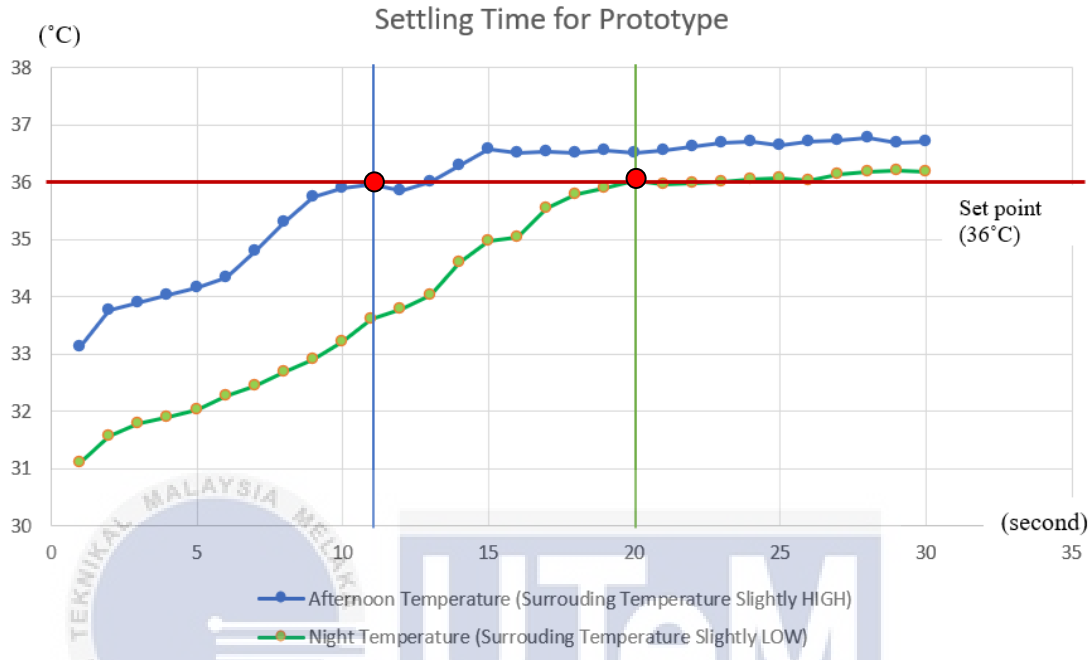

Figure 4.8 Settling time for prototype

From the graph figure 4.8 above, the reason of why the blue line graph hits the set point first is because the seizure tracker works better in afternoon time. When in afternoon, the person who did the experiment is in awake mode and the temperature of surrounding is just nicc. This can cause the data collected the settling time for seizure tracker reach the set point faster which is in between 10 to 15 seconds.

For the green line graphs, it takes above 20 seconds to reach the set point and this is becasue the person who doing this experiment took the data before sleep. When human being tired or going to sleep, the body temperature will be decrease down slightly as the internal energy of the person might be using off.

4.3 Factors that affect Data and Analysis

In this chapter will discuss about the function of the project prototype with the weather on that day as to ensure that the prototype runs in a correct way. In this section the aim will be more to the temperature of detected object, while the ambient temperature for both detection devices is just for the reference of the accuracy for both devices.

For the graph, the data of 7 days will be analysed and separate into 3 session which is:

- Morning (0900 hour)
- Afternoon (1200hour)
- Evening (1800 hour)

Besides that, only two different places that the data will be collected, which is:

- Indoor
- Outdoor

These two categories (time and place) will be cross with each other to find out the overall accuracy of the seizure tracker prototype.

For the starting of this topic, the comparison of Indoor and Outdoor situation will be taken. Table 4.9 and 4.10 below shows the average data of indoor and outdoor taken from seizure tracker prototype.

Table 4.9 Indoor average data

Indoor		
	IR Thermometer	Seizure Tracker Prototype
Morning	35.61	35.69
Afternoon	36.43	36.59

Evening	35.79	36.86

Table 4.10 Outdoor average data

Outdoor		
	IR Thermometer	Seizure Tracker Prototype
Morning	36.43	36.47
Afternoon	37.00	36.77
Evening	36.54	36.67

In this project, the factors that had been observed which is quite obvious, that will affect the accuracy of data given out by DS18B20 temperature sensor is:

- Weather
- Situation/Place

DS18B20 is a type of sensor with accuracy of ±0.5˚C when the temperature that detected is in -10˚C to +85˚C. Which means in this case, a normal adult person has a body temperature range between 36.1˚C to 37.2˚C and kids is about 36.4˚C in room temperature. But the situation and weather cannot be set and determined at first of this project, and its also the most important things that included in this project which is to develop a activity tracker with a high accuracy sensor.

By referring the studies in chapter 2, the wrist part in human's body is considered "Approved" in medication detection which used technologies. Besides that, by considering human being will sweat in outdoor. According to (Gagnon & Crandall, 2018), sweating is the strongest autonomic thermoeffector. The only method of heat loss when the ambient temperature is higher than the skin temperature is sweat evaporation, which has by far the

highest potential for heat loss. By referring to this journal, if outdoor can make human being sweat, which means the temperature that get by outdoor will either be abit lower or higher compared to indoor temperatures.

According to the recorded 7 days weather result, most of the weather in morning do not rain, but it cannot consider is a good weather as there is fog together with the sun for 5 days and 2 cloudy days, makes the temperature of the surrounding decreases. For afternoon, the weather is cloudy without sun for the 6 days and only one day have thunderstorm. Lastly for evening time, the weather can consider to be slightly cooler as the days are mostly cloudy and one with thunderstorm.

From the recorded data of weather and data from weather report, mostly of the weather in this 3 timing, which is morning (0900 hour), afternoon (1200 hour) and evening (1800 hour), the 7 days period that the experiment was done is considered as rainy season, so the data that we collected from the IR thermometer and seizure tracker prototype is quite near the readings as no matter in indoor or outdoor the temperature is cooler, so the sweating might not happened to the person in experiment.

4.4 Price Range of Prototype

By referring back to the objectives in chapter 1 of this report, the aim of this project is to develop a low-cost and user-friendly activity tracker for kids with seizure detection capability. Therefore, cost is an important criteria too in this project.

From the literature reviews in chapter above, the price range is clearly meantioned. Mostly of the activity tracker with seizure detection capability are in price range of RM 350 to RM 1000 per unit. Together in the package will have smartphone applications which either charging of monthly subscription fees or not. If yes, the monthly fees could be from RM40

to RM200. Although it might seem normal to families that can afford this tracker. But for some families or some countries which is poor, for example families which are still taking the basic income of RM1500 per month, or third world nations, their loved kids might be in danger or even dead in seizure because they cannot afford the medication fees, or even a activity tracker with seizure detection capability to avoid accidents to be happened.

The activity tracker that developed in this project is consider as a cheap but useful product for kids with seizure. The components/software which included to develop a activity tracker for kids with seizure detection capability project are as follow:

- NodeMCU ESP8266
- Blynk App
- DS18B20
- 3.7V LiPo Battery 1000mAH
- Battery Charger
- Jumper/Wire
- PCB donut
- Sports wrist strap

Table 4.11 below shows the price of each component/software which needed.

Table 4.11 Price Range of Components/Software of Project

Components/Software	**Price (RM)**
NodeMCU ESP8266	19.90
Blynk App	FOC
DS18B20	6.00
3.7V LiPo Battery 1000mAH	20.00

Battery Charger	5.00
Jumper/Wire	2.00
PCB Donut	4.90
Sports Wrist Strap	10.00
Total	**RM67.80**

From the price range above, we can conclude that the components and software which included in doing this project in below RM100. Although software is using Blynk App which might need to pay for the copyrights fee, but it is just one-time charging fees only, not a monthly subscription fees.

4.5 Discussion

For this subtopic, the discussion will be explained. From the beginning of this chapter, firstly the prototype of this project had been created out. From the prototype designed in breadboard until the final prototype soldered up and able to wear in hand, there are a few software and website had been referenced.

Moving on to the next part which is data analysis. There are total of 5 data that we got from the prototype which been listed down in Appendix 1. From the data, it proved that the prototype with using digital temperature sensor DS18B20 is functioning very well because the comparision data with IR thermometer does not change too much, which is between the range of ±0.05˚C in room temperature situation and ±0.10˚C in situation with air conditioning or outdoor situation. This is due to the body temperature react by human skin. From the graph analysis that shown, there will be either more than 4 out of 7 cross-

sectional points inside the graph, or the graph pattern for the two sensor detector will be running is the same pathwat, just the range with ±0.5˚C.

From the graphs in subtopic 4.2.2 above, it shows that there is the same problem for day 1 indoor which the point of IR thermometer and seizure tracker start slightly further, but the both points are still in the range of ±0.5˚C.. The experiments run in indoor situation for the both detectors will be nearly same for the graph pattern as in indoor, human's body temperature will be affect by the room temperature and it is quite stable. For the outdoor's graph, it has slightly difference for the both graphs in some days as this may due to the weather of surrounding. When the outdoor weather is hot or cold, it might straightly affect the body tempeature of human skin. For example, sweating under a hot sun or standing beside a big rain will make the body temperature not stable as been detected by both detectors.

For the prototype of this project, the soldered components on the PCB donut will be attached to a sports wristband. By using this wristband, it is very flexible for kids to wear depending on their wrist size. Besides that, the elasticity of this wristband will also allow kids to wear this activity tracker on their forearm or area near their armpit.

Coming back to the price of this project. The overall budget of this prototype did not exit the limit of RM100. With a very useful function which is detecting the kids' temperature, it is costs below RM100. For acy future works like putting on GPS or accelerometry on it, the range of the price for this prototype cannot exit the limit of RM300. As from the journal that found, most of the respondonts accept the price range withing RM200-RM500 for an activity tracker. Besides that, the detecting and notificationing software will also be included together with this prototype.

4.6 Summary Topic

From the summary of this topic can concluded that the development of this project works no matter in hardware or software and it give benefits to the people.

From the data analysis above, it proved that with the main components in this project, microcontroller ESP8266, DS18B20 digital temperature sensor and Blynk App as IoT-Based cloud platform, they works well and the data of the monitoring object can be sent to smartphone without hesitation.

Although the digital temperature sensor DS18B20 works well with a ±0.5˚C in detection human body temperature, the situation and weather might change the value of the detected temperature. For example, the data could be affected in either indoor or outdoor situation, moving or sitting, sleeping or awaking. Besides that, weather could also affect the accuracy of DS18B20 sensor too. For example, when the weather is very hot and the user is in outdoor situation, user might be sweating the the sweats might either make the sensed data a bit higher or lower than the normal temperature. Blynk App will also send pop-up notification together with an alert ringtone when the temperature hits 38˚C.

Lastly, the price of the project that has been calculated above is considered as low-cost as from the literature reviews in chapter 2, a studies shows most of the respondents willing to buy an activity tracker with price rance of $50-$200, converted to ringgit Malaysia which is roughly about RM200-RM400. The prototype of this development is the basic idea of this activity tracker for kids with seizure detection capabilities. More of the improvement will be discussed in the following chapter, which is future work.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

By the end of this project with the title of "Development of IoT-Based Kids' Activity Tracker with Seizure Detection Capability", 3 objectives had been set as the aim which find in problem statement in this title. By the end of this chapter, the 3 objectives which are been set had been achieved successfully.

For the first objective, to investigate seizures among kids. In chapter 2, literature review, listed with different kinds of seizures. Seizures can be happen to anybody without giving precautions to the patient. If this thing happen to an adult, it might be dangerous because jerking, or a sudden faint will make the person had some body damages. But if it happen to a kid, the dangerous and damaged with be doubled compared to adult. From literature review, the symptoms of kids seizure, which called as "Febrile Seizure", are listed down the the following development that wish to do is to prevent kids from having the sudden attack by seizure without any precaution.

The next objective is to develop lost cost and user-friendly kids seizure detector for parents. In the era glabalization, medication are all linked to money. The more money that willing to pay, medication treatment given will be more advanced. In other words, poor people does not deserve the rights to get treatment. This thing happen in the world. Poor families, third world nations could not get treatment and this make their loved one past away. So the aim of this project is to make a low cost and user-friendly seizure detector which can be afford by people with not much income, so they can protect their family members from the attack of seizure.

The last objective is to develop an application for kids seizure monitoring. In chapter 3, which is methodology and chapter 4, which is data and analysis, the project is planned to make an activity tracker with seizure detection capability. The procedure of the project is explained in chapter of methodology and the sensor that used is DS18B20, a digital temperature sensor wich working principle of direct conversion of temperature into a digital value. Together with the help of ESP8266, the ESP8266 will first give a command to the DS18B20 to let it sense the temperature of the object, in this case is the wrist of human body, and send the data back to ESP8266. Lastly the ESP8266 will send the accurate sensed temperature by DS18B20 to smartphone through Blynk App. Besides that, Blynk App will also send to pop-up notification with special alert notification when the body temperature hits 38˚ C.

5.2 Future Works

Every project needs to have future work in order to develop a more useful product to the human being. In this case, the aim of the project is to let every family which cannot afford the high price of a real multi-function seizure tracker to protect their loved ones from the danger and damages from the attack of seizure.

In this project, a digital temperature sensor DS18B20 with the working principle of direct conversion of temperature into digital value, a microcontroller ESP8266 (NodeMCU brand), other brand will be fine, battery charger, LiPO battery and lastly Blynk App with monitoring and notification function is included in this project.

To improve the project, which not just limit the user range in age of 6 months to 8 years-old, an accelerometer can be also included to detect the jerking movement of the patient when seizure attacks. This project do not include accelerometer because kids seizure,

also called as Febrile Seizure, do not have the symptom of jerking. Kids seizure just stays in high fever. The project can be improved which every age of seizure patient can use, which includes more sensor such as accelerometer for detecting jerking movement, GPS for monitoring tracker user in anywhere, auto-calling for hospital emergency and send location to the rescue teams in order to ensure that patient can get first-aid in anywhere when they got attacked by seizure.

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APPENDICES

Appendix A Data from prototype of project in morning, afternoon and evening (indoor and outdoor)

Day 1 – Indoor (27 November 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	26.2	26.40	36.2	36.72
		26.43		36.70
		26.45		36.65
		26.35		36.60
		26.45		36.59
Afternoon (1200 hour)	26.9	26.73	36.9	36.59
		26.79		36.60
		27.80		36.57
		27.82		36.52
		26.77		36.53
Evening (2000 hour)	25.8	25.90	36.4	36.50
		25.91		36.56
		25.94		36.50
		25.91		36.55
		25.89		36.61
Day 1 – Outdoor (27 November 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	31.0	30.98	36.5	36.71
		30.87		36.77
		30.80		36.70
		30.79		36.71
		30.81		36.75
Afternoon (1200 hour)	31.5	31.80	37.3	36.87
		31.85		36.80
		31.83		36.86
		31.86		36.84
		31.85		36.88
Evening (2000 hour)	26.7	27.00	36.4	36.96
		26.96		36.91
		26.96		36.90
		26.91		36.85
		26.89		36.87

Day 2 – Indoor (28 November 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	25.8	25.96	35.8	36.05
		26.04		36.07
		25.99		36.02
		25.90		35.98
		25.87		35.97
Afternoon (1200 hour)	26.6	26.79	36.5	36.77
		26.75		36.81
		26.70		36.78
		26.67		36.73
		26.68		36.70
Evening (2000 hour)	26.1	26.15	36.0	36.13
		26.21		36.19
		26.17		36.20
		26.14		36.17
		26.13		36.15
Day 2 – Outdoor (28 November 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	31.2	31.56	36.1	36.39
		31.53		36.41
		31.50		36.38
		31.52		36.37
		31.49		36.38
Afternoon (1200 hour)	32.1	32.40	37.0	37.08
		32.37		37.01
		32.41		37.00
		32.39		36.99
		32.46		37.05
Evening (2000 hour)	27.9	28.16	36.8	36.80
		28.07		36.85
		28.01		36.88
		28.04		36.85
		28.00		36.79

Day 3 – Indoor (29 November 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	25.3	25.46	35.8	35.90
		25.41		35.87
		25.38		35.82
		25.34		35.79
		25.30		35.82
Afternoon (1200 hour)	25.4	25.50	36.4	36.69
		25.42		36.62
		25.39		36.57
		25.40		36.61
		25.42		36.63
Evening (2000 hour)	24.2	24.30	36.0	36.12
		24.26		36.08
		24.27		36.07
		24.30		36.01
		24.27		35.97
Day 3 – Outdoor (29 November 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	29.6	30.01	36.5	36.61
		29.79		36.57
		29.68		36.52
		29.61		36.47
		29.60		36.43
Afternoon (1200 hour)	25.8	25.90	36.7	36.59
		25.92		36.55
		26.01		36.53
		26.04		36.50
		26.09		36.54
Evening (2000 hour)	25.1	25.34	36.0	36.49
		25.39		36.44
		25.34		36.40
		25.29		35.38
		25.30		36.42

Day 4 – Indoor (30 November 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	24.8	23.92	35.7	35.41
		23.88		36.48
		23.86		36.44
		23.90		36.47
		23.91		36.50
Afternoon (1200 hour)	26.2	26.25	36.1	36.43
		26.23		36.40
		26.18		36.38
		26.20		36.40
		26.17		36.42
Evening (2000 hour)	25.4	25.45	35.3	35.30
		25.40		35.27
		25.37		35.29
		25.39		35.31
		25.42		35.33
Day 4 – Outdoor (30 November 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	30.6	32.21	36.5	36.31
		30.14		36.29
		30.20		36.31
		30.28		36.25
		30.31		36.28
Afternoon (1200 hour)	31.2	31.42	37.1	36.78
		31.39		36.75
		31.43		36.70
		31.41		36.68
		31.40		36.73
Evening (2000 hour)	25.9	25.78	36.8	36.94
		25.74		36.89
		25.70		36.91
		25.75		36.87
		25.81		36.90

Day 5 – Indoor (1 December 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	25.4	25.41	35.3	35.45
		25.37		35.42
		25.35		35.38
		25.35		35.39
		25.32		35.41
Afternoon (1200 hour)	29.3	29.24	36.2	36.60
		29.28		36.58
		29.30		36.56
		29.35		36.58
		29.33		36.61
Evening (2000 hour)	25.7	25.81	35.6	35.75
		25.78		35.71
		25.72		35.68
		25.70		36.66
		25.71		36.75
Day 5 – Outdoor (1 December 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	29.6	29.59	36.5	36.40
		29.62		36.37
		29.65		36.30
		29.59		36.36
		29.62		36.39
Afternoon (1200 hour)	32.0	31.79	36.9	36.65
		31.82		36.60
		31.79		36.54
		32.76		36.51
		32.73		36.49
Evening (2000 hour)	27.3	27.20	36.2	36.41
		27.25		36.39
		27.29		36.34
		27.32		36.40
		27.30		36.44

Day 6 – Indoor (2 December 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	25.1	25.11	35.0	35.05
		25.08		34.99
		25.02		34.95
		24.98		35.01
		25.05		35.06
Afternoon (1200 hour)	28.7	28.89	36.6	36.61
		28.86		36.67
		28.79		36.65
		28.74		36.70
		28.75		36.75
Evening (2000 hour)	24.3	24.32	35.2	35.19
		24.28		35.23
		24.30		35.26
		24.31		35.29
		24.26		35.27
Day 6 – Outdoor (2 December 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	28.6	28.69	36.5	36.39
		28.64		36.42
		28.60		36.48
		28.55		36.51
		28.54		36.52
Afternoon (1200 hour)	31.9	31.72	36.8	36.70
		31.66		36.69
		31.71		36.74
		31.74		36.70
		31.66		36.72
Evening (2000 hour)	26.5	26.47	36.4	36.71
		26.50		36.68
		26.48		36.64
		26.44		36.70
		26.40		36.65

Day 7 – Indoor (3 December 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	25.6	25.75	35.5	35.45
		25.71		35.49
		25.68		35.50
		25.61		35.48
		25.62		35.40
Afternoon (1200 hour)	29.4	29.31	36.3	36.60
		29.36		36.57
		29.30		36.61
		29.29		36.53
		29.28		36.58
Evening (2000 hour)	26.4	26.30	36.0	35.91
		26.40		35.98
		26.42		36.00
		26.39		36.05
		26.43		36.04
Day 7 – Outdoor (3 December 2022)				
	IR Thermomter (Ambient)	Seizure Tracker (Ambient)	IR Thermometer (Object)	Seizure Tracker (Object)
Morning (0900 hour)	28.5	28.52	36.4	36.47
		28.50		36.40
		28.49		36.38
		28.51		36.41
		28.52		36.49
Afternoon (1200 hour)	30.7	30.59	37.2	37.10
		30.62		37.09
		30.70		37.01
		30.65		37.09
		30.62		37.05
Evening (2000 hour)	27.9	27.80	36.8	36.61
		27.75		36.56
		27.71		36.54
		27.67		36.58
		27.74		36.52

Appendix B Data for settling time of prototype

Time (in second)	Afternoon Temperature (Surrouding Temperature Slightly HIGH)	Night Temperature (Surrouding Temperature Slightly LOW)		Time (in second)	Afternoon Temperature (Surrouding Temperature Slightly HIGH)	Night Temperature (Surrouding Temperature Slightly LOW)
1	33.13	31.09		16	36.52	35.03
2	33.75	31.56		17	36.53	35.54
3	33.89	31.78		18	36.50	35.78
4	34.02	31.89		19	36.56	35.89
5	34.15	32.03		20	36.50	36.02
6	34.34	32.26		21	36.55	35.97
7	34.79	32.45		22	36.61	35.99
8	35.29	32.69		23	36.69	36.00
9	35.75	32.90		24	36.71	36.05
10	35.89	33.20		25	36.64	36.07
11	35.97	33.60		26	36.70	36.02
12	35.86	33.79		27	36.73	36.13
13	36.01	34.02		28	36.77	36.19
14	36.29	34.59		29	36.68	36.20
15	36.57	34.98		30	36.70	36.17