DISASTER ALERT SYSTEM (DISAST)

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Mechatronics Engineering

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"I hereby declare that I have read through this report entitle "Disaster Alert System (DISAST)" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering."

Signature : ....

Supervisor's Name : DR. AHMAD ZAKI BIN HJ SHUKOR

Date : 15/6/17

I declare that this report entitle "*Disaster Alert System (DISAST)*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : Pei

Name : TEOW BOON PEI

Date : 15/6/2017

To my beloved mother and father

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ABSTRACT

Earthquake is a type of natural disaster that cannot be predicted accurately while flooding is the most common natural disaster where the effect vary greatly especially in terms of property damage. Therefore, a Disaster Alert System is proposed where the system could detect earthquake and flood disaster by using sensors and then send the alert message to the recipient with an image of water level condition through smartphone application. In this system, accelerometer is used to sense the vibration (earthquake) while ultrasonic sensor is used to sense the water level (flood). Then, both signals are transmitted into Raspberry Pi, where it is used as a controller in this embedded system. A medium range earthquake disaster and a low level to high level of flood disaster are measured by this system. In addition, a USB camera is used to capture the image of water level condition once the ultrasonic sensor is triggered and the image is saved in JPEG format. Next, Raspberry Pi is triggered by the input signals of both sensors and then the alert message is sent to the recipient's mobile phone with the saved image through Telegram messenger application which is pre-installed in the mobile phone. This will help to alert the users to take the safety precaution in a shorter period when the earthquake and flood disaster are happened in order to save their lives. The experiments on time needed for detecting earthquake and flood disaster, sending, receiving and displaying the message are conducted since time is a crucial parameter that will affect the efficiency of the victims to take the precaution measurement. The effectiveness of this system is demonstrated by the results of the experiments. It is believed that many innocent lives could be saved with the introduction of this system.

ABSTRAK

Gempa bumi merupakan salah satu jenis bencana alam yang masa berlakunya tidak dapat diramalkan secara tepat manakala banjir merupakan kejadian yang biasa di mana kesannya amat teruk terutamanya kerosakan harta benda. Oleh itu, satu sistem telah dicadangkan di mana sistem ini boleh mengesan gempa bumi dan banjir dengan menggunakan sensors, dan menghantar mesej amaran kepada penerima bersama dengan gambar keadaan paras air dengan melalui aplikasi telefon pintar. Dalam system ini, sensor getaran telah digunakan untuk mengesan getaran (gempa bumi) manakala sensor ultrasonik telah digunakan untuk mengesan paras air (banjir) dan kedua-dua isyarat ini akan dihantar kepada Raspberry Pi, di mana ia merupakan pengawal dalam sistem ini. Sistem ini akan mengukur gempa bumi dalam rangkaian yang sederhana dan mengukur banjir bagi tahap rendah hingga tahap tinggi. Tambahan lagi, satu kamera USB telah digunakan untuk menangkap gambar keadaan paras air sesekalinya ultrasonik sensor dicetuskan dan gambar tersebut akan disimpankan dalam format JPEG. Seterusnya, isyarat input daripada kedua-dua sensor itu telah mencetuskan Raspberry Pi untuk menghantar mesej amaran kepada telefon bimbit penerima bersama dengan gambar tersebut dengan melalui Telegram aplikasi yang dipasang dalam telefon bimbit dari awal lagi. Ini akan membantu pengguna untuk mengambil langkah keselamatan dalam masa yang singkat demi menyelamatkan nyawa mereka apabila berlakunya gempa bumi dan banjir. Eksperimen pada masa yang diperlukan untuk sistem ini mengesan gempa bumi dan banjir, menghantar, menerima dan memaparkan mesej telah dijalankan disebabkan masa merupakan satu parameter utama yang akan mejejaskan kepantasan mangsa untuk mengambil langkah keselamatan. Keberkesanan system ini telah ditunjukkan oleh keputusan eksperimen. Ia dipercayakan bahawa kebanyakan nyawa yang tidak berdosa dapat diselamatkan dengan pengenalan system ini.

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LIST OF ABBREVIATIONS

PWM - Pulse Width Modulation

ADC - Analog-to-Digital Converter

USB - Universal Serial Bus

FPGA - Field Programmable Gate Array

IP - Internet Protocol

RAM - Random Access Memory

CPU - Central Processing Unit

GPU - Graphical Processing Unit

ARM - Advanced RISC Machine

GPIO - General Purpose Input/Output

SoC - System on Chip

g - Gravity Force

Trig - Trigger

LED - Light Emitting Diode

SMS - Short Messaging Service

HDMI - High Definition Multimedia Interface

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CHAPTER 1

INTRODUCTION

1.1 Overview

There are five subtopics will be presented and discussed in this chapter, which are motivation, problem statement, objective, scope and report outline. Besides that, limitation and target of the project will be explained throughout this chapter. In addition, statistic of reliable fact which is related to the project will be shown.

1.2 Motivation

Among top five of most common type of disaster that happened globally from year 2005 to 2014, flood was considered as the most common while earthquake was considered as second for of natural disaster as shown in Figure 1.1 [1].

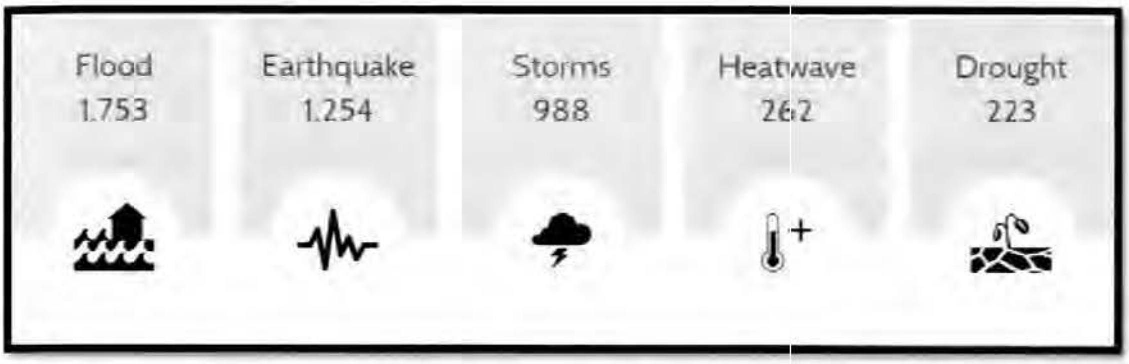


Figure 1.1: Top 5 most common disasters in worldwide from year 2005-2014 [1].

In Malaysia, flood disaster considers as a regular natural disaster which will happen almost every year during the monsoon season [2]. The most common natural disaster that happened in Malaysia are floods and landslides as well as forest fire and haze [3]. On 18 July 2016, flooding was occurred at two areas of Kedah state, Yan and Baling. 441 people were removed out from the affected regions and moved into three relief centres that prepared by NADMA. On the same day, parts of Penang state were also reported flooding, where the affected regions consisted of Teluk Bahang, Penang International Airport, Relau, Natu Maung, Teluk Kumbar and Bayan Lepas. Teluk Bahang was the worst hit region, where the flood water increased up to 50 cm deep due to the combination of heavy rain and rivers overflow [4].

Next, an extreme rainfall that happened from 7 March 2016 to 9 March 2016 at Sarawak had caused an inland flood which affected many villagers where the rain fell about 93.2mm within 24 hours in the first two days [5]. Besides that, floods had affected two districts of Malacca state on 8 February 2016, Alor Gajah and Jasin, due to the overflowing of Malacca River and flash floods on 5 February 2016. About 8000 people were affected and 47 families were housed in the relief centres of the state [6]. Besides of Malacca, the heavy rain that started on 5 February 2016 had seriously affected Johor, Negeri Sembilan and Sarawak. Two people were reported that they died during the flood disaster in Johor [6].

Not only in Malaysia, Indonesia is a country that often facing flood disaster [7]. Garut Regency, Indonesia had experienced a severe flooding due to the heavy rain on the evening of 20 September 2016, where the height of the flood water up to about 2 meters. During the flood, around 23 people had considered as dead while they were 18 persons still in missing.

On the same day, two people had died due to the landslide that happened in Cimareme, Sumedang [8].

Furthermore, some of the countries in Southeast Asia also experienced serious flooding, such as Thailand, Laos and Vietnam on 12 August 2016 [9]. In Thailand, five districts were affected, seven bridges and more than 20 buildings were destroyed at Mae Hong Son while at Nan Province, the flood was affected 127 small districts and the flood water level up to 3 metres deep [10]. 4977 people were affected by the flooding happened in Laos. In Vietnam, seven people were died due to the Typhoon Dianmu, at least 44 homes were devastated by the storm, two people were missing during the flood and more than 600 houses were destroyed.

Moreover, in Northeast Asia, such as Korea, also facing a severe flood disaster due to the typhoons and localised concentrated rainfall, which caused 35 people killed, and 13 others missing [11].

Other than flood disaster, earthquake also happened worldwide during these days. In India, there was an earthquake on 12 October 2016 at 4.01am with a Richter scale of 5.3 that hit Lakshadweep Sea area [12]. On 26 August 2016, there was an earthquake in Ranau, Sabah, East Malaysia at 9.39am, which measured 4.0 on the Richter scale and a depth of 10km [13]. Climbers were rushing down quickly from 4095m peak of mountain with the assistance of mountain guides. It was smaller in the magnitude when compared to the earthquake which happened on last year, 5 June at the same place but with a highest magnitude of 6.0 on the Richter scale which lasted for 30 seconds where it was the strongest earthquake that hit Malaysia since 1976. During that earthquake, 18 people died on the Mount of Kinabalu.

There is a total number of reported natural disasters in five continents, which are Asia, Europe, Africa, Americas and Oceania in the year of 2011 to 2015 as shown in Table 1.1 and Table 1.2 [14]. From Table 1.1 and Table 1.2 below, it can be concluded that the continents number of flood disaster from year 2011 to 2015 is higher than the number of earthquake disaster.

However, the total deaths in 2015 due to earthquake disaster is more than the total deaths of flood disaster. Malaysia is a country still outdated in flood and earthquake disaster management and many citizens thought that Malaysia is a country free of disaster. Hence, Malaysians do not have any precaution or preparation when there is a disaster happens. People start to get panic and do not know what to do. Therefore, we have to explore more on flood and earthquake management, so that the total loss of lives and property damage will be reduced.

Table 1.1: Total number of reported flood disaster in continents between 2011 and 2015.

FLOOD	**2011**	**2012**	**2013**	**2014**	**2015**
No. of Disaster	156	136	149	135	152
Total Deaths	6,163	3,544	9,836	3,532	3,433
Total Affected	1,364,477,230	639,620,190	32,075,880	415,692,120	34,774,984

Table 1.2: Total number of reported earthquake disaster in continents between 2011 and 2015.

EARTHQUAKE	**2011**	**2012**	**2013**	**2014**	**2015**
No. of Disaster	30	29	28	26	21
Total Deaths	20,946	711	1,120	773	9,526
Total Affected	1,747,620	28,602,580	70,311,620	32,118,620	71,709,830

1.3 Problem Statement

The problem in disaster management is not lack of technology or the presence of related information, but it is usually lack of accessibility of the information. The key spirit of investigating and identifying the solutions for disaster recovery are the ability to use, discover and manage the information efficiently, the capability to analyse critically, and the ability to utilize such information to solve a problem properly. Therefore, it is crucial to determine and access the data efficiently in order to figure out the problem effectively.

Besides that, there is a very high false alarm rate by the present warning system which is beyond weather forecasts. A real time flood monitoring system requires sensing the flood conditions, which includes the presence of water, the level of water, the velocity of water and the rate of rain. Fixed water level sensors, satellites, and optical measurements are insufficient.

In addition, many people still lack of education on safety precaution teaching in these days. For an example, Malaysian which never thought of happening a natural disaster in Malaysia is considered as a very bad assumption since it brings higher risk to those people. When the natural disaster occurs, they are not capable to handle and manage the situation to save their precious life. They will get panic and scare in order to save their life. This causing the situation goes chaos and unorganized as they do not follow the step which could lead to more disastrous.

Not only that, scientists and researchers cannot predict flood and earthquake disaster as they can happen in a sudden time. Thus, precaution measurement cannot be taken out and inform to citizens. Hence, time is the most important variable that help to save human life. The earlier the disaster awareness or alert message received, the more lives of people could be save.

Furthermore, a large amount of cost is needed in order to develop a whole new system that consists of more functions on flood and earthquake disaster. Most collaborative proposals are not been funded although they have outlined the main components because of the higher cost needed. Wireless sensor network also need a huge amount of cost of its purchase and development. By using a platform that is already available will be wiser since it could reduce time and budget to develop.

It is important to get to know the disaster precautions in order to prevent the loss of human lives and minimizing the property damages. Hence, safety precautions and alert system should be planned well before the disasters strike. Therefore, in this research, the main idea is to develop an alert system that will sense the earthquake and flood disasters, then display the warning or precaution message to people in a shorter time in order to reduce deaths and injuries.

1.4 Objective

The objectives of this research are stated as below:

1. To design a disaster alert system that detects a low to high level of flood disaster and a medium range of earthquake disaster by using ultrasonic sensors and accelerometer respectively.
2. To develop a disaster messaging system for sending alert information and image of water level condition by using USB camera through smartphone's application.
3. To calculate the rate of efficiency for delivering and displaying the alert message with image.

1.5 Scope

The scopes of research are outlined to achieve the target of the study would be:

1. The system senses the earthquake and flood disasters when they happen and then sends the warning message.
2. The project only applicable for low to high level of flood disaster and small to medium range of earthquake disaster.
3. The range of water level measurement is up to 4 meters while the range of earthquake measurement is between 3.5 to 5.9 magnitude scales.
4. The project is mainly focused on sending the warning message directly to personal smartphone to make people alert when disasters happen.
5. The project uses wireless system to send the alert message through smartphone application.
6. The project selects Raspberry Pi as a controller to interface with the sensors.
7. The projects chooses USB camera to capture the image of water level condition, save it and send it together with the alert message.

1.6 Report Outline

This report and project is about a natural disaster alert system by using sensors to detect earthquake and flood disaster, Raspberry Pi as a controller, USB camera as a tool to capture the image and a smartphone application to send the warning message.

Chapter 2 gives a description and basic theories on the disaster and background of natural disaster which is including earthquake and flood disaster. This chapter also provides a brief discussion on the type of measurement used for measuring the earthquake and flood disaster. Besides that, the comparison between early warning system used for alerting people and their limitations are also presented in this chapter. In this chapter, the review of previous related work of the natural disaster alert system is also discussed and summarized.

Chapter 3 provides a brief review of selected components and calculation for this research. Apart from that, the experimental works for this research are also presented in order to obtain a desired result and to ensure that the objectives are achieved. This chapter also covers the methods and techniques used in designing this Disaster Alert System. The process for the entire system are presented by flow chart. The material and apparatus used, and the steps to conduct the experiments are explained in details. Different types of sensor are chosen and compared through the experiment in order to choose the best sensor for this research.

Chapter 4 presents the results obtained for each experiment and the results are discussed thoroughly. The threshold values for converting analog values to digital values are calculated by using formula. The performance for each sensors are tested and a comparison is made. The result values get for each experiment are tabulated and discussed in this chapter.

Chapter 5 provides a summary of this research and outlined the future work for improving this project. Some recommendation is also presented for further studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter presents the theoretical background of disaster and type of the disasters. A general descriptions on the measurement for flood and earthquake disaster are also presented. Besides, the early alert system that used for informing people the happening of flood and earthquake disasters are described in this chapter. Some criteria are chosen to make a comparison between the related journals or conference papers found and the result is evaluated.

2.2 Theories on Disaster

Basically, definitions for disaster are collected from glossaries found in books, reports and web page. A software program called Leximancer was used to analyse the concurrence between the various definitions identified, the most homogeneous definition for disaster emerged to be the universal interruption and injury to a community that surpass its capability to handle and overcome its properties [15]. A significant definition of the word disaster in disaster medicine is referred to lacking [16]. Besides that, the word of disaster also indicates a sudden devastating and out of the blue situation [17]. Moreover, disaster is a level of suffering that goes beyond the ability of adjustment that affected community through an incident of disturbing the normal conditions of existence [18]. In order to transfer data of disaster into a database, four conditions are set and at least one of them must be fulfilled, which are ten or more people reported killed, hundred or more people reported affected, state of emergency declaration and call for international assistance [19].

Disaster is classified into two categories, which are natural hazards and technological. Natural hazards are physical phenomena which are occurring naturally and caused by fast or slow onset events while technological are events that normally generated by humans [20]. The natural hazards are further divided into six subcategories, which are geophysical, meteorological, hydrological, climatological, biological, and extra-terrestrial while technological is further divided into three subcategories, which are industrial accident, transport accident and miscellaneous accident [21].

2.2.1 Natural Disaster

Nowadays, natural disaster that happened in worldwide causing severe damage of property, loss of lives and physical harm [22]. There were 377 reported natural disaster happened globally in 2015 [14]. The highest percentage of natural disasters happened was consisted of hydrological (45.4%), followed by 33.2% of meteorological. Climatological, geophysical and biological disasters consisted less percentage, which were 9.8%, 7.4% and 4.2% respectively. Out of 171 hydrological disasters, 152 times were happened as flood disaster. 115 times of storm were happened among 125 meteorological disasters. Moreover, there were 21 times of earthquake happened among 28 geophysical disasters. 26 times of drought and 16 times of epidemic were happened among 37 climatological disasters and 16 biological disasters respectively. The rest number of natural disaster happened consisted of 47 times of other types. The classification of type of disasters is shown in Table 2.1.

Classification of type of disasters [21], [23]:

Table 2.1: Classification of type of disasters.

Disaster Subgroup	Disaster Main Type	Disaster Sub Type
Geophysical	Earthquake	Ground Shaking
		Tsunami
	Dry Mass Movement	Rock fall
		Landslide
		Avalanche
		Subsidence
	Volcanic Activity	Ash Fall
		Lahar
		Pyroclastic Flow
		Lawa Flow
Meteorological	Storm	Extra-tropical Storm
		Tropical Storm
		Connective Storm
	Extreme Temperature	Cold Wave
		Heat Wave
		Severe Winter Conditions
	Fog	Not Available
Hydrological	Flood	Coastal Flood
		Riverine Flood
		Flash Flood
		Ice Jam Flood
	Landslide	Avalanche (snow, debris, mudflow, rock fall)
	Wave Action	Rogue Wave
		Seiche
Climatological	Drought	Not Available
	Glacial Lake Outburst	Not Available
	Wildfire	Forest Fire
		Land Fire
Biological	Epidemic**	Viral Disease
		Bacterial Disease
		Parasitic Disease
		Fungal Disease
		Prion Disease
	Insect Infestation	Grasshopper
		Locust
	Animal Accident**	Not Available
Extra-terrestrial**	Impact	Airburst
	Space Weather	Energetic Particles
		Geomagnetic Storm
		Shockwave

** Not included yet in the World Disaster Report.

2.3 Flood

Flood disaster is defined as an event which occurs when the land is covered by water where the land is normally in dry condition [24]. It is considered as an enormous disaster in India which greatly affect human beings, animals and soil [25]. It is the most common type of natural disasters in Asia region [22] and also in the United States which causes major and irrecoverable damage to life and property [26]. It usually causes major loss in economic, human, and bringing social tragedies [27]. There are four common types of flooding as shown in Table 2.1, which are coastal flood, riverine flood, flash flood and ice jam flood.

Coastal flooding occurs when they is a strong ashore winds push the water along the edges of oceans, bay or inlet onto the land. This type of billows is normally related to the tropical storms, hurricanes or tsunami. Tsunamis are generated by the earthquake in ocean or coastal regions [28]. When a large storm or tsunami happens, the sea starts to surge the inland [29]. Low pressures occur in the storm that beyond the ocean draw the water toward the centre. As the storm moves toward the land, it carries a vault of water that goes beyond 25 feet or 7.6 meters in diameter. It causes a huge damage when the vault of water reaches the shoreline [30].

Riverine flooding which is also called as overbank flooding occurs when the water within a river spill over its banks and spreads out along the land due to the heavy rain or melting snow. Freshet is mainly caused by these heavy rain and melted snow especially in the spring [27]. It is because the river basin is filled too rapidly during winter or spring rains which is paired together with the melting snows [31]. Not only that, the heavy rain from thunderstorms which is happened repeatedly for a long time may also contributed to river flooding. This type of flooding takes days to disperse.

Flash flood is mainly caused by an excessive rainfall that transmits a river or other body of water quickly out of its banks and this event normally occurs in a short period of time, which is only few hours or less than it [31]. It is commonly peak in less than six hours [32]. It is an unexpected discharge of a huge amount of water [33]. A piece of dry area suddenly turns into under water is called as flash flooding [34]. They are normally defined as a flooding that grows very rapidly in the streams and rivers with a relatively high peak of discharge [35]. They are also represented by a speedy acceleration of fast moving water, which is considered as very dangerous condition, where the movement of water is 10 miles per hour, 2.7 meters per second and carry out the pressures which are same as wind gusts of 270 mph or 434 kph [30]. More than 5000 unexpected people were killed and millions dollars of property were damaged during this flash flooding [34]. It is the main factor of serious damage and causing loss of many lives [36].

Usually, bodies of water are frozen in cold temperatures. Ice jam flooding is known when chunks of ice that caused by heavy precipitation are pushed together and a dam is created. The water begins to accumulate behind of the dam and spreading over to the river nearby. At last, the wall of ice starts to break and the rapid-moving water rushing down to the stream like a common flash flood, causing the objects along the path damage [30].

2.3.1 Measurement

There are many different methods that are used to measure the level of water in a drainage or riverbanks. Many researchers have used different sensors to sense the level of water while some of them using the method of hydrological modelling for the flood forecasting through the collected rainfall data.

Ultrasonic sensor is one of the most common sensor that used to detect the water level at any time in a river [25]. When there is a flood in the river, which means that the height of the water is above the safe level, the sensor will detect and sends the water level data to the control room. After that, river sided people will be informed since their mobile numbers are saved in the control room. By using this type of sensor, the height of the water can only be measured up to four meters [7]. Basically, ultrasonic sensor is used to sense the water level of river since it is able to sense the water level continuously and four conditions are applied to the operation of the sensor, where the level of measurement is divided into low, medium and high level [25].

Besides that, "citizen sensor" which is also acts as a tool to measure the flood disaster is proposed to use in France [35]. This method is about the citizen gives the information via the application of completing the form when he observes a flood is happening or non-living things are destroying in front of him.

Moreover, a different way of measuring the flood disaster is used in the area of the state of Oregon, United States. A multi-hop sensor network is implemented, which is using roadside sensor to send the signal to the sink and continue update the temperature and moisture data. The sensor is small in size, cheaper and programmable [37]. It is mainly used to monitor the road situation and make the drivers be alert if there is a flooding detected.

Besides of ultrasonic sensor, liquid sensor is applied in developing a remote water level alarm system [38]. This sensor is used because of its ability to detect liquid substances. Water level sensors have also been used in a flood monitoring system (MyFMS) [2]. It is mainly used to detect the level of water either in a safety level or in a dangerous zone. This system is only able to detect variations of water level of 1.5m.

Nowadays, wireless sensor networks are widely used to detect and monitor the flood in disaster prone areas. It is mainly used to track the victims and help the rescuers to determine the situation from a safe distance. Hence, an effective rescue plan is ready and allowed them to rescue the victims [3]. It is also referring to the conditions of physical and environment are monitored through the detection, measurement, and sending the data information upon the network by spatially distributed of a bundle of autonomous sensors [39].

This wireless sensor network system is able to measure the level of river water and different weather conditions. It is also able to forecast the possibility of future disasters by using data mining [34]. Different sensors are used in this system, such as temperature sensor, vibration sensor, humidity sensor, as well as water level sensor.

In addition, a combination of one or more multiple passive infrared temperature sensors with ultrasonic rangefinders are used to monitor the presence of water level, pluviometry, vehicle speeds, counts and density [32]. This combination is usually used as a backbone for a dual urban traffic wireless sensor network due to its multifunction. The time of flight *T (t)* of the ultrasonic wave are computed as follow:

$$T\,(t) = 2\int_0^{z_0} \frac{dz}{c(\theta(z,t))} \tag{2.1}$$

Furthermore, some researchers are using radar technology for analysing rainfall forecast. In Western Puerto Rico, the average rainfall is only 357mm from January until April [40]. This forecast analysis is used to obtain the spatial distribution of the flooding depth through the model of distributed hydrologic. The general relationship between cumulative depth, *H(t-i)* and current depth, *H(t)* can be computed as a simple linear equation:

$$Y = a_0 + a_1X \tag{2.2}$$

$$R^2 = 0.4844 \tag{2.3}$$

where Y is *H(t)* and X is *H(t-i)*. In Sugar Land, Texas, a radar-based system is also presented due to its wide-ranging of coverage when compared with the rain and stream gauges [41].

Apart from that, prediction of flood can be analysed by using Artificial Neural Network due to the unstable and highly fluctuation of flood water level. A model of flood prediction is proposed in Kuala Lumpur, which is Multilayer Perceptron neural Network (MLPNN) [42]. This model is able to predict one hour ahead of flood water level so that precaution steps can be taken.

2.3.2 Early Flood Alert System

Early flood alert system is very essential and crucial for everyone, especially the citizens that stay nearby rivers or seas. This system helps to make people alert on flooding is going to happen so that they can get ready to run away from the prone areas. In these days, there are many flood alert system around the world.

The most common system used is via Short Message Service (SMS), which is available for rural area users as well as urban area users. The main target users will be the non-smartphones users. The text message will be activated if the water level reaches the dangerous level which is triggered by the sensor used. The feature of sending message frequency can be developed or set easily [2]. The system can be set to detect few types of water level [2], [7], [25].

Next, smartphone technology plays an important role during these days. The use of internet is much more beneficial and convenient in alerting people for various type of disasters, especially for smartphone's users. Users able to receive text warnings or emergency calls of flood disaster through smartphone's applications [35]. Table 2.2 shows the comparison of the criteria of flood disaster from studied journal.

2.3.3 Criteria Comparison

Table 2.2: Comparison of the criteria of flood disaster from journal.

SYSTEM FOR FLOOD DISASTER MESSAGING AND ALERT					
JOURNAL/IEEE CONFERENCE	**1**	**2**	**3**	**4**	**5**
CRITERIA	**Application of Satellite Navigation System [43]**	**Flood Forecasting and Alert System for Arda River Basin [44]**	**Advanced River Flood Monitoring, Modelling and Forecasting [27]**	**Tsunami Flood Modelling for Aceh & West Sumatra [45]**	**Evaluation of Flash Flood Severity in Korea Using the Modified Flash Flood Index [11]**
Type of Model	N/A	SURFEX-TOP Meteorological Model	Hydrological Model	Delf3D Model	Hydrological Model
Medium Used to Communicate	Satellite Navigation System	Internet	Geoportal	Internet	Internet
Device Used for Messaging	Satellite Phone	Web Service	Web Service & Mobile Phone	N/A	N/A
Information Source	NTT DATA Corporation	ECOCLIMAP-II/Europe Database	Aerospace Data	RiskMap	Flash Flood Index
Post or Pre Disaster System	Pre	Pre	Pre and Post	Pre	Pre

JOURNAL/IEEE CONFERENCE	**6**	**7**	**8**	**9**	**10**
CRITERIA	**A Smartphone Application to Help Alert in Case of Flash Floods [35]**	**Flood Monitoring System (MySMS) [2]**	**Early Flood Alerts Using SMS [7]**	**SMS Flood Alert System [38]**	**Developing a Radar-Based Flood Alert System for Sugar Land, Texas [41]**
Hardware and/or Software System	Software using HTML5 Hybrid App	Hardware and Software using C programming	Hardware and Software using C programming	Hardware and Software using C programming	Software
Medium Used to Communicate	SMS	SMS	SMS	SMS	Internet
Device Used for Messaging	Mobile Phone	GSM Module	GSM Modem	GSM Module	N/A
Information Source	Citizen	Sensor	Sensor	Sensor	Sugar Land Floodplain Map Library
Sensor Used	Citizen sensor	Water Level Sensor	Ultrasonic Sensor, Distance Sensor	Liquid Sensor	N/A
Controller Used	N/A	Microcontroller	Microcontroller	Microcontroller	N/A
Backup Battery for Device	N/A	Direct Power	Solar Panels	15V Power Supply	N/A
Post or Pre Disaster System	Pre	Pre	Pre	Pre	Pre
Water Level Measurement	N/A	N/A	4 meters	1.5 meters	N/A
Number of Water Level Conditions	N/A	5	3	4	N/A

2.4 Earthquake

An earthquake is a sudden disturbance in the Earth's crust [39] where two segments of the Earth suddenly slide past one another. There are two different locations for an Earth's surface, which are called hypocentre and epicentre. Hypocentre is a place where the earthquake starts and is located below the Earth's surface while epicentre is the location exactly above it [46]. There are four major layers of an Earth, which are inner core, outer core, mantle and crust. A thin skin which is a combination of the crust and the top of the mantle is made up of many pieces which is similar to a puzzle covering the surface of the Earth. These puzzle pieces which are called as tectonic plates, are slowly moving around and slipping past one another and clashing with each other. The edges of the plates which are called as plate boundaries, are made up of many faults and normally rough in surface. Hence, when the rest of the plates are moving, they get stuck. When the plates are moving far away, the edges of the plate start to unstick on one of the faults and an earthquake is happening at that time. No one can predict when the earthquake will happen as it is a sudden incident. It brings a huge effect to the living things, as well as the non-living things, such as loss of lives and damage to property [39].

2.4.1 Measurement

There are different methods that used to measure the strength of an earthquake, either light or serious cases. A seismograph is used to record the signal of the earthquake and then to determine how strong the earthquake is. Ground motions around the world is continuously recorded by the networks of seismographs in order to check and investigate the worldwide earthquake and other sources of seismic activity.

Next, a Richter magnitude scale is used to rate the magnitude of the earthquake by determining the amplitude of the waves that recorded from the seismograph by using seismometer as shown in Figure 2.1. The Richter scale is established by Charles F. Richter in 1935, which is from California Institute of Technology. The Richter scale is based on logarithmic scale, which means that a tenfold is increased when a whole number is jumped. Magnitude is represented in whole numbers and decimal fractions on the Richter scale. For instance, a moderate earthquake is rated with magnitude 5.3 while a strong earthquake is rated with magnitude 6.3 [47].

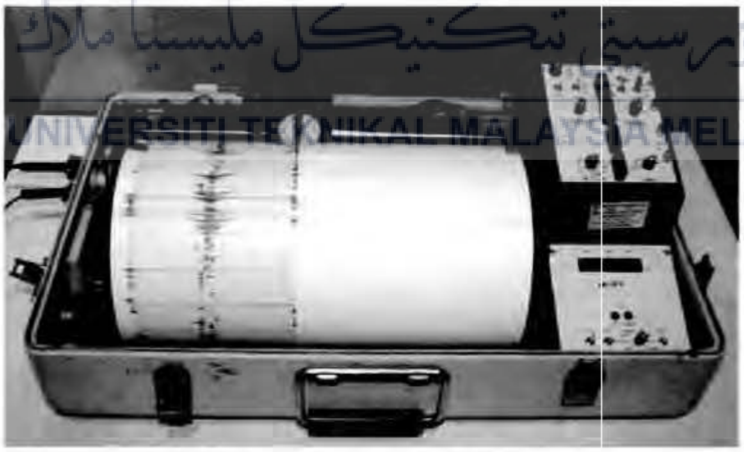


Figure 2.1: Seismometer and seismograph.

Two magnitude were evolved, which are m_b and M_s scales, due to the excitement of both body waves by earthquake, which travelled into and through the Earth, and surface-wave, which are restricted to follow the natural wave guide of the uppermost layers of the Earth. The standard body-wave magnitude formula is:

$$m_b = log_{10}\left(\frac{A}{T}\right) + Q(D, h) \quad [48] \tag{2.4}$$

where *A* is the maximum vertical amplitude of surface wave ground motion (in microns); *T* is the period (in second); *D* is the distance between station and epicentre; *h* is the focal depth of the earthquake (in kilometres), and Q is a function of distance *D* and depth *h*. The standard surface-wave formula is:

$$M_s = log_{10}\left(\frac{A}{T}\right) + 1.66log_{10}(D) + 3.30 \quad [49] \tag{2.5}$$

Besides that, another method to determine the strength of an earthquake is to use Mercalli scale, which is invented by Giuseppe Mercalli in 1902. The measurement is based on the observations of the people who feel or experienced the earthquake. This scale is important to the business and property owners. Some of them will use various types of software to record the level of intensity and spread to others if an earthquake does occur. However, it is useless in an inhabited area of a developed country, especially in the middle of desert or in a place without any houses, trees and railways. In addition, people might exaggerate the conditions of an earthquake and may not find more than two people to agree on that statement. The total amount of damage and deaths that caused by the earthquake may not record precisely.

Table 2.3: Classification of earthquake magnitude classes and effects [50], [51].

Magnitude	Class	Effects
Less than 1 to 2.9	Micro	Normally not felt by people but able to record by seismograph
3 to 3.9	Minor	No damage occurred but felt by many people
4 to 4.9	Light	Minor destruction of objects and felt by all people
5 to 5.9	Moderate	Slightly damage to buildings and weak structures
6 to 6.9	Strong	A lot of moderate damage in very populated areas
7 to 7.9	Major	Severe destruction over large areas and loss of life
8 or greater	Great	Able to completely destroy the communities that near the epicentre

Table 2.4: Richter scale with correspond acceleration.

Richter Scale	Approximate Acceleration (cm/s^2)	Approximate Mercalli Equivalent
<3.5	1	I
3.5	2.5	II
4.2		III
4.5	10	IV
4.8	25	V
5.4	50	VI
6.0	150	VII
6.5	250	VIII
6.9		IX
7.3	500	X
8.1	780	XI
>8.1	980	XII

2.4.2 Early Earthquake Alert System

It is very crucial to have an alert system on earthquake disaster as it is an unpredictable disaster. The estimation of seismic intensities and expected arrival time provided by the Earthquake Early Warning system is based on the analysis of the magnitude of the earthquake by using the wave form data that observed by the seismographs which is near to the epicentre. This system is mainly enabling people to protect themselves immediately from the various environments, such as offices, houses, factories, mountains and near cliffs. Many private companies have started to manufacture earthquake early warning systems in order to protect their infrastructure, such as fire stations, gas lines and elevators. Table 2.5 shows the comparison of the criteria of earthquake disaster from previous studied journal [49].

2.4.3 Criteria Comparison

Table 2.5: Comparison of the criteria of earthquake disaster from previous studied journal [49].

SYSTEM FOR DISASTER MESSAGING AND ALERT					
CRITERIA	**Beidou Communication Device**	**GSM Alarm Device**	**Google Cloud Messaging**	**Fire Alarm System Using Raspberry Pi**	**Earthquake Monitoring Using Volunteer Smartphone Based Sensor Network**
Hardware and/or Software System	Hardware	Hardware and Software using C Programming	Software	Hardware and Software using Python Language	Hardware and Software
Medium Used to Communicate	SMS through Self Configured MANET	SMS or CBM through DEWN	Internet	Internet	Internet
Device Used for Messaging	Beidou Device, Repeater and Beidou Satellite	GSM Module	Mobile Phone	GSM Module	Mobile Phone
Disaster Information Source	Meteorology Department	Meteorology Department	Meteorology Department	Sensor	Sensor
Sensor Used	N/A	N/A	N/A	Smoke Sensor	Accelerometer Sensor
Controller Used	N/A	Microcontroller	N/A	Raspberry Pi and Arduino Uno	N/A
Server	MANET	DEWN	Disaster Managing Server	IDLE Software	Earthquake Network Android Application
Backup Battery for Device	Solar Recharging Additional Battery	Battery for Approximately 7 Hours	N/A	N/A	N/A
Post or Pre Disaster System	Post	Pre	Pre	Pre	Pre

Time	Any Time After Disaster	Minutes Before	Real Time	Real Time	Notified Few Second From When It Strike

2.5 Evaluation

Based on the journals that studied, there are a lot of methods to do a disaster alert system. There are pre-warning system and post-warning system. All of these systems manage the disaster by using their own way in order to save people life and reduce the possibility of damage. The research consists of various types of platform, medium and precaution steps. The main priority of managing the disaster efficiently is the effectiveness of the system.

From Table 2.2, for the first five journals, they focused on monitoring the level of water by using software and do prediction while for the next four journals, they used sensor to sense the flood disaster. The sensors that are used in Journal 6 to Journal 9 are citizen sensor, water level sensor, ultrasonic sensor and distance sensor, and liquid sensor respectively. These all sensors are able to sense the real condition of the water and give warning to the public in order to save their lives. However, these kind of systems are much more complex compared to the system that only send warning messages to public by using software due to its sensors in the system.

Furthermore, Journal 7 to Journal 9 from Table 2.2 and Fire Alarm System Using Raspberry Pi from Table 2.5 use two different controllers to control the embedded system. Journal 7 to Journal 9 use microcontroller while fire alarm system uses Raspberry Pi and Arduino Uno as a controller. The system that uses Raspberry Pi is much more advanced when compare with the system that using microcontroller due to its higher processor. Hence, the system is faster. However, some of the software part consists of pre-code while some of them have to construct own programming codes from scratch. The developers have to learn to write the programming code of Raspberry Pi which is in Python language in order to develop the project.

Moreover, for the flood monitoring and prediction, the systems using sensors from Journal 7 to Journal 9 are better compare to the system that only use runoff graph due to its ability of measuring the level of water. People able to know the level of water and it is in which type of condition. Hence, they can prepare to run out from the prone areas if the water level is in dangerous zone. However, some of the sensors are limited with the range of measurement, such as liquid sensor, which can only measure up to 1.5 meters and ultrasonic sensors can only measure up to 4 meters.

In addition, in term of sending the alert messages, the information obtained from the citizens may be false positive although it is faster due to the observation from the river side people in Journal 6. From Journal 1, satellite-based communication is the best known system as it can detect and locate emergency beacons activated by aircraft, ships and backcountry hikers. However, the use of a satellite phone is not as common as compared to the mobile phones. The maintenance of satellite communication service and operation are costly too. The systems that using information from related department and database through internet is more portable and convenient but the system may cause delay since some disaster cannot be predicted. This system may fail to save people lives especially during earthquake. Besides, not everyone owns a smartphone that can connect to internet and receive the information at first hand. The systems using SMS to send the message is more useful compared to others due to its ability to send the alert message to either smartphone users or non-smartphones users. However, it cannot be used in all kind of disaster especially earthquake disaster since it does not have any sensing ability and not in real time. The most suitable disaster to use this system is Tsunami warning.

Not all the system can be used in all kinds of disaster, although there are many available system for disaster messaging that can save lots of people's lives. For a disaster monitoring, managing and messaging system, the information has to be in real-time and accurate in order to make public alert and the precaution steps can be taken to save their precious life.

2.6 Summary

There are advantages and disadvantages of each system that are available in today's world. However, the systems that are available today are not able to measure and manage all types of disaster. It is depending on the scope of the disaster to be measured. It is much more useful and wiser to have an embedded system that combines the function of sensing and messaging in order to make sure lots of life can be saved at the shortest time. There are many systems that are able to save many life and reduce the possibility of property damage. However, time is the most priority factor for a disaster alert system. The faster or the earlier the system able to sense and transmit the signal and gives warning to the public at which time and which place, the higher the number of people's lives can be saved.

After the comparison of the available systems and its pros and cons, the method that is chosen in this project is to use ultrasonic sensor to sense the water level and accelerometer to sense the earthquake with interface to the Raspberry Pi due to its real time controller and access to a smartphone application in order to send the warning message. Since smartphone applications are widely used nowadays, thus it is chosen as a medium of communication in this project due to its ease of use with the connection of Wi-Fi access.

CHAPTER 3

METHODOLOGY

3.1 Overview

In this chapter, method to be used in order to design and develop a disaster alert system will be discussed and described. A series of experiments will be conducted to evaluate the performance of the designed system in order to achieve the objectives. Apparatus and materials used, and steps for conducting each of the experiments will also be listed out in this chapter. The theoretical method that has been applied to this project will also be illustrated.

The project is done by following the time frame of FYP 1 and FYP 2 as shown in Figure 3.1. The details of the timeline is displayed by using flow chart. This project is divided into two parts, which are software and hardware that both have to be integrated as one. The software part includes designing of controller in order to control the hardware and also the application used for sending the alert message. For hardware part, it is more focused on the type of sensors used for sensing both earthquake and flood disaster, type of camera used for capturing the image of flood and messaging tools for displaying the alert message. All of the electrical components used will be analysed and discussed in this chapter.

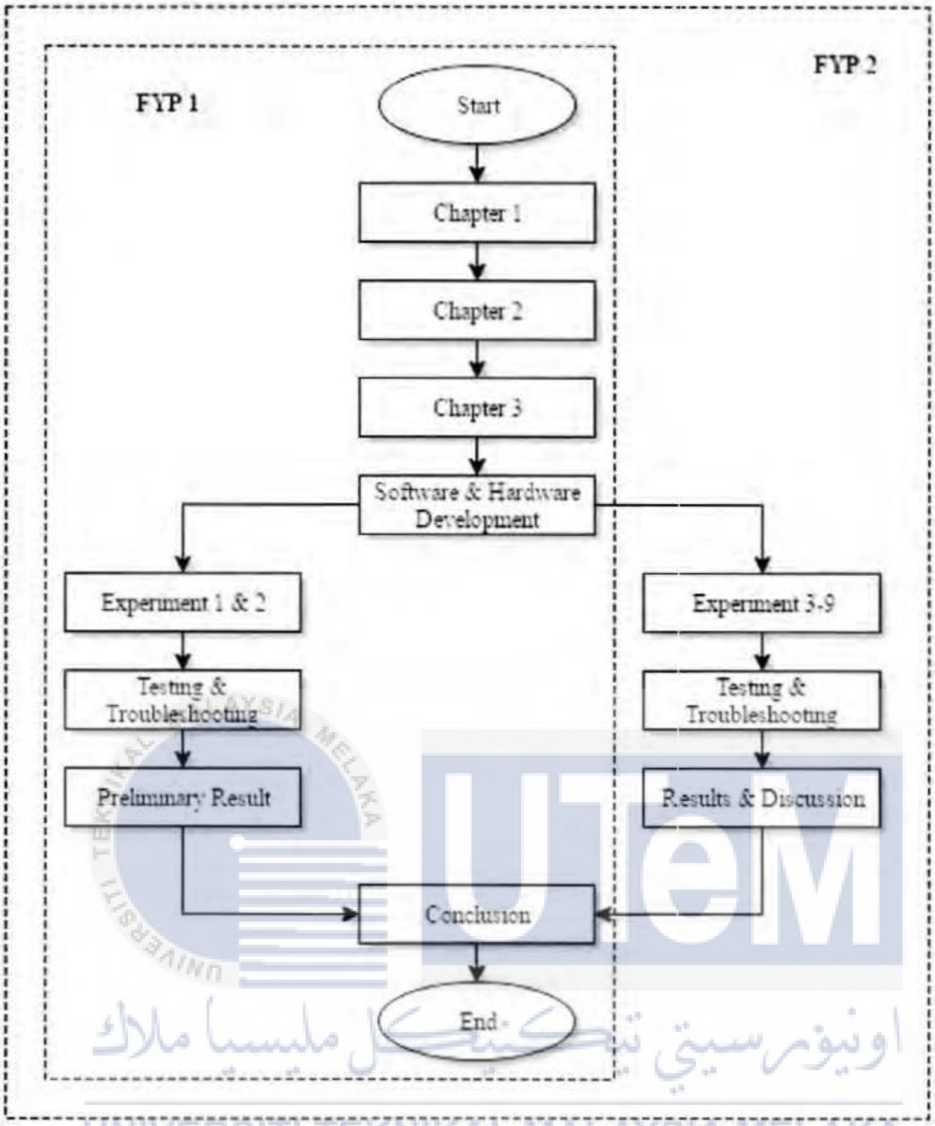


Figure 3.1: Time frame for completion of the project.

3.2 Milestone

Table 3.1: Milestone for FYP 1.

NO.	ACTIVITY	DATE
1	Title Discussion and Selection	19 September 2016
2	Journal Finding and Literature Review	19 October 2016
3	Set the Objectives and Scope	11 October 2016
4	Selection of Components	1 November 2016
5	Experiments Design and Procedures	30 November 2016
6	Preliminary Result and Discussion	5 December 2016
7	First Draft of Report Compiling	8 December 2016
8	Submission of First Draft Report	9 December 2016
9	FYP 1 Presentation	19 December 2016
10	Submission of Final FYP 1 Report	26 December 2016

Table 3.2: Milestone for FYP 2.

NO.	ACTIVITY	DATE
1	Completion of Comparison Experiment between Ultrasonic Sensor and Infrared Sensor	24 February 2017
2	Completion of Integration Experiment between Accelerometer and Ultrasonic Sensor	17 March 2017
3	Completion of Experiment Sending Alert Message through Telegram Application	29 March 2017
4	Completion of Experiment Capturing and Storing Image of Disaster by using USB Camera	13 April 2017
5	Completion of Experiment Sending Alert Message with Saved Image of Water Level Condition through Telegram Application	20 April 2017
6	Completion of Efficiency Test at Indoor and Outdoor Environment	28 April 2017
7	Completion of Reliability Test at Indoor and Outdoor Environment	3 May 2017
8	Result and Discussion	6 May 2017
9	Conclusion and Recommendation	7 May 2017
10	First Draft of Final Report Compiling	8 May 2017
11	Submission of First Draft Final Report	10 May 2017
12	Completion of PowerPoint Slide and Video	26 May 2017
13	FYP 2 Presentation	29 May 2017
14	Submission of Final FYP 2 Report	2 June 2017

3.3 System Process Flow Chart

Before further discussing on the project, the process flow for a system plays an important role so that it is able to follow the purpose stated before and will not deviate much. Thus, the process flow for this designed Disaster Alert System is presented by flow chart as shown in Figure 3.2.

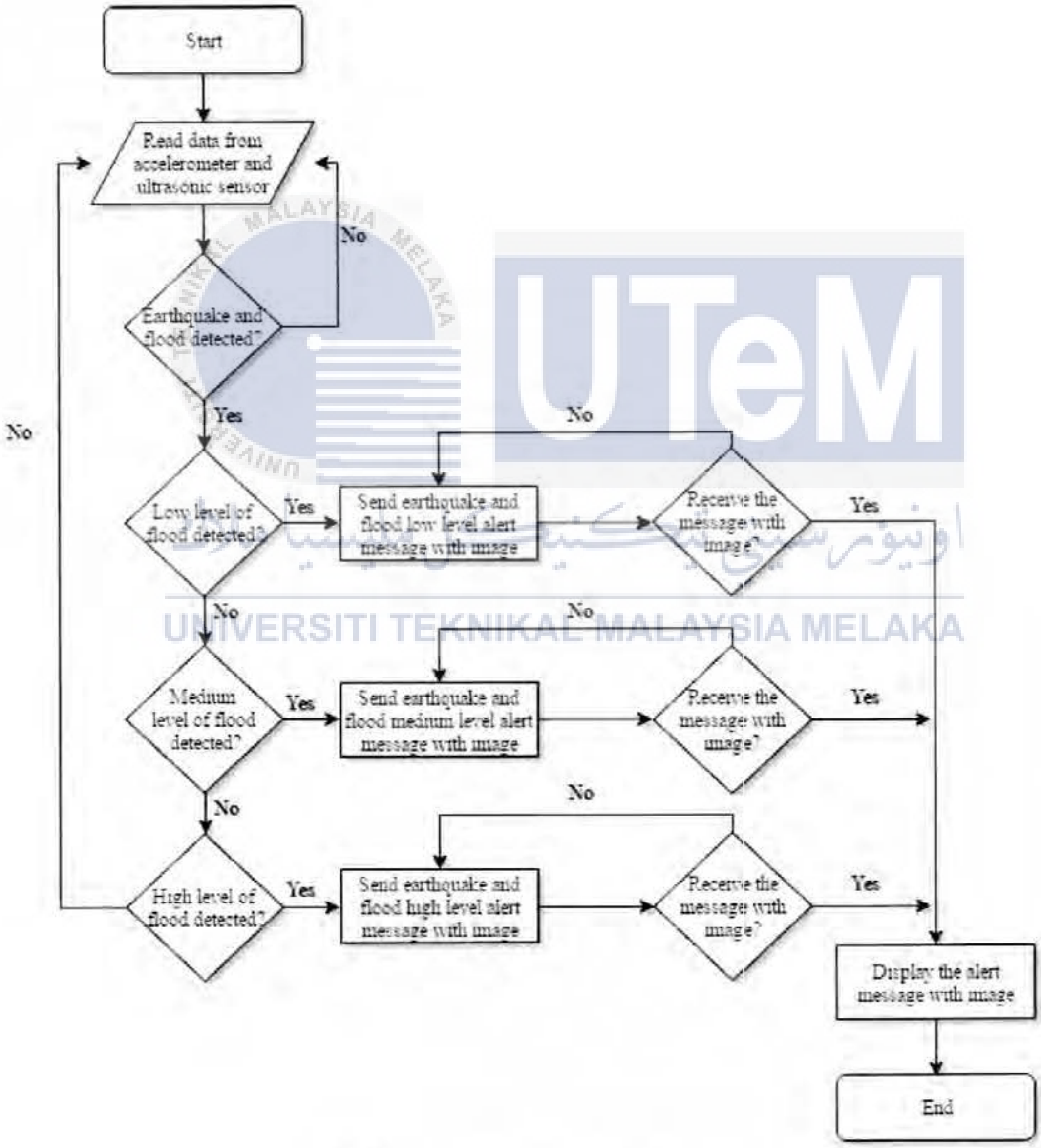


Figure 3.2: System process flow chart.

From Figure 3.2, the system is activated when the sensors are triggered. If the earthquake and flood disasters happen at the same time, both accelerometer and ultrasonic sensor will be triggered. The USB camera will be activated simultaneously. Thus, the image of the flood condition is captured and saved. If a low level of water level is sensed by ultrasonic sensor, an earthquake and flood low level alert message with the image will be sent to the users through the smartphone's application. If a medium level of water level is sensed by ultrasonic sensor, an earthquake and flood medium level alert message with its flood image will be sent to the users through the smartphone's application. If a high level of water level is sensed by ultrasonic sensor, an earthquake and flood high level alert message with the image of flood condition will be sent to the users through the smartphone's application. In the end, the information is passed to the users by displaying the alert message in their smartphones so that users able to take early safety precaution.

3.4 Selection of Hardware Component

In this section, the selection of hardware component will be discussed. The selection of components for developing hardware system plays an important role in order to ensure that the system functions accurately and efficiently especially when sending the alert message as soon as possible during the earthquake and flood disasters.

Based on previous study, it was shown that Raspberry Pi has a higher processor when compared with Arduino Uno and it is important to choose a better controller with a faster processor in this Disaster Alert System [49]. Hence, Raspberry Pi is chosen as a controller to interface with sensors and USB camera in this project. In addition, it is also mentioned that accelerometer gives a faster and better respond when compared with vibration sensor during the shaking test to illustrate the situation of earthquake [49]. Thus, accelerometer is chosen as a sensor to detect earthquake disaster in this project. In this project, ultrasonic sensor is chosen as a sensor to sense flood disaster due to its ability of real-time monitoring. It can measure the level of water continuously, more accurately and cover more distance when comparing with FPGA based system [25]. Moreover, USB camera is chosen to capture the image of flood condition due to its low cost when compared with IP webcam, which is suitable for this Disaster Alert System.

Therefore, the features and details of all these selected hardware components are described and presented in the next section.

3.4.1 Raspberry Pi

Raspberry Pi is a single board computers which is developed by Raspberry Pi Foundation in 2009 in United Kingdom, England. It is a credit-card sized computer and considers as a low cost device that everyone can carry around. It can be connected to a television or computer monitor and control it by using a mouse and standard keyboard. In addition, its operating system is Linux-based Fedora, which is powerful to handle daily jobs that done with word processing and so on. The programing languages that available for supporting this device are Python, BBC Basic, C and Perl.

In this project, a Raspberry Pi 2 Model B is chosen as a controller due to its ability to deliver six times higher of processing capacity when compared with previous models. This type of Raspberry Pi has increased its memory capacity to 1 GB and upgraded its system on chip to Broadcom BCM2836 processor, where the core architecture is quad-core ARM Cortex-A7 and runs at a higher frequency of 900 MHz as shown in Figure 3.3. The specifications of the Raspberry Pi 2 Model B is shown in Table 3.3 while the GPIO connector is shown in Table 3.4. Besides, the programming language that used for this project is Python language.

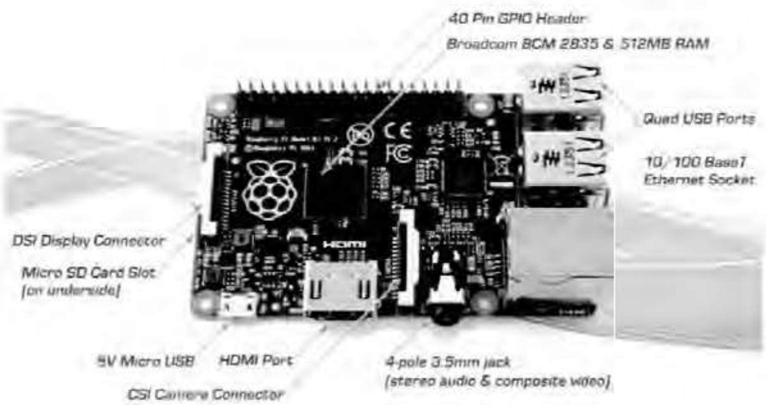


Figure 3.3: Raspberry Pi 2 Model B.

Table 3.3: Specifications of the Raspberry Pi 2 Model B.

FEATURE	RASPBERRY PI 2 MODEL B
Architecture	ARMv7 (32-bit)
System on Chip (SoC)	Broadcom BCM2836
Core Architecture	Quad-core ARM Cortex-A7
Central Processing Unit (CPU)	900 MHz
Graphical Processing Unit (GPU)	Broadcom Video Core IV @ 250 MHz, OpenGL ES 2.0 (24 GFLOPS), MPEG-2, VC-1, 1080p30 H.264/MPEG-4 AVC High Profile Decoder and Encoder
Memory (SDRAM)	1 GB
USB 2.0 Ports	4
GPIO pins	40
On-board Storage	Micro SD Card Slot
On-board Network	10/100 BaseT Ethernet Socket
Video Output	HDMI (rev 1.3), Composite Video
Audio Output	3.5 mm Phone Jack via HDMI
Power Ratings	800 mA (4 W)
Current Ratings	2 A
Power Source	5 V via Micro USB or GPIO Header
Dimensions	85 mm x 56 mm x 17 mm
Weight	45 g

Table 3.4: General-purpose input/output connector.

GPIO#	2ND FUNCTION	PIN#	PIN#	2ND FUNCTION	GPIO#
N/A	+3.3V	1	2	+5V	N/A
GPIO 2	I2C1_SDA	3	4	+5V	N/A
GPIO 3	I2C1_SCL	5	6	GND	N/A
GPIO 4	GPCLK0	7	8	UART_TXD0	GPIO 14
N/A	GND	9	10	UART_RXD0	GPIO 15
GPIO 17	GEN0	11	12	GEN1	GPIO 18
GPIO 27	GEN2	13	14	GND	N/A
GPIO 22	GEN3	15	16	GEN4	GPIO 23
N/A	+3.3V	17	18	GEN5	GPIO 24
GPIO 10	SPI_MOSI	19	20	GND	N/A
GPIO 9	SPI_MISO	21	22	GEN6	GPIO 25
GPIO 11	SPI_SCLK	23	24	SPI_CE0	GPIO 8
N/A	GND	25	26	SPI_CE1	GPIO 7
EEPROM	ID_SD	27	28	ID_SC	EEPROM
GPIO 5	N/A	29	30	GND	N/A
GPIO 6	N/A	31	32	N/A	GPIO 12
GPIO 13	N/A	33	34	GND	N/A
GPIO 19	N/A	35	36	N/A	GPIO 16
GPIO 26	N/A	37	38	DIGITAL IN	GPIO 20
N/A	GND	39	40	DIGITAL OUT	GPIO 21

3.4.2 Accelerometer

An accelerometer is a transducer, either a mechanical or an electromechanical device normally used to measure the specific acceleration or deceleration of forces which is produced by an object. The acceleration is the rate of increase and decrease of the velocity of a moving object while the force is measured due to the experience of a weight exerted by the object. For a static acceleration, the device is used to measure the degrees at which an object is inclined with respect to the ground while the movement or vibration of the object is able to predict by the accelerometer in dynamic acceleration.

There are three types of accelerometer that usually used to convert mechanical motion into electrical signal in industrial applications, which are piezoelectric, piezo resistive and capacitive. All these devices have a very high stability and linearity. A typical accelerometer has the following fundamental specifications:

- Frequency response
- Accelerometer grounding
- Resonant frequency
- Temperature of operation
- Sensitivity
- Number of axis
- Analog/Digital output
- Mass
- Amplitude stability

In this project, the model of accelerometer used is a triple axis ADXL 335 from Analog Devices as shown in Figure 3.4. It is a famous and mature device with signal conditioned voltage outputs, which is small in size and thin. It has an extremely low noise and power consumption, which is merely 320 uA. It is able to measure the acceleration with a minimum full-scale range of ± 3 g. It is able to support the voltage range from 2.5 V to 6 V since the breakout board comes along with the on-board 3.3 V voltage regulator. The board is also completely assembled and tested with those external components that installed in it. The bandwidth of each axis is set to 50 Hz by the 0.1 uF capacitors that are included in the board. The functional block diagram of the module is shown in Figure 3.5 and its features are shown in Table 3.5.

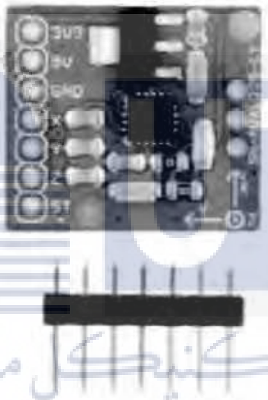


Figure 3.4: Accelerometer ADXL 335.

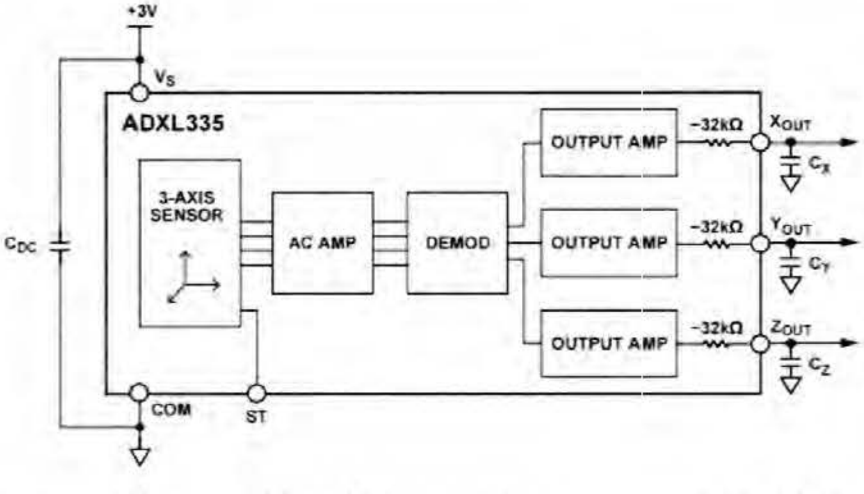


Figure 3.5: Functional block diagram of accelerometer ADXL 335.

Table 3.5: Features of accelerometer ADXL 335.

FEATURES	**ACCELEROMETER (ADXL 335)**
On-board Voltage Regulator	3.3 V
Operating Voltage	2.5 V – 6V
Typical Current	300 uA
Range	± 3 g
Number of Axis	3-axis sensing
Capacitance	0.1 uF
Acceleration	0 g
Operating Temperature Range	-40 °C to +85 °C

3.4.2.1 Calculation of Threshold Value

The threshold values for different magnitude of earthquake are needed to figure out in order to develop this Disaster Alert System to sense the earthquake. There are some calculation to identify the threshold in term of ADC value have to be completed since the peak ground accelerations have been determined from the research with respected magnitude scale as shown in Table 2.4. The calculation of threshold value is able to carry out based on the acceleration that have been known in Table 2.4 which respects to the magnitude and by referring the specifications of the accelerometer according to the data sheet.

There are three axes that will be calculated. Hence, the formula for calculating the acceleration for any axis by using accelerometer ADXL 335 and the initial condition are set as below:

- Sensitivity = 330mV/g = 0.33V/g
- Gravity force = g
- Voltage at 0g for X-axis and Y-axis, V_{0g} = 1.65V
- Analog to Digital Converter value = adc
    - adc for X-axis = adcRx
    - adc for Y-axis = adcRy
- Reference voltage, V_{ref} = 3.3V
- Gravity force respect to acceleration = Rx
- Delta voltage = Voltage different between output voltage and V_{0g}
- $1\text{g} = 9.81\frac{\text{m}}{\text{s}^2}$
- Ground peak acceleration = acc $\frac{\text{m}}{\text{s}^2}$

To calculate gravitational force respect to the acceleration, Rx:

$$Rx = \frac{1g * acc(\frac{m}{s^2})}{9.81(\frac{m}{s^2})} \tag{3.1}$$

To calculate analog to digital converter value, adcRx:

$$adcRx = \frac{|(Rx * Sensitivity) + V_{0g}| * 1023}{Vref} \tag{3.2}$$

3.4.3 Ultrasonic Sensor

In this project, ultrasonic sensor HC-SR04 are used for the purpose of detecting the level of water during flood disaster. This model of ultrasonic sensor is capable to measure the distance from a non-contact object in the range of 2cm to 400cm with a fine accuracy up to 3mm. There are three basic components in this module, which are ultrasonic transmitters, receiver and control circuit. Moreover, this module only consist of four pins, which named as VCC, Trig, Echo and GND as shown in Figure 3.6 whereas the connection of the ultrasonic sensor to the Raspberry Pi is shown in Figure 3.7.

Figure 3.6: Ultrasonic sensor HC-SR04.

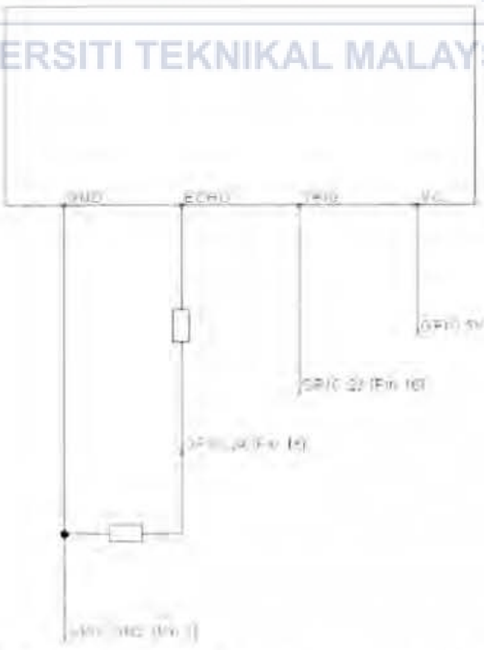


Figure 3.7: Connection of ultrasonic sensor to the Raspberry Pi.

Based on Figure 3.7, pin VCC and pin GND of ultrasonic sensor are connected to the 5V and Ground of the Raspberry Pi which are Pin 2 and Pin 6 respectively. Next, pin TRIG of the sensor is connected to GPIO 23 of Raspberry Pi which is Pin 16. Pin Echo of the sensor is connected to 1kΩ of resistor and then connected to GPIO 24 of Raspberry Pi, which is Pin 18. Then, it is continued connecting to 2kΩ of resistor, and back to the ground.

The basic operation of this sensor is started by connecting a 5V power supply to the VCC pin and GND pin in order to complete the electrical pathway. Next, a pulse of high level signal (5V) is supplied to the Trig pin for at least 10us. Next, the module will automatically transmits eight cycle burst of ultrasound at 40 kHz and waiting for the reflection. If there is an object detected by receiver, where the signal is sending back, the Echo pin will set to high (5V) and delay for a period which is proportional to the distance. The sensor output signal on the sensor (ECHO) is rated at 5V which could damage the input pin of the Raspberry Pi that rated at 3.3V. Hence, a voltage divider is used in order to reduce the voltage of the output voltage. The specifications of this module is shown in Table 3.6.

Table 3.6: Specifications of ultrasonic sensor HC-SR04.

FEATURES	**ULTRASONIC SENSOR (HC-SR04)**
Operating Voltage	DC +5 V
Operating Current	15 mA
Operating Frequency	40 Hz
Range	2 cm – 400 cm
Measuring Angle	30 degree
Effectual Angle	< 15 degree
Trigger Input Signal	10us TTL pulse
Echo Output Signal	Input TTL lever signal and the range in proportion
Dimension	45 mm x 20 mm x 15 mm

3.4.3.1 Calculation of Distance

Based on the working of basic principle that stated above, the timing diagram of distance measurement by ultrasonic sensor is shown in Figure 3.8.

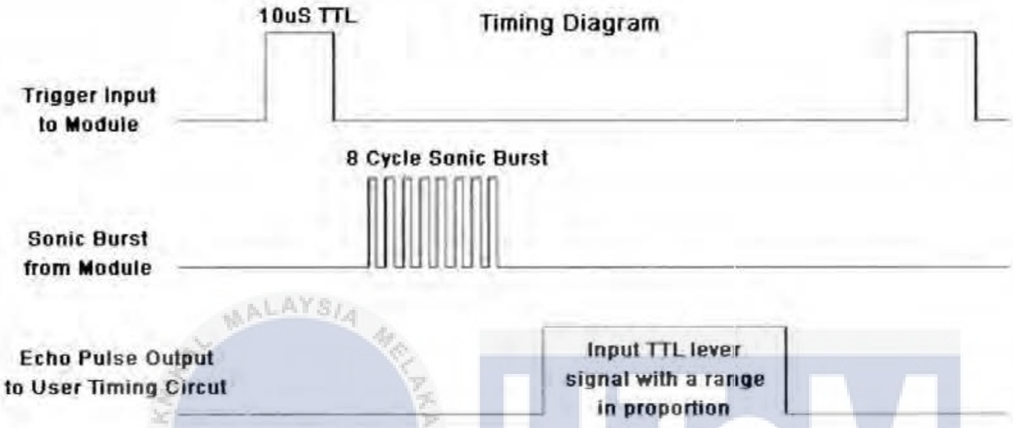


Figure 3.8: Timing diagram of distance measurement by ultrasonic sensor.

In order to obtain the distance between ultrasonic sensor and the obstacles, the width of Echo pin is measured according to the formula below:

$$t = w \tag{3.3}$$

where t is time and w is width of echo pulse measured in microsecond.

Moreover, the general formula to calculate the distance is as below:

$$d = t \, x \, v \tag{3.4}$$

where d is distance measured in metre, t is time measured in second, and v is speed measured in metre per second.

Hence, the formula to measure the distance between ultrasonic sensor and the object is shown as below:

$$d = \frac{t\,x\,c}{2} \tag{3.5}$$

where d is the distance measured in centimetre, t is time measured in second, and c is speed of sound measured in centimetre per second.

From Equation 3.5, the number '2' is in the formula due to the sound has to travel away from the sensor at first, then strikes to the surface and returns back. However, the common speed of sound is travelled at approximately to 340 m/s and this value is corresponding to around 29.412 us/cm, which is 29 us/cm after rounding off.

Therefore, the simple method to calculate the distance is shown in the formula below:

$$\begin{aligned} d &= \frac{t\,(us) \times 29\,(\frac{us}{cm})}{2} \\ &= \frac{\mathrm{t\,(us)}}{2} \times \frac{\mathrm{1\,(cm)}}{\mathrm{29\,(us)}} \\ &= \frac{\mathrm{t}}{58}\,\mathrm{(cm)} \end{aligned} \tag{3.6}$$

where t is the time measured in microsecond (us).

3.4.4 USB Camera

In this Disaster Alert System, a USB 2.0 webcam with the model of Logitech QuickCam Communicate STX is chosen for capturing the image of flood condition as shown in Figure 3.9. It provides an improved image clarity even in low light, which is a sharper images even in dim lighting. The details of its specifications is shown in Table 3.7. It just have to connect to Raspberry Pi that have USB port then it is able to function by typing some program codes.

Figure 3.9: Logitech QuickCam Communicate STX.

Table 3.7: Specifications of Logitech QuickCam Communicate STX.

FEATURES	LOGITECH QUICKCAM COMMUNICATE STX
Interface	USB 2.0
Image Sensor	CMOS
Maximum Image Resolution	640 X 480
Effective Pixels	1.3 MP (interpolated)
Frame Rate	30 fps
Focus Setting	Fixed focus

3.5 Experiment Setup

There are several types of experiment to be conducted in order to obtain desired results and to achieve the objectives that have been stated in Chapter 1. Each objective is tested by few experiments for the reason of testing the functionality and reliability of the system. A brief explanation on each experiment is presented. Different materials and apparatus are used for different experiments according to the purpose of testing. Each of the experiments is equipped with the procedures, which are the steps for doing the experiments.

3.5.1 Experiment 1: Sensor Test for Detecting Flood Disaster

This experiment is about the project methodology to achieve first objective. The types of sensor for detecting the flood disaster is compared while the selection of sensor is done based on their specification and the result from the experiment.

Objective 1: To design a disaster alert system that detects a low to high level of flood disaster and a medium range of earthquake disaster by using ultrasonic sensors and accelerometer respectively.

3.5.1.1 Comparison between Ultrasonic Sensor and Infrared Sensor

In this experiment, there are two different types of sensor chosen for comparison, which are ultrasonic sensor and infrared sensor. The most common applications of this two sensors are used for level measurement. Thus, both of this sensors can be used in this project when constructing a prototype of sensing flood disaster. The specifications of both sensors are listed out as shown in Table 3.8. Both sensors have similar characteristics, which are lower in cost and their inputs are measured in analog. However, both sensors have different number of pins, ways to connect, ways to use and output. Hence, both sensors are compared since it is essential to make sure the best sensor is used in this Disaster Alert System in term of the suitability.

Table 3.8: Specifications of ultrasonic sensor and infrared sensor.

FEATURES	**ULTRASONIC SENSOR (HC-SR04)**	**INFRARED SENSOR (GP2Y0A21YK)**
Operating Voltage	5 V	5 V
Operating Current	15 mA	30 mA
Sensing Range	2 cm – 400 cm	10 cm – 80 cm
Analog/Digital Input	Analog	Analog
Analog/Digital Output	Analog	Analog
Cost	Low cost	Low cost
Application	Level sensing, filing sensing, collision protection, position control, height measurement and slope control	Remote sensing, sorting devices, flame monitors, IR imaging devices, LD monitors and human body detection

3.5.1.2 Setup of Experiment 1

In this experiment, the materials and apparatus used are listed out:

1. Ultrasonic sensor HC-SR04
2. Infrared sensor
3. Six LEDs
4. Raspberry Pi
5. Container
6. Water
7. A stopwatch
8. Marker pen
9. Breadboard
10. Jumper wires

In real situation, an ultrasonic sensor is able to measure the distance up to 4m, therefore there are three conditions are set for the operation of ultrasonic sensor:

1. Condition one: If the distance between the sensor and water is about three meters, then the level is considered as low level.
2. Condition two: If the distance between the sensor and water is about two meters, then the level is considered as medium level.
3. Condition three: If the distance between the sensor and water is less than or equals to one meter, then the level is considered as high level.

In this experiment, a container which is measured 31.5cm x 17cm x 25.5cm is prepared in order to conduct level measurement test for testing the response and efficiency of the sensors to sense the water level. However, the size of the container is not sufficient for measuring the distance in real situation, which is in meter since it is just a prototype. In addition, infrared sensor that are going to use for comparison in this experiment is only able to measure from 10cm to 80cm. Hence, a scaling method is done by scaling down the value from meters to centimetres. The container is then marked with three different levels by using a marker pen, where the conditions of levels are defined as low, medium and high level. Thus, low, medium and high levels are marked at 5cm, 10cm and 15cm respectively, where the measurement is started from the bottom of the container as shown in Figure 3.10. It is to make sure that both sensors are compared at the same measurements in order to get a valid results.

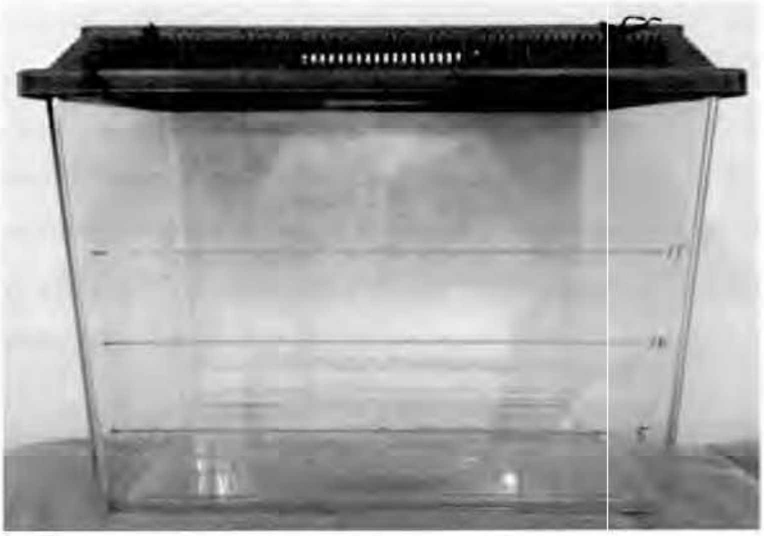


Figure 3.10: Low, medium and high levels are marked at 5cm, 10cm and 15cm respectively.

Therefore, the distance between the sensor and water is calculated by the formula:

$$d = H - L \tag{3.7}$$

where d is distance, H is height of the container, L is marking level, and all measured in centimetre.

By using the formula above, a new condition for this project is given as below:

1. Condition one: If the distance between the sensor and water measured between 19.5cm to 20.5cm, then the level is considered as low level.
2. Condition two: If the distance between the sensor and water measured between 14.5cm and 15.5cm, then the level is considered as medium level.
3. Condition three: If the distance between the sensor and water is less than or equals to 10cm, then the level is considered as high level.

After finished the marking process, a program code of Raspberry Pi for ultrasonic sensor and infrared sensor to measure the water level are constructed according to the calculated distance in the conditions above. Next, three LEDs are connected to ultrasonic sensor and another three LEDs are connected to infrared sensor as an output in order to differentiate the level of the water. Low level, medium level and high level of water are represented by Green LED, Blue LED and Red LED respectively. Both sensors are connected to the coded Raspberry Pi. After that, both sensors are placed at two opposite end of the container with constant distance between them by using breadboard. This is to ensure that both sensors receive same amount of water level measurement. Two stopwatches are used in this experiment. One stopwatch is to record the time needed for ultrasonic sensor LEDs to light up while another stopwatch is to record time taken for infrared sensor LEDs to light up. The setup of experiment is shown in Figure 3.11.

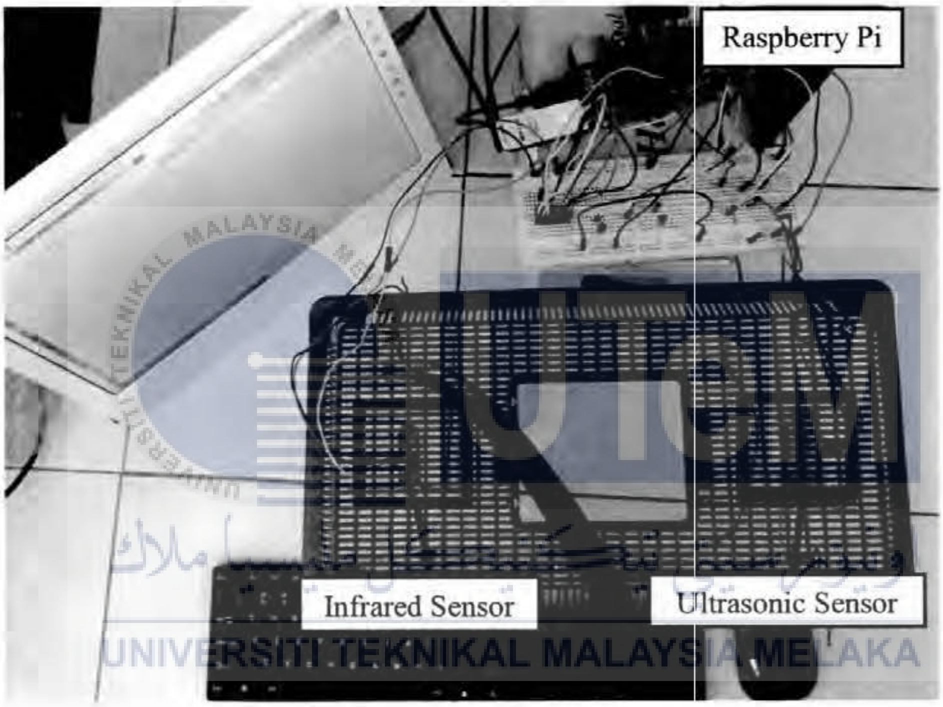


Figure 3.11: Setup of Experiment 1.

At first, the water is added into the container up until 5cm, which is low level, and both stopwatches are started to measure the time taken to light up LEDs at the same time. The time needed for both Green LEDs to light up once the both sensors sense the water at the low level are recorded by pressing lap function in the stopwatches of the mobile phones. After that, the water is continued added into the container which is from low level until medium level. The time needed for both Blue LEDs to light up once both sensors sense the water at the medium level are recorded again by pressing the lap function in the stopwatches. Lastly, the water is continued pouring into the container which is from medium level to high level. The time needed for both Red LEDs to light up once both sensors sense the water at the high level are also recorded by pressing the lap function in the stopwatches. The steps of adding water and obtaining the time needed to light up three different colours of LEDs for both sensors are repeated for 10 times. The data is then collected and tabulated for each level for both sensors. The average value of time taken for each level of LEDs to light up are also calculated. The result is compared while a faster response and precise sensor is chosen for the next experiment. Besides, the volume of the added water for each level is measured and recorded. It is used to measure the flow rate of the water for each level and for each trial. The flow rate for each trial is calculated for both sensors by using formula as shown in below:

$$Q = \frac{v}{t} \tag{3.7}$$

where Q is the flow rate (ℓ/s), v is the volume (ℓ), and t is the total time taken (s).

3.5.2 Experiment 2: Integration of Sensors for Measuring Earthquake and Flood Disaster

This experiment is a part of methodology for testing the entire system to achieve first objective. Based on the sensor test from Experiment 1, a better sensor to detect the flood disaster is chosen and is combined with accelerometer for detecting earthquake in this experiment. The purpose of this experiment is to test on the functionality of the system for detecting both earthquake and flood disaster by using both sensors.

Objective 1: To design a disaster alert system that detects a low to high level of flood disaster and a medium range of earthquake disaster by using ultrasonic sensors and accelerometer respectively.

3.5.2.1 Setup of Experiment 2

In this experiment, the materials and apparatus used are listed out:

1. Ultrasonic sensor HC-SR04
2. Accelerometer
3. Two LEDs
4. Raspberry Pi
5. Container
6. Water
7. Soil and sand
8. A stopwatch
9. Breadboard
10. Jumper wires

At first, the same container in Experiment 1 is used and is filled up with soil and sand, and the water is added into the container until low level, which is 5cm height from the bottom of the container, for the purpose of testing the functionality for both accelerometer and ultrasonic sensors respectively when both earthquake and flood disaster happen at the same time. The setup of the experiment is shown in Figure 3.12. The condition is set as shown in Table 3.9. '1' represents the disaster is detected.

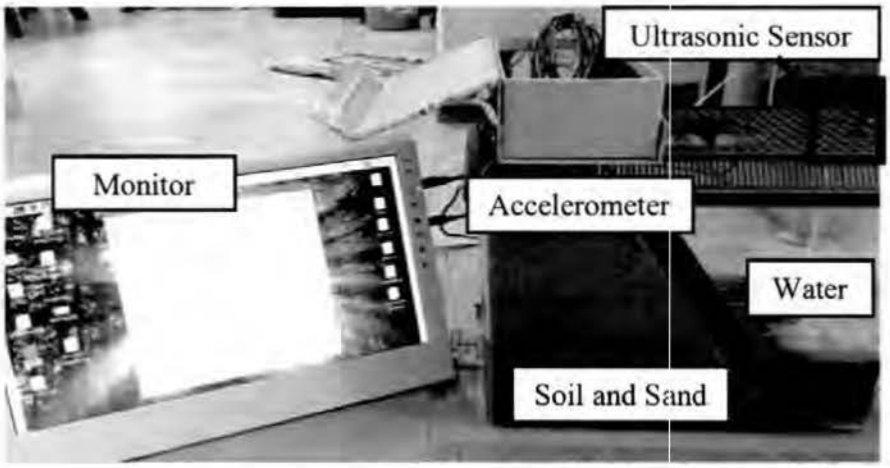


Figure 3.12: Setup of Experiment 2.

Table 3.9: Condition for testing the functionality of sensors.

Earthquake	Flood	LED
1	1	ON

A program code for sensing both sensors are written and transferred into the Raspberry Pi for lighting up the LEDs. Green LED and Red LED are used for sensing X-direction and Y-direction of accelerometer respectively. Both LEDs are connected to Raspberry Pi as an output for each direction of vibration. After that, the accelerometer is placed on the soil and sand in the container while the ultrasonic sensor is mounted on the inside surface of the cover of the container. This is to ensure that the accelerometer absorb a sufficient amount of vibration whereas the ultrasonic sensor is able to detect the water level accurately starting from the bottom of the container respectively.

At first, the water is added into the container up to 5cm height. In order to test the functionality of both ultrasonic sensor and accelerometer for the condition in Table 3.9, the container is shake up and down parallel to X-direction until the threshold value where the threshold value is set to 511 in ADC value (3.5 Richter scale). At the same time, the time taken for light up the Green LED is recorded by using stopwatch. The experiment is repeated for another 9 times to test for functionality. Then, the steps are repeated by shaking the container in parallel to Y-direction with the same ADC value and same water level. The data is collected and tabulated.

3.5.3 Experiment 3: Sending Alert Message through Smartphone Application

Nowadays, the most common and popular smartphone application used for messaging is Telegram messenger due to the population of 100 million monthly active users as of early February of 2016. 350,000 new users sign up everyday and 15 billion messages delivered daily. Telegram messages are heavily encrypted and it is able to self-destruct. It is cloud-based where it lets users to access their messages from multiple devices. Besides that, it delivers messages faster than any other messenger application and their servers are spread worldwide for security and speed. It keeps the message safe from hacker attacks. The most important feature is telegram is free of charge with no advertisement and subscription fees. In addition, it has no limits on the size of the file, media or chats and it opens an API and protocol that are free for everyone. Telegram messenger application can be accessed by installing Python Telegram Bot library into Raspberry Pi, where it is a Python library which allows users to login and use the Telegram service.

Objective 2: To develop a disaster messaging system for sending alert information and image of water level condition by using USB camera through smartphone's application.

3.5.3.1 Setup of Experiment 3

Basically, the materials and apparatus used for this experiment is only Raspberry Pi, monitor and a mobile phone. Firstly, Telegram application is downloaded and installed on the mobile phone. Next, a bot account, which is a special kind of account for machines, is required to obtain for the owner of the Raspberry Pi before connecting to Raspberry Pi. Hence, the Telegram is opened on the mobile phone and a user which is called BotFather is searched. He is the Father of All Bots, which is a machine that accepts special commands. Some commands are typed in order to obtain the bot account. Few questions are answered, which are the name and username for the new bot account. After replying the message, the username is then stored in the Telegram databases. Then, a token number is given by the BotFather which represents the bot account. Next, the Raspberry Pi is started to use it. LX terminal is opened and all the library that necessary for using Telegram is downloaded. Normally, several steps of coding and commands from the server are involved in order to install the Telepot library into the Raspberry Pi. After installing the Telepot library into Raspberry Pi, which is a Python package that enables the Pi to speak Telegram Bot API, the photos, audio files, documents and so on are able to send and receive.

Next, some commands with the token number are typed in the Python interpreter in order to test the functionality of the token. Few different messages are typed as shown in Table 3.10 in order to test for the functionality of sending and receiving of the command typed. The file is named, saved, and then run in Pi. Next, the Telegram application is opened on the mobile phone and the username set before is searched. Lastly, the message is typed to see the response of the application.

Table 3.10: Different messages for testing.

Message Sends To Raspberry Pi	**Echoing Message By Raspberry Pi**
Hello!	Hello^^
How are you?	I am fine!^^
What is the time now?	*Current time*
Okay, thank you!	You are welcome!
Goodbye!	Goodbye!!!

3.5.4 Experiment 4: Capturing and Storing the Image of Disaster by using USB Camera

It is important to know the increasing of water level until certain conditions before flood disaster happen. Thus, an image is essential for displaying the severity of the water level condition. It is able to monitor the water level condition by capturing the image of water level and save it. Then, this image may help the user to get well-prepared before the condition goes severe. Therefore, the purpose of this experiment to install the USB camera by connecting it to Raspberry Pi, snap a picture and save it.

Objective 2: To develop a disaster messaging system for sending alert information and image of water level condition by using USB camera through smartphone's application.

3.5.4.1 Setup of Experiment 4

In this experiment, the materials and apparatus used are listed out:

1. Raspberry Pi
2. USB camera
3. Monitor

Firstly, the compatibility between type of USB camera and Raspberry Pi plays an important role before proceed to capture the picture. Thus, the compatibility between the chosen USB camera and Raspberry Pi is checked by typing lsusb command in the terminal. Then, there is a name of the USB camera will be listed out in the output of the command. If the name of the USB camera is not listed out in the command window, it means that the Raspberry Pi has no sufficient power supply for the USB camera. Therefore, a USB power hub can be used for separating the power line for the USB camera, and the process of typing lsusb command is repeated. If it is still cannot be recognized, a different model of USB camera is suggested to be used.

At first, the USB camera is located perpendicular to the side of the container in order to capture the picture. Once the USB camera is successfully connected to the Raspberry Pi, a functionality test is given to the USB camera by taking some of the pictures for the purpose of verifying the functionality of the USB camera. Hence, the next step for doing so is to install a small webcam application, which is fwebcam that is able to install directly from the Raspbian repository. After that, a command for capturing the image with the default resolution and to save it in which format is made. Since Telegram messenger only accept the picture either in JPEG or PND format, therefore the type of image format is chosen to be saved in JPEG file for this experiment due to its high quality of picture with small degree of compression. However, different values of resolution are made to test for the best picture colour and clearer image. Since Raspberry Pi only can accept two types of image sizes, which are 320x240 and 640x480, therefore the experiment is tested with this two image sizes and a comparison of clearer image between this two options is made.

3.5.5 Experiment 5: Sending Alert Message with Saved Image of Water Level Condition through Smartphone Application

This experiment is conducted by integrating the system of sending alert message with the image of water level condition through smartphone application. The purpose of this experiment is to test the functionality of sending the alert message and image of water level condition through Telegram messenger.

Objective 2: To develop a disaster messaging system for sending alert information and image of water level condition by using USB camera through smartphone's application.

3.5.5.1 Setup of Experiment 5

In this experiment, the materials and apparatus used are listed out:

1. Raspberry Pi
2. USB camera
3. Mobile phone
4. A stopwatch
5. Monitor

Another method of sending the message is used which is sending the message automatically from Raspberry Pi. At first, a new channel is created and is named in the Telegram application. Next, a picture is captured with the resolution of 320x240 and is saved in JPEG file. Then, a command is typed for sending a simple alert message with an image to the mobile phone automatically through Telegram application. The time needed for delivering the alert message with the image and to reach the mobile phone is taken by using stopwatch. The process is repeated for another 9 times and the average of time taken for delivering the message with image is calculated. The experiment is repeated by changing the image resolution to 640x480. A comparison of time taken for receiving the message with image is made in order to choose the shortest time with the condition of clearer picture.

3.5.6 Experiment 6: Efficiency Rate of the System Test at Indoor Environment

This experiment is conducted for the purpose of determining the efficiency rate of the system, which is the time needed for delivering and receiving the alert message with image. It is an indoor test where the experiment is carried out at the same place and in a small area. The sensing and messaging system is placed near to each other where the mobile phone is placed at beside of the system. A complete hardware system is setup with perfectly function in order to conduct this experiment smoothly.

Objective 3: To calculate the rate of efficiency for delivering and displaying the alert message with image.

3.5.6.1 Setup of Experiment 6

In this experiment, the materials and apparatus used are listed out:

1. Raspberry Pi
2. Accelerometer
3. Ultrasonic sensor
4. USB camera
5. Hose
6. Container filled with water, sand and soil
7. A stopwatch
8. MCP3008
9. USB mouse
10. USB keyboard
11. HDMI cable
12. Monitor
13. 1kΩ resistor
14. 2kΩ resistor
15. Jumper wires
16. Mobile phone
17. Stripboard

A container which is measured 31.5cm x 17cm x 25.5cm is loaded with soil and sand at the left hand side of the container and is filled with water below low level at the right hand side of the container. An accelerometer is placed on the soil and sand, and an ultrasonic sensor is mounted on the inside surface of the cover of the container at the right hand side. Besides, a USB camera is placed perpendicular at the right hand side outside of the container and is connected to Raspberry Pi. Next, the accelerometer is connected to MCP 3008 and the output of MCP3008 is connected to Raspberry Pi. At the same time, the ultrasonic sensor is connected to 1kΩ of resistor, 2kΩ of resistor and Raspberry Pi. Moreover, three different colours of LEDs are used which are Green, Blue, and Red LEDs to represent Low, Medium, and High water level respectively. Then, the Raspberry Pi is connected to monitor by using HDMI cable. In addition, USB mouse and USB keyboard are also connected to the Raspberry Pi. The recipient phone with the specific phone number is prepared by installing Telegram messenger application. The setup of the hardware base of front view, top view and side view are done as shown in Figure 3.13, Figure 3.14 and Figure 3.15 respectively. The system process is discussed next.

Process 1: X-direction

The code from the LX terminal is run by using the smallest threshold value, which is 511 and it is corresponding to 3.5 magnitude scale for the accelerometer whereas the code of ultrasonic sensor to sense low level is set and simulated together. The entire system is placed in indoor, where the sensing and messaging system is placed near to each other at the same place. The experiment is started by filling up the container with water until low level. After that, a shaking test is carried out by shaking the container up and down with both hand in opposite direction, where the direction is parallel to X-direction of the accelerometer and the container is shake until it is above the threshold value. The time needed for the message and image to be displayed in Telegram messenger of the mobile phone is measured by using stopwatch and the time taken is recorded. The stopwatch is started once the Green LED light up where both conditions are achieved and is stopped when the message and image are received by the recipient. The shaking test is repeated for another 9 times (total = 10 times) and the average time taken for delivering and displaying the message is calculated. A standard deviation, σ for the 10 collected data are also calculated.

Process 2: Y-direction

Process 1 is repeated by shaking the container parallel to Y-direction. All of the data are tabulated in a table form.

Process 3: Changing of Threshold Value

Process 2 is repeated by changing the threshold value to 516 (5.4 Magnitude Scale). All of the data are tabulated in a table form.

Process 4: Changing the Water Level

Process 3 is repeated by changing the water level measurement to medium level (Blue LED) and high level (Red LED) by adding the water to almost the marking levels. All of the data are tabulated in a table form.

Formula to calculate average:

$$\bar{x} = \frac{x_1 + x_2 + \dots + x_n}{n} \tag{3.8}$$

Formula to calculate standard deviation:

$$\sigma = \sqrt{\frac{\Sigma(x-\bar{x})^2}{(n-1)}} \tag{3.9}$$

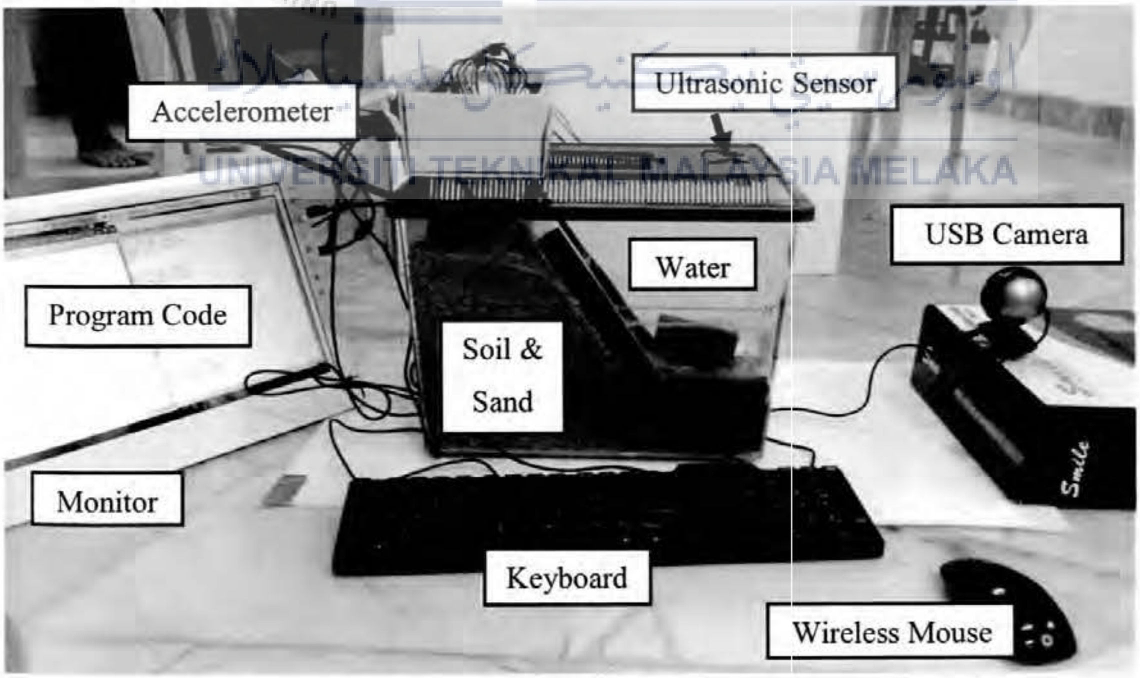


Figure 3.13: Setup of hardware base from front view.

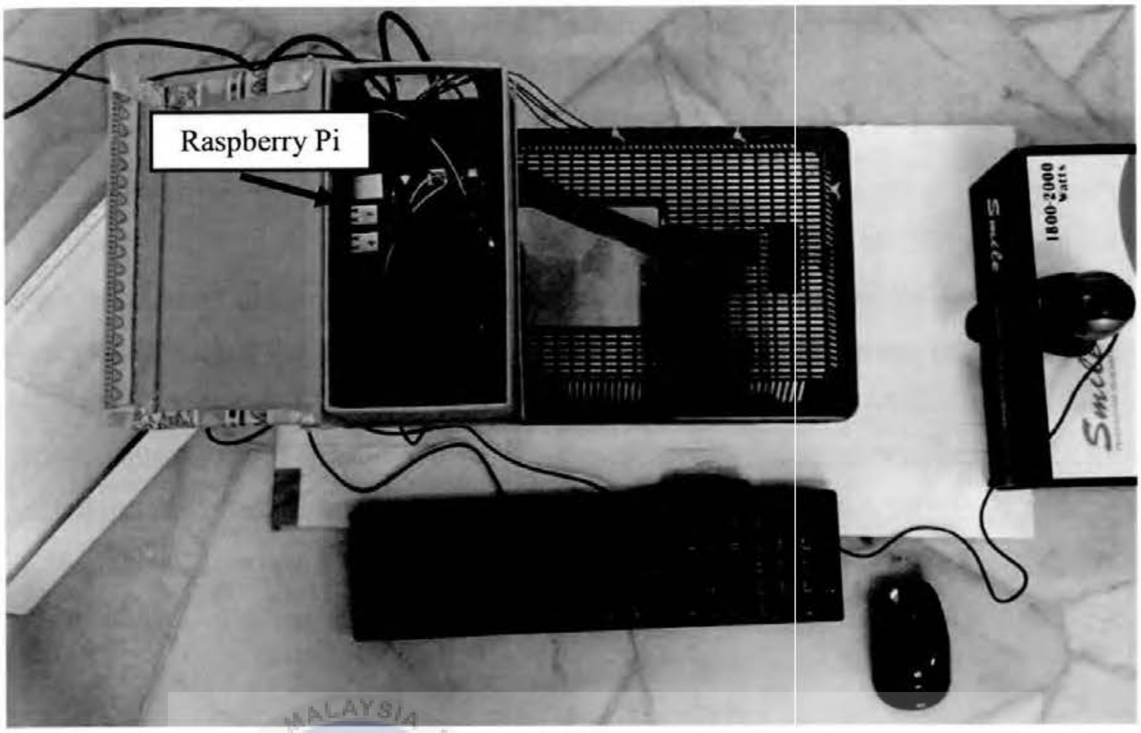


Figure 3.14: Setup of hardware base from top view.

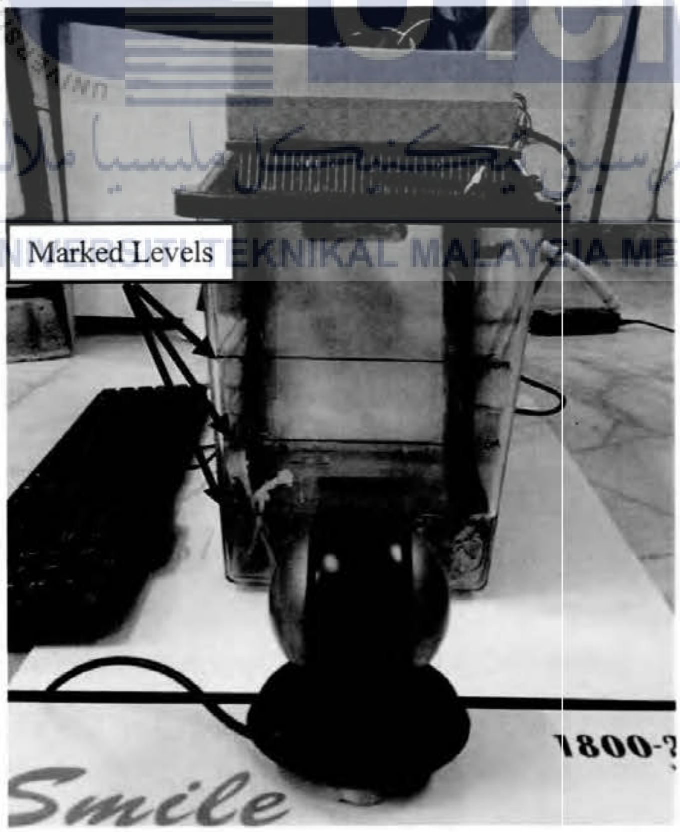


Figure 3.15: Setup of hardware base from side view.

3.5.7 Experiment 7: Efficiency Rate of the System Test at Outdoor Environment

This experiment is carried out for the purpose of determining the efficiency rate of the system, which is the time needed for delivering and receiving the alert message with image at outdoor. The sensing and messaging system are placed at two different places with particular amount of distance between both of them. The disaster sensing system is placed at Fakulti Kejuruteraan Elektrik (FKE), UTeM as shown in Figure 3.16 while the messaging system is placed at Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer (FKEKK) and Fakulti Kejuruteraan Mekanikal (FKM), UTeM. The distance from FKE to FKEKK and FKM is about 210m and 6.45km as shown in Figure 3.17 and Figure 3.18 respectively. The time taken for delivering and displaying the message with image is measured and recorded.

Objective 3: To calculate the rate of efficiency for delivering and displaying the alert message with image.

3.5.7.1 Setup of Experiment 7

In this experiment, the materials and apparatus used are listed out:

1. Raspberry Pi
2. Accelerometer
3. Ultrasonic sensor
4. USB camera
5. Hose
6. Container filled with water, sand and soil
7. Three stopwatches
8. MCP3008
9. USB mouse
10. USB keyboard
11. HDMI cable
12. Monitor
13. 1kΩ resistor
14. 2kΩ resistor
15. Jumper wires
16. Mobile phone
17. Stripboard

Similar hardware entire system from Experiment 6 is used for this experiment. The sensing system is placed at FKE while the messaging receiver system is placed at FKEKK. The distance between these two faculties is 210m. The system running process is discussed next.

Process 1: X-direction

The code from the LX terminal is run by using the smallest threshold value, which is 511 and it is similar to 3.5 magnitude scale for the accelerometer whereas the code of ultrasonic sensor to sense low level is set and simulated together. The experiment is started by filling up the container with water until low level. After that, a shaking test is carried out by shaking the container up and down with both hand in opposite direction, where the direction is parallel to X-direction of the accelerometer and the container is shake until it is above the threshold value. In this experiment, four mobile phones are used. One is at the sender side to inform the lightning of LED. Another three is at recipient side, where one is used as stopwatch, another one is used to receive the message and image, and the last one is to communicate with the sender. Throughout the whole experiment, it is make sure that the sender is on the phone call with the recipient. Hence, when both condition is achieved at the same time, the Green LED is lighten up, the sender should inform the recipient through phone call immediately and the recipient should start the stopwatch at the same time. The time taken for the recipient to receive the message and image in Telegram application are recorded by pressing lap function in the stopwatch of the mobile phone. Once the message and image are received by the recipient, the time taken is recorded in a table form. After that, the stopwatch is reset. The shaking test is repeated for another 9 times (total = 10 times) and the average time taken for delivering and displaying the message is calculated. A standard deviation, σ for the 10 collected data are also calculated.

Process 2: Y-direction

Process 1 is repeated by shaking the container parallel to Y-direction. All of the data are tabulated in a table form.

Process 3: Changing of Threshold Value

Process 3 is then repeated by changing the threshold value to 516 (5.4 Magnitude Scale). All of the data are tabulated in a table form.

Process 4: Changing the Water Level

Process 3 is repeated by changing the water level measurement to medium level and high level by adding the water to almost the marking levels. All of the data are tabulated in a table form.

Process 5: Different Places

Finally, process 4 is repeated by placing the receiver at different place, FKM where the distance between both FKE and FKM faculties is about 6.45km. The distance between FKE to FKEKK and FKE to FKM are shown in the Figure which is taken from Google Map. All of the data are tabulated in a table form.

Formula to calculate average:

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} \tag{3.10}$$

Formula to calculate standard deviation:

$$\sigma = \sqrt{\frac{\Sigma(x-\bar{x})^2}{(n-1)}} \tag{3.11}$$

Figure 3.16: Setup of hardware base at FKE.

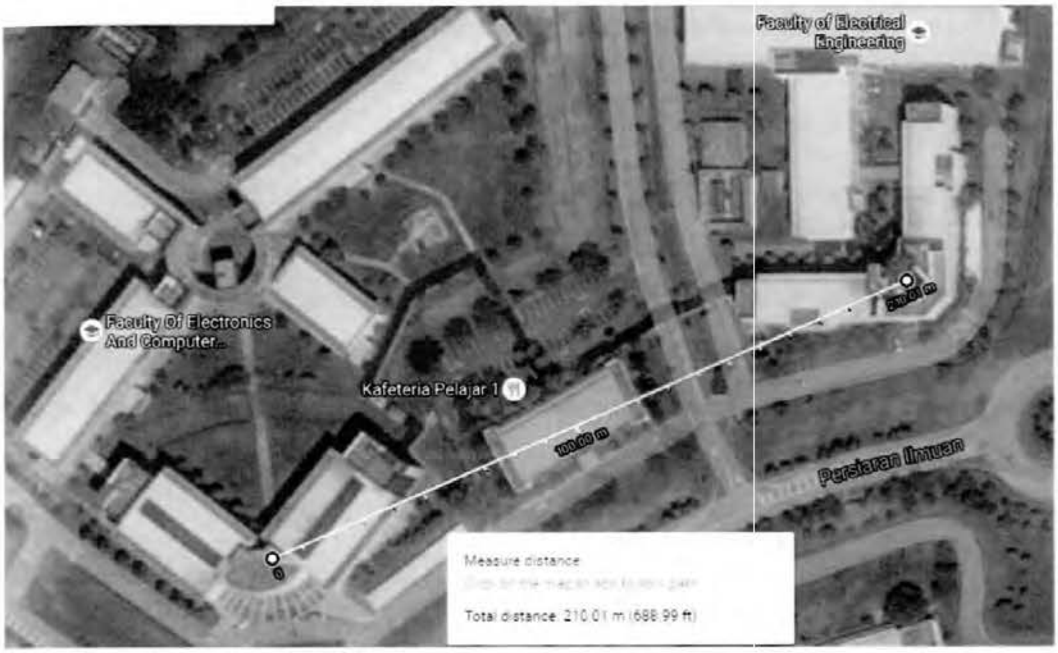


Figure 3.17: Distance between FKE and FKEKK.

Figure 3.18: Distance between FKE and FKM.

3.5.8 Experiment 8: Reliability of the System Test at Indoor Environment

The reliability of the system is taken into account. Thus, this experiment is conducted by determining the number of times the system fully functioned when every time there is a shaking test carried out. The experiment is conducted for 10 times at indoor environment where the place is same as in the Experiment 6. The reliability of the system is determined and recorded by referring to the number of times the message and image are successfully sent and displayed on the receiver.

Objective 3: To calculate the rate of efficiency for delivering and displaying the alert message with image.

3.5.8.1 Setup of Experiment 8

In this experiment, the materials and apparatus used are listed out:

1. Raspberry Pi
2. Accelerometer
3. Ultrasonic sensor
4. USB camera
5. Hose
6. Container filled with water, sand and soil
7. MCP3008
8. USB mouse
9. USB keyboard
10. HDMI cable
11. Monitor
12. 1kΩ resistor
13. 2kΩ resistor
14. Jumper wires
15. Mobile phone
16. Stripboard

A similar prototype as shown in Experiment 6 is used for this experiment. The system process is discussed next.

Process 1: X-direction

The code from the LX terminal is run by using the smallest threshold value, which is 511 and it is corresponding to 3.5 magnitude scale for the accelerometer whereas the code of ultrasonic sensor to sense low level is set and simulated together. The entire system is placed in indoor, where the sensing and messaging system is placed near to each other at the same place. The experiment is started by filling up the container with water until low level. After that, a shaking test is carried out by shaking the container up and down with both hand in opposite direction, where the direction is parallel to X-direction of the accelerometer and the container is shake until it is above the threshold value. The number of times where the system is able to well-functioned and successfully displayed the message with image is essential in order to conduct the reliability test of the entire system. The system is tested for 10 times and the number of times where the system is able or unable to function is recorded.

Process 2: Y-direction

Process 1 is repeated by shaking the container parallel to Y-direction. All of the data are tabulated in a table form.

Process 3: Changing of Threshold Value

Process 2 is then repeated by changing the threshold value to 516 (5.4 Magnitude Scale). All of the data are tabulated in a table form.

Process 4: Changing the Water Level

Process 3 is repeated by changing the water level measurement to medium level and high level by adding the water to almost the marking levels. All of the data are tabulated in a table form.

3.5.9 Experiment 9: Reliability of the System Test at Outdoor Environment

The reliability of the system is taken into consideration in order to confirm the functionality of the system. Hence, this experiment is conducted by determining the number of times the system well-functioned when every time there is a shaking test is carried out. The experiment is conducted for 10 times at outdoor where the place is same as in the Experiment 7, which is the distance between FKE and FKEKK, as well as FKE to FKM. The reliability of the system is determined and recorded by referring to the number of times the message and image are successfully sent and displayed on the recipient phone.

Objective 3: To calculate the rate of efficiency for delivering and displaying the alert message with image.

3.5.9.1 Setup of Experiment 9

In this experiment, the materials and apparatus used are listed out:

1. Raspberry Pi
2. Accelerometer
3. Ultrasonic sensor
4. USB camera
5. Hose
6. Container filled with water, sand and soil
7. MCP3008
8. USB mouse
9. USB keyboard
10. HDMI cable
11. Monitor
12. 1kΩ resistor
13. 2kΩ resistor
14. Jumper wires
15. Mobile phone
16. Stripboard

It is important to use a same prototype for all experiments in order to confirm the reliability of the system. Hence, this experiment is carried out by using the same prototype used in Experiment 6. The message sending system is placed at FKE while the receiver is placed at FKEKK. The system process is discussed next.

Process 1: X-direction

The code from the LX terminal is run by using the smallest threshold value, which is 511 and it is similar to 3.5 magnitude scale for the accelerometer whereas the code of ultrasonic sensor to sense low level is set and simulated together. The experiment is started by filling up the container with water until low level. After that, a shaking test is carried out by shaking the container up and down with both hand in opposite direction, where the direction is parallel to X-direction of the accelerometer and the container is shake until it is above the threshold value. The number of times where the system is able to display the message with image plays an important role in order to conduct the reliability test of the entire system. The system is tested for 10 times and the number of times where the system is able or unable to function is recorded.

Process 2: Y-direction

Process 1 is repeated by shaking the container parallel to Y-direction. All of the data are tabulated in a table form.

Process 3: Changing of Threshold Value

Process 2 is then repeated by changing the threshold value to 516 (5.4 Magnitude Scale).

Process 4: Changing the Water Level

Process 3 is repeated by changing the water level measurement to medium level and high level by adding the water to almost the marking levels.

Process 5: Different Places

Finally, process 4 is repeated by placing the receiver at different place, FKM where the distance between both FKE and FKM faculties is about 6.45km.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Overview

Results of every experiments will be presented and discussed throughout this chapter. The efficiency of the system will also be determined through the collected data from each of the experiments. In addition, the reliability of this Disaster Alert System will be determined in order to conclude the role of this system in real situation.

4.2 Calculation of Threshold Value

Different values of accelerations are set and the gravitational force are calculated according to the formula stated in Equation (3.1). Besides, the threshold value for different gravitational force are calculated according to the Equation (3.2). The results are shown in Table 4.1. The calculation of gravitational force and threshold value are shown in Appendices B and Appendices C respectively.

Table 4.1: Threshold value for different acceleration and magnitude scale.

Magnitude Scale	**Acceleration (m/s2)**	**Gravitational Force (g)**	**Analog-to-Digital Converter (ADC) Value**
3.5	0.01	0.00102	511
4.2	0.025	0.0102	511
4.8	0.25	0.0259	514
5.4	0.5	0.05097	516
6.0	1.5	0.15291	527

4.2.1 Discussion on Calculation of Threshold Value

Table 4.1 shows different magnitude with respected acceleration, gravitational force and analog-to-digital (ADC) value. The threshold value, which is the values of ADC will be used in the program code in order to send the message when it is surpass. 3.5 magnitude scale earthquake will generate an acceleration of $0.01 m/s^2$, 0.00102g of gravitational force and 511 of ADC value. Besides that, 4.2 magnitude scale earthquake will accelerate the ground with $0.025 m/s^2$, and will produce 0.0102g of gravitational force and 512 of ADC value. In addition, 4.8 magnitude scale earthquake will generate an acceleration of $0.25 m/s^2$, 0.0259g of gravitational force and 514 of ADC value. Moreover, 5.4 magnitude scale earthquake will produce an acceleration of $0.5 m/s^2$, 0.05097g of gravitational force and 516 of ADC value. Lastly, 6.5 magnitude scale earthquake will generate an acceleration of $1.5 m/s^2$, 0.15291g of gravitational force and 527 of ADC value. In this Disaster Alert System, the experiments will be conducted only by using 511 ADC and 516 ADC as threshold value in order to determine the average time needed for the alert message to send to the recipient with the image. Higher ADC value is not suitable to conduct together with high water level because the water will spread out to the outside since larger force is needed to shake the container in order to reach the threshold value. Then, the efficiency of time taken for recipient to receive the message and image is evaluated.

4.3 Results of Experiment 1

Table 4.2: Comparison of time taken for LEDs to light up at three different water level conditions between ultrasonic sensor and infrared sensor.

Number of Trials	Time Taken for Light Up LEDS (s)						Flow Rate (l/s)
	Ultrasonic Sensor			Infrared Sensor			
	Low Level (Green)	Medium Level (Blue)	High Level (Red)	Low Level (Green)	Medium Level (Blue)	High Level (Red)	
1	35.6	87.2	156.7	38.7	92.5	158.5	0.0479
2	35.8	86.7	148.9	39.6	95.3	151.9	0.0504
3	34.5	85.6	136.4	39.1	96.2	140.5	0.0550
4	35.7	90.2	140.4	40.1	100.2	145.8	0.0534
5	32.6	83.4	154.6	36.4	90.7	156.6	0.0485
6	33.7	84.6	150.2	37.8	93.6	153.1	0.0499
7	34.6	86.4	148.6	39.3	95.8	151.2	0.0505
8	35.2	90.8	155.2	39.8	100.5	159.6	0.0483
9	34.8	89.7	152.6	38.1	93.1	155.1	0.0491
10	33.5	86.5	149.6	37.9	92.9	152.4	0.0501
Average	**34.6**	**87.1**	**149.3**	**38.7**	**95.1**	**152.5**	**0.0502**

4.3.1 Discussion on Experiment 1

In this experiment, the humidity is assumed to be constant which is 70±10% as the experiment is done in indoor environment where the efficiency of the sensor will not be much affected. Table 4.2 discloses the time taken for both ultrasonic sensor and infrared sensor to light up the LEDs. From the calculated average result of time taken, it shows that ultrasonic sensor gives a better and faster response than infrared sensor when detecting the level of water level. For the detection of low level, ultrasonic sensor lighten up the Green LED at an average of 34.6 seconds while infrared sensor takes 38.7 seconds. For detecting medium level of water, ultrasonic sensor gives response in 87.1 seconds averagely while infrared sensor takes 95.1 seconds to light up the Blue LED. Next, ultrasonic sensor lighten up the Red LED within 149.3 seconds averagely while infrared sensor takes 152.5 seconds. The average flow rate of the water is 0.0502 litres per second.

By comparing the ultrasonic sensor and infrared sensor, ultrasonic sensor gives a better real time response than infrared sensor. There is a delay for infrared sensor to detect the water level because it can only detect the infrared images based on the thermal energy levels or variants of temperature of the objects. It is hard for the infrared sensor to detect the differences in the objects that have a very close temperature range and this resulted in inaccuracy. Besides that, infrared sensor is more expensive rather than ultrasonic sensor.

Apart from that, there is a weakness of the program code for converting the voltage level of infrared sensor to the distance where the specific program code is shown in Equation 4.1 as attached in Appendix F.

$$d1 = 27.86\ x\ v^{-1.15} - 9 \qquad (4.1)$$

where $d1$ is represented as distance1 and v is volts.

From Equation 4.1, the last digit number has to recalibrate everytime when restart the experiment which is running the program code again due to the destabilization of the response of the infrared sensor.

Hence, it is clearly shown that ultrasonic sensor will be a better choice than choosing infrared sensor in term of its fast response, accuracy, and cost for this Disaster Alert System.

4.4 Results of Experiment 2

Table 4.3: Time taken for different colours of LEDs to light up at different direction of vibration.

Number of Trials	Time Taken for Light Up LED	
	Low Level & 511 ADC Value	
	X-Direction (Green LED)	Y-Direction (Red LED)
1	7.10	2.27
2	2.24	10.14
3	4.38	2.28
4	1.98	6.15
5	2.44	1.73
6	2.57	9.41
7	2.30	4.67
8	3.78	9.02
9	2.37	13.68
10	4.56	2.68

4.4.1.1 Discussion on Experiment 2

In this experiment, the ultrasonic sensor and accelerometer are successfully connected to Raspberry Pi. The sensors used are able to trigger and lighten up the LEDs. From Table 4.3, it shows that when both accelerometer and ultrasonic sensor successfully detect the threshold value, it lights up the LED. Hence, the system is function well. There are different time taken for every trials because different forces are applied to shake the container. The larger the force of shaking the container, the faster the vibration to reach the threshold value, the shorter the time to light up the LED. Since every trials are able to light up the LED, therefore the system is confirmed as functioning but in the condition of both accelerometer and ultrasonic sensor must achieve the threshold value set earlier.

4.5 Results of Experiment 3

Firstly, Telegram application is successfully downloaded in a mobile phone. In order to create a new bot account in Telegram, Bot Father is searched and command "/newbot" is typed. Then, the bot is named as "Yvonne" and the username is named as "tbp_bot". The name and username can be written as any name. After that, a token number is given by the Bot Father in order to access the HTTP API as shown in Figure 4.1.

Next, Raspberry Pi is make sure that it is able to access internet. Then, putty is opened and an IP address of the Raspberry Pi is typed in the box, which is to connect the Raspberry Pi via SSH. It is used to install Telegram Bot on Raspberry Pi. After that, a Python package is installed by typing and running two commands on the command line in LX terminal.

Coding:

```
sudo apt-get install python-pip
```

```
sudo pip install telepot
```

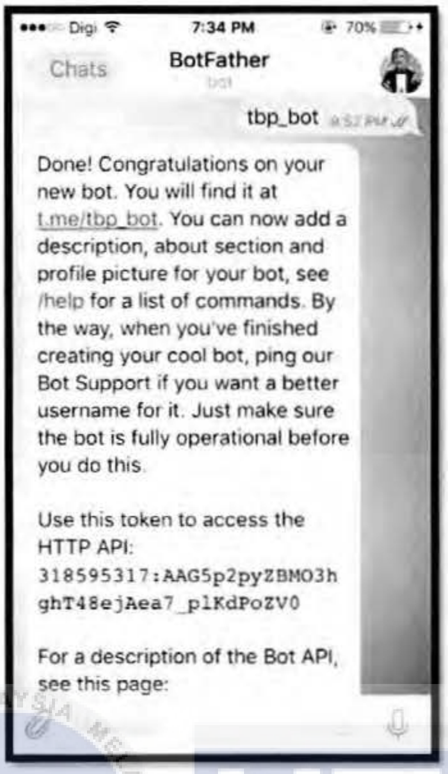
Then, a git is cloned by typing the command as below:

```
git clone https://github.com/salmanfarisvp/TelegramBot.git
```

Then, the bot token number is copied and pasted by typing the command as below:

```
bot = telepot.Bot('copy bot token number that gave by Bot Father')
```

Next, a python file is created and saved as "telegrambot.py". After that, the Telegram is opened in the mobile phone and username is searched, which is tbp_bot. "Start" is clicked in order to join the bot and the messages as shown in Table 3.10 are typed to see the response of the Raspberry Pi. The file is run in order to test for the functionality of sending and receiving the messages. The result is shown in Figure 4.2.



tbp_bot

Done! Congratulations on your new bot. You will find it at t.me/tbp_bot. You can now add a description, about section and profile picture for your bot, see /help for a list of commands. By the way, when you've finished creating your cool bot, ping our Bot Support if you want a better username for it. Just make sure the bot is fully operational before you do this.

Use this token to access the HTTP API:
`318595317:AAG5p2pyZBMO3hghT48ejAea7_plKdPoZV0`

For a description of the Bot API, see this page:

Figure 4.1: Token number which is given by Bot Father.

/start

Hello!

Hello^^

How are you?

I am fine!^^

What is the time now?

2017-03-01 17:49:37.693430

Okay, thank you!

You are welcome!:)

Goodbye!

Goodbye!!!

Photo please!

Figure 4.2: Echo messages that sent to Raspberry Pi.

4.5.1 Discussion on Experiment 3

sudo apt-get install python-pip and *sudo pip install telepot* are the commands used to install python library and telepot which enables Pi to speak with Telegram Bot API. *git clone https://github.com/salmanfarisvp/TelegramBot.git* and *bot = telepot.Bot('copy bot token number that gave by Bot Father')* are the commands used to run the python code.

At first, the users have to search for tbp_bot in Telegram Application and clicking "start", then only able to access the sending and receiving function which is to send and receive the message from Raspberry Pi. This experiment is done by using echo command, which means that the sender sends the message to Raspberry Pi and once the Raspberry Pi receives it, the Raspberry Pi will echo back the message to the sender.

The echoing messages are set earlier in the program code as shown in Appendix G. Once the Raspberry Pi receives same messages from the Telegram bot, it will automatically reply the messages that set earlier in the program code. Hence, the Raspberry Pi plays a dual role in this experiment which is receiving and sending back the message. From Figure 4.2, the screenshot result shows that Telegram application is successfully connected to the Raspberry Pi through the process of sending and echoing the messages. Hence, the alert message can be successfully sending through this Telegram application.

4.6 Results of Experiment 4

In order to use a standard USB camera to capture an image, a fswebcam package is installed by typing command in LX terminal as below:

```
sudo apt-get install fswebcam
```

Next, a Bash script is created by opening up the editor of choice and writing the code:

```
#!/bin/bash

DATE=$(date+ "%Y-%m-%d_%H%M")

fswebcam -r 320x240 /home/pi/Dekstop/image.jpg
```

All of the commands in the above are saved in a 'sh' file where the file is named as webcam.sh. Next, a python file is created, which is to call the webcam.sh file and run it. The size of image can be changed by editing the number of 320x240 to 640x480 in the program code, and the processes of calling out the file and executing it are repeated. The results of image size for the resolution of 320x240 and 640x480 are shown in Figure 4.3 and Figure 4.4 respectively.

Figure 4.3: Picture with the resolution of 320x240.

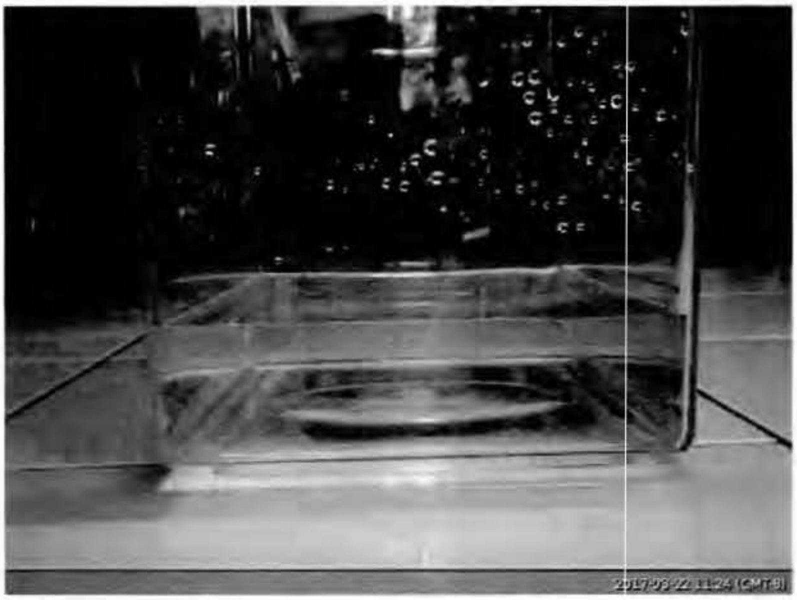


Figure 4.4: Picture with the resolution of 640x480.

4.6.1 Discussion on Experiment 4

Throughout this experiment, the result shows that the chosen USB camera is compatible with the Raspberry Pi. The program code of saving the image is successfully written and saved in the webcam.sh file. Besides that, a Python code for calling out the file is also done as shown in Appendix H. Next, the USB camera successfully captured the image after simulating the Python code. Then, the picture is successfully saved in JPEG format.

From Figure 4.3 and Figure 4.4, the results show that picture taken with a resolution of 640x480 has a better and clearer image than the picture with a resolution of 320x240. In order to capture the image for showing water level of a flood condition, a clearer and brighter picture is needed so that users are convinced to take earlier precaution. Hence, a picture with a resolution of 640x480 is chosen for this experiment.

4.7 Results of Experiment 5

Table 4.4: Time taken for receiving the message and image with different resolution.

Number of Trials	Time Taken for Receiving the Message and Image (s)			
	Message	**Image (320x240)**	**Message**	**Image (640x480)**
1	2.43	13.50	3.71	14.98
2	2.57	12.79	2.59	13.98
3	2.45	12.28	2.39	13.80
4	3.48	12.47	2.32	13.83
5	3.13	13.19	3.50	14.97
6	2.58	12.03	2.30	13.67
7	2.42	11.49	3.55	14.07
8	2.69	11.44	2.83	13.66
9	2.25	11.27	2.75	14.02
10	2.39	11.53	2.35	13.84
Average	**2.64**	**12.20**	**2.83**	**14.08**

4.7.1 Discussion on Experiment 5

There is another method of sending the message automatically from Raspberry Pi instead of the users have to send the message first and wait for reply as in Experiment 3. Therefore, this experiment is done by sending the message and image automatically to the users of Telegram application.

At first, a new channel is created in the Telegram application and is named as "Disaster Alert System". This channel is set to public where everyone can search for it and join the channel. Moreover, the link is set to *t.me/fyptbp* where people can share this link with others and find this channel by using Telegram search. Next, a Python code for sending the message and image automatically as shown in Appendix I is simulated.

The result of time taken for sending both message and image is shown in Table 4.4. This experiment is started by sending the message and image automatically with a resolution of 320x240. The mobile network used for this experiment is YES 4G huddle with 4GB plan. From Table 4.4, it shows that the average time taken for the message and image to reach the mobile phone are 2.64 seconds and 12.20 seconds respectively. Next, the experiment is done by sending the message and image with a resolution of 640x480 by changing the number in the program code. The average time taken for the message and image to reach the mobile phone are 2.83 seconds and 14.08 seconds respectively. The differences in time taken for sending the message and image for both different resolutions are 0.19 seconds and 1.88 seconds.

From the result, it shows that lower resolution of image takes a shorter time to reach the mobile users. On the other hand, higher resolution of image gives a clearer and better picture to the users. As we know that time plays an important role in the disaster alert system however, a clearer picture may help the victim to predict the time and ready for earlier precaution. Since the difference of time taken for sending both message and image is less than 2 seconds, and even if the victim receives the alert notification earlier within this 2 seconds, they might not take any earlier precaution too. Hence, the best option for this project is to send the message and image with a resolution of 640x480.

4.8 Results of Experiment 6

Table 4.5: Time taken for recipient to receive message and image at different internet plans at indoor test.

Number of Trials	Time Taken for Recipient to Receive Message and Image at Different Internet Plans (s)															
	511 ADC Value and Low Water Level															
	X - direction								Y - direction							
	Unifi		Streamyx (4Mbps)		Yes 4G		Digi Plan		Unifi		Streamyx (4Mbps)		Yes 4G		Digi Plan	
	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image
1	2.3	8.0	3.2	11.9	1.4	16.7	1.1	10.3	2.7	8.1	3.2	13.3	1.8	10.8	1.3	12.0
2	3.0	7.2	4.1	12.1	2.9	13.1	1.7	10.8	1.7	6.7	3.9	14.3	1.4	13.5	0.9	10.9
3	2.2	9.0	4.4	14.2	1.6	15.5	1.0	10.4	1.3	7.0	2.5	13.6	1.7	12.0	1.6	9.4
4	1.4	9.9	2.7	13.8	3.1	13.6	1.3	9.5	1.3	8.4	1.6	11.9	1.5	14.9	0.7	11.0
5	1.1	9.6	2.5	11.3	1.5	11.9	1.4	11.0	0.5	8.9	2.3	12.5	1.6	11.4	1.2	9.3
6	0.4	9.0	1.7	14.7	1.1	10.7	1.5	10.5	0.5	9.2	1.7	11.7	2.2	12.3	1.0	10.4
7	0.8	8.9	4.5	15.4	1.3	11.8	1.1	13.0	0.8	8.1	3.4	11.7	2.8	13.3	1.4	10.8
8	1.5	8.4	3.5	14.4	1.4	11.7	1.0	9.9	1.3	8.4	2.3	13.4	0.9	11.0	0.9	10.2
9	1.0	10.2	2.2	13.9	1.5	10.8	0.7	12.4	2.9	7.3	1.6	12.3	1.8	11.1	0.9	11.3
10	0.5	8.7	3.9	14.4	1.7	11.1	1.1	10.4	1.3	8.5	3.1	14.2	1.5	11.3	1.0	10.3
Average	**1.42**	**8.89**	**3.27**	**13.61**	**1.75**	**12.69**	**1.19**	**10.82**	**1.44**	**8.06**	**2.56**	**12.89**	**1.72**	**12.16**	**1.09**	**10.56**

Table 4.5 shows the time taken for recipient to receive the message and image by using different internet plans and the experiment is done indoor. There are four different types of internet plans used in this experiment, which are Unifi, Streamyx with 4Mbps, Yes 4G and Digi data plan. The experiment is tested only with 511 ADC value (3.5 magnitude scale) to detect the vibration by accelerometer and low water level to sense by ultrasonic sensor.

When the shaking test was conducted in X-direction, the recipient takes 1.42 seconds and 8.89 seconds averagely to receive message and image respectively when using Unifi, 3.27 seconds and 13.61 seconds averagely to receive message and image respectively when using Streamyx with 4Mbps, 1.75 seconds and 12.69 seconds averagely to receive message and image respectively when using Yes 4G, and 1.19 seconds and 10.82 seconds averagely to receive message and image respectively when using Digi data plan.

On the other hand, when the shaking test conducts in Y-direction, the recipient takes 1.44 seconds and 8.06 seconds averagely to receive message and image respectively when using Unifi, 2.56 seconds and 12.89 seconds averagely to receive message and image respectively when using Streamyx with 4Mbps, 1.72 seconds and 12.16 seconds averagely to receive message and image respectively when using Yes 4G, and 1.09 seconds and 10.56 seconds averagely to receive message and image respectively when using Digi data plan.

From the average results taken, it shows that the recipient receives the message in the shortest time by using Digi data plan, however the shortest time to receive the image is obtained by using Unifi for both X and Y-direction. The recipient takes a longer time to receive the message and image when using Streamyx with 4Mbps. Hence, this experiment shows that Unifi has a better and faster internet connection for the usage of this Disaster Alert System, followed by Digi data plan, Yes 4G and Streamyx. Therefore, Unifi is chosen to be used for the experiment of testing the efficiency of the complete system at indoor environment respectively.

Table 4.6: Time taken for recipient to receive message and image at 3.5 Richter scale at indoor test.

Number of Trials	Time Taken for Recipient to Receive Message and Image at 511 ADC Value (s)											
	Low Level				Medium Level				High Level			
	X - direction		Y - direction		X - direction		Y - direction		X - direction		Y - direction	
	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image
1	2.3	8.0	2.7	8.1	2.2	7.8	1.1	8.2	1.9	9.3	1.3	8.6
2	3.0	7.2	1.7	6.7	4.6	7.9	2.3	7.9	2.7	8.0	1.5	8.9
3	2.2	9.0	1.3	7.0	1.0	8.7	2.2	7.4	2.2	7.6	2.9	7.4
4	1.4	9.9	1.3	8.4	2.3	7.9	1.8	7.9	1.7	7.8	2.1	8.9
5	1.1	9.6	0.6	8.9	1.3	8.2	2.4	7.3	1.5	7.7	1.4	9.1
6	0.4	9.0	0.5	9.2	1.2	9.8	1.9	7.9	3.4	7.1	1.5	8.6
7	0.8	8.9	0.8	8.1	1.7	8.0	2.4	7.1	1.3	7.4	1.4	9.8
8	1.5	8.4	1.3	8.4	1.1	8.4	2.0	7.7	2.0	8.6	2.4	8.7
9	1.0	10.2	2.9	7.3	0.8	8.6	1.5	8.1	1.3	8.0	2.1	8.3
10	0.5	8.7	1.3	8.5	1.0	8.9	1.7	8.3	1.8	8.0	2.4	8.0
Average	**1.42**	**8.89**	**1.44**	**8.06**	**1.72**	**8.42**	**1.93**	**7.78**	**1.98**	**7.95**	**1.90**	**8.63**
Standard Deviation	**0.85**	**0.89**	**0.81**	**0.82**	**1.13**	**0.61**	**0.42**	**0.40**	**0.65**	**0.62**	**0.55**	**0.65**

Table 4.7: Time taken for recipient to receive message and image at 5.4 Richter scale at indoor test.

Number of Trials	Time Taken for Recipient to Receive Message and Image at 516 ADC Value (s)											
	Low Level				Medium Level				High Level			
	X - direction		Y - direction		X - direction		Y - direction		X - direction		Y - direction	
	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image
1	2.3	9.2	2.3	12.4	3.3	8.7	2.0	10.0	1.3	9.7	2.0	8.3
2	1.0	9.5	1.7	12.3	1.5	8.6	1.6	8.7	2.4	9.2	2.1	10.2
3	1.3	8.8	1.2	9.6	1.3	9.8	2.3	8.4	1.5	9.2	2.1	8.9
4	1.2	9.3	1.2	9.1	2.2	8.8	2.9	9.0	2.2	8.0	1.4	11.2
5	1.5	9.0	1.0	9.6	2.5	7.6	1.3	9.2	1.4	9.8	1.3	10.1
6	2.1	8.7	1.5	8.0	1.3	9.7	2.2	8.0	1.7	9.2	1.6	9.1
7	2.4	9.0	2.2	8.5	1.2	9.6	2.3	8.3	1.3	9.0	2.4	8.7
8	1.1	10.4	2.5	8.6	2.2	8.2	1.5	8.9	1.9	9.3	1.3	14.9
9	1.2	9.3	2.1	10.3	2.4	8.0	2.0	8.3	1.0	9.6	2.9	9.0
10	1.4	9.7	1.1	8.9	1.3	9.0	1.1	10.5	1.1	8.4	1.0	9.7
Average	**1.55**	**9.29**	**1.68**	**9.73**	**1.92**	**8.80**	**1.92**	**8.93**	**1.58**	**9.14**	**1.81**	**10.01**
Standard Deviation	**0.52**	**0.50**	**0.56**	**1.53**	**0.71**	**0.74**	**0.55**	**0.79**	**0.46**	**0.56**	**0.59**	**1.92**

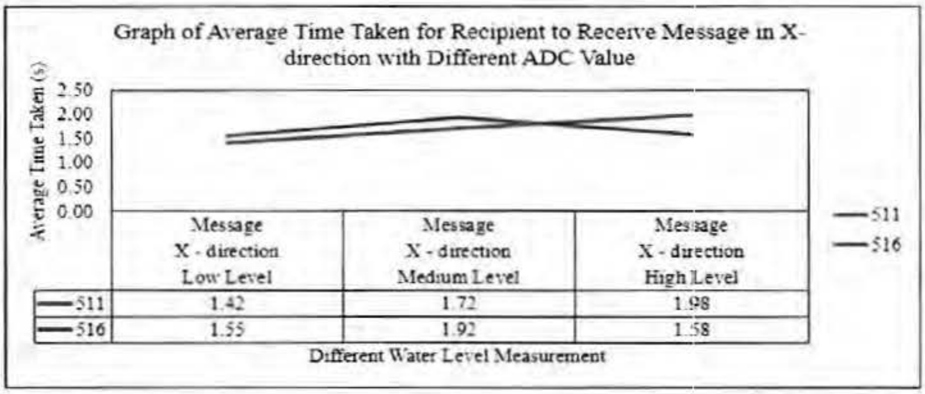


Figure 4.5: Average time taken for recipient to receive message in X-direction with different ADC value.

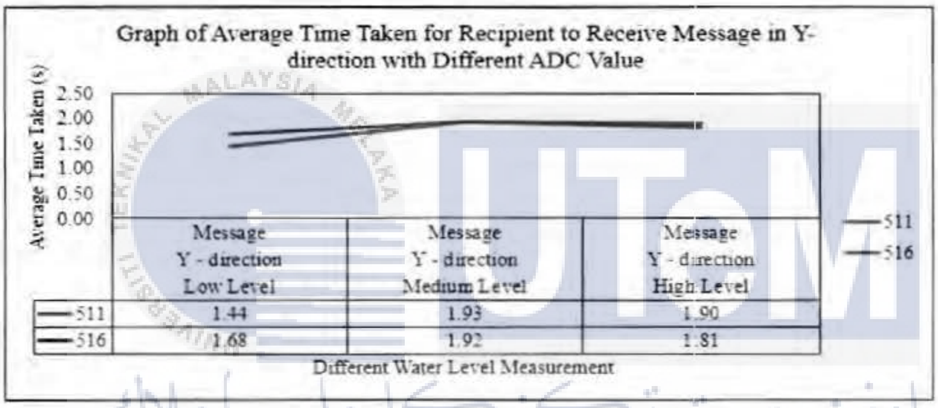


Figure 4.6: Average time taken for recipient to receive message in Y-direction with different ADC value.

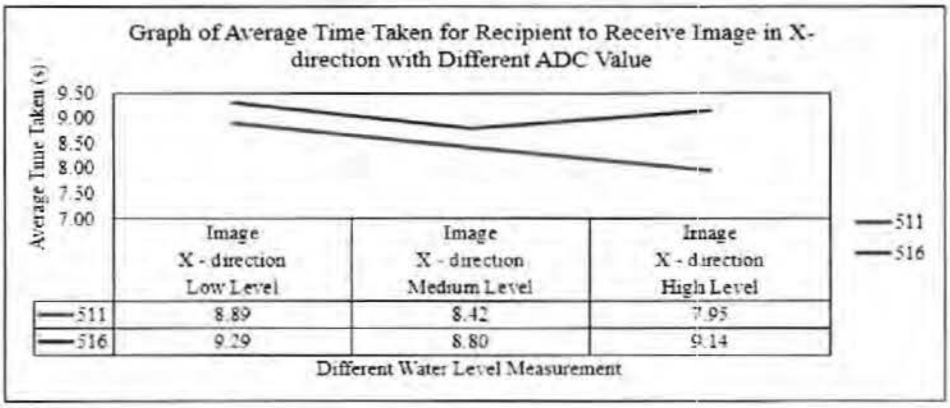


Figure 4.7: Average time taken for recipient to receive image in X-direction with different ADC value.

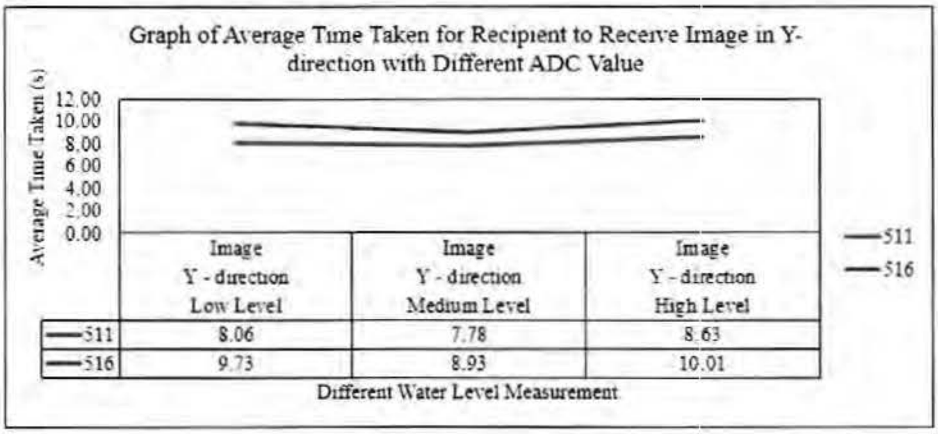


Figure 4.8: Average time taken for recipient to receive image in Y-direction with different ADC value.

Table 4.6 and Table 4.7 show time taken for recipient to receive message and image at 511 and 516 ADC value which are 3.5 and 5.4 Richter scale respectively for 10 trials at indoor test. The entire system is placed near to the mobile phone of the recipient and the system is using Unifi internet plan in order to send and receive the message and image. The average time taken and standard deviation are calculated by using the formula stated in the procedures of Experiment 6.

From Figure 4.5, the average time taken for recipient to receive message at 3.5 Richter scale increased steadily from low level to high level which is from 1.42 seconds to 1.72 seconds and to 1.98 seconds while the average time taken for recipient to receive message at 5.4 Richter scale is 1.55 seconds at low level, then increased to 1.92 seconds at medium level, and decreased to 1.58 seconds at high level, where the shaking test was conducted in X-direction.

From Figure 4.6, when the shaking test was conducted in Y-direction, the average time taken for receiving message increased significantly from 1.44 seconds at low level to 1.93 seconds at medium level and decreased insignificantly to 1.90 seconds at high level for 3.5 Richter scale while the average time taken for 5.4 Richter scale is 1.68 seconds at low level, then increased significantly to 1.92 seconds at medium level, and decreased steadily to 1.81 seconds at high level.

From Figure 4.7, the average time taken for the recipient to receive image at 3.5 Richter scale and the shaking test conducted in X-direction, the average time taken at low level is 8.89 seconds decreased to 8.42 seconds at medium level, and decreasing again to 7.95 seconds at high level. For 5.4 Richter scale, the image takes 9.29 seconds averagely to reach the recipient at low level, and then decreased to 8.80 seconds at medium level, and finally increased to 9.14 seconds at high level.

From Figure 4.8, where the shaking test was conducted in Y-direction, the average time taken for recipient to receive the image at low level is 8.06 seconds decreased gradually to 7.78 seconds at medium level, and increased back to 8.63 seconds at high level with 3.5 Richter scale. For 5.4 Richter scale, the average time taken at low level is 9.73 seconds, was decreasing to 8.93 seconds, and then increasing back to 10.01 seconds.

4.8.1 Discussion on Experiment 6

From Figure 4.5 and Figure 4.6, the average time taken for recipient to receive the message is within 1 second to 2 seconds while from Figure 4.7 and Figure 4.8, the average time taken for recipient to receive the image is within 8 to 10 seconds for both 511 ADC value (3.5 Richter scale) and 516 ADC value (5.4 Richter scale). Although the time taken for every trials show an unsteady output, however the time taken is still in the range.

At low water level measurement and in both X and Y-direction, the average time taken for recipient to receive the message at 3.5 Richter scale is shorter than the 5.4 Richter scale. However, the average time taken for recipient to receive image with 3.5 Richter scale is shorter than 5.4 Richter scale when shaking test was conducted in X-direction and vice versa.

At medium water level measurement, the average time taken for recipient to receive the message at 3.5 Richter scale is shorter than 5.4 Richter scale in X-direction and vice versa. For the average time taken for recipient to receive the image for both X and Y-direction, 3.5 Richter scale gives a faster response than 5.4 Richter scale.

At high water level measurement and for both X and Y-direction, the average time taken for recipient to receive the message at 5.4 Richter scale is shorter and faster than 3.5 Richter scale. On the other hand, the average time taken for recipient to receive image at 3.5 Richter scale gives a faster and better response than 5.4 Richter scale.

Besides that, from the Table 4.6, the biggest standard deviation is 1.13 seconds where the shaking test was conducted in X-direction and medium water level measurement, and the mean value is 1.72 seconds, which means that the message will be received by the recipient in the range of 0.59 seconds and 2.85 seconds. From Table 4.7, the biggest standard deviation is located at high water level measurement and the shaking test conducted in Y-direction, which is 1.92 seconds, and the mean value is 10.01 seconds, which means that the image will be received by the recipient in the range of 8.09 seconds and 11.93 seconds. From both Table 4.6 and Table 4.7, all of the values of standard deviation shows a very small deviation, which is not more than 2 seconds, and the time taken are not more than 15 seconds after deviation, therefore the results are precise and the system works fully based on the processing of the controller.

Since the time taken for every trials for both 3.5 and 5.4 Richter scale are not more than 15 seconds, and the highest time taken also only 14.9 seconds, therefore the Disaster Alert System is working efficiently compared to previous research which is more than 20 seconds of message reception. Hence, it can be concluded that different water level measurement and different threshold value do not affect the time for delivering the message and image. The Disaster Alert System works perfectly in any timing, any water level measurement and any Richter scale as threshold value. The biggest factor that affects the efficiency or the time of delivering and receiving the message and image is the speed of internet. The weaker the speed of internet connection, the slower the time to send and receive the alert message and image.

4.9 Results of Experiment 7

4.9.1 Result between FKE and FKEKK

Figure 4.9: Recipient receives message and image at FKEKK.

Table 4.8: Time taken for recipient to receive message and image at 3.5 Richter scale at outdoor test between FKE and FKEKK.

Number of Trials	Time Taken for Recipient to Receive Message and Image at 511 ADC Value between FKE and FKEKK (s)											
	Low Level				Medium Level				High Level			
	X - direction		Y - direction		X - direction		Y - direction		X - direction		Y - direction	
	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image
1	1.7	13.0	2.5	10.6	1.2	11.0	2.0	11.5	2.4	12.6	2.1	10.4
2	1.2	11.2	1.0	9.9	1.8	12.3	1.3	10.7	1.1	9.9	1.5	10.1
3	3.0	10.8	1.3	9.7	1.0	10.0	1.5	10.1	1.5	11.0	1.2	9.5
4	1.3	11.2	0.9	11.3	1.1	11.0	1.1	11.0	1.9	11.4	1.3	10.7
5	2.6	8.3	1.1	11.9	1.1	10.3	1.4	10.7	1.3	11.0	1.0	9.5
6	1.7	9.4	1.0	9.7	1.7	10.4	1.3	11.8	1.2	11.5	0.7	11.0
7	1.8	14.9	1.2	9.1	1.2	10.3	1.4	10.3	0.9	13.6	0.9	9.9
8	1.4	10.6	1.0	10.3	1.0	10.5	1.1	10.0	1.0	9.8	1.1	11.2
9	1.3	11.3	1.3	9.2	1.4	10.8	1.7	10.2	1.8	11.6	1.7	11.0
10	1.0	15.0	1.0	10.5	1.1	12.5	1.0	9.7	1.4	11.3	2.0	11.8
Average	**1.70**	**11.57**	**1.23**	**10.22**	**1.26**	**10.91**	**1.38**	**10.60**	**1.45**	**11.37**	**1.35**	**10.51**
Standard Deviation	**0.64**	**2.16**	**0.47**	**0.89**	**0.28**	**0.85**	**0.30**	**0.67**	**0.46**	**1.13**	**0.47**	**0.76**

Table 4.9: Time taken for recipient to receive message and image at 5.4 Richter scale at outdoor test between FKE and FKEKK.

Number of Trials	Time Taken for Recipient to Receive Message and Image at 516 ADC Value between FKE and FKEKK (s)											
	Low Level				Medium Level				High Level			
	X - direction		Y - direction		X - direction		Y - direction		X - direction		Y - direction	
	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image
1	1.0	9.1	1.1	12.1	2.1	18.5	1.0	11.9	2.0	13.7	1.8	10.4
2	1.7	9.6	1.0	11.0	0.8	11.0	1.5	11.3	1.3	10.7	1.1	11.9
3	1.5	10.7	0.9	10.5	0.9	9.5	1.1	11.2	1.1	12.3	1.0	11.2
4	0.7	10.0	1.0	11.5	1.2	9.4	1.2	15.1	1.5	13.6	1.2	10.7
5	0.9	9.9	1.2	10.4	1.3	10.1	0.9	11.3	1.8	11.4	1.5	11.6
6	1.0	10.8	1.5	10.0	1.0	9.6	1.0	11.1	1.0	10.6	1.3	11.0
7	1.2	10.5	1.3	10.6	1.2	10.4	1.2	13.2	0.9	10.3	0.9	12.2
8	1.1	11.4	0.8	10.5	1.1	11.0	1.1	11.6	1.7	12.2	1.1	10.5
9	1.3	10.4	1.1	11.5	0.7	10.5	1.1	13.7	1.2	10.4	1.7	13.6
10	1.0	11.1	1.0	11.8	0.9	11.2	0.8	11.6	1.4	10.3	1.2	11.6
Average	**1.14**	**10.35**	**1.09**	**10.99**	**1.12**	**11.12**	**1.09**	**12.20**	**1.39**	**11.55**	**1.28**	**11.47**
Standard Deviation	**0.30**	**0.70**	**0.20**	**0.70**	**0.39**	**2.67**	**0.19**	**1.35**	**0.36**	**1.33**	**0.30**	**0.96**

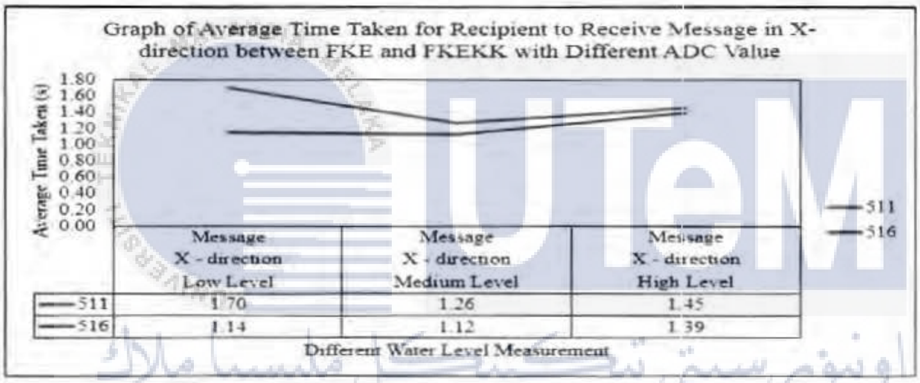


Figure 4.10: Average time taken for recipient to receive message in X-direction between FKE and FKEKK with different ADC value.

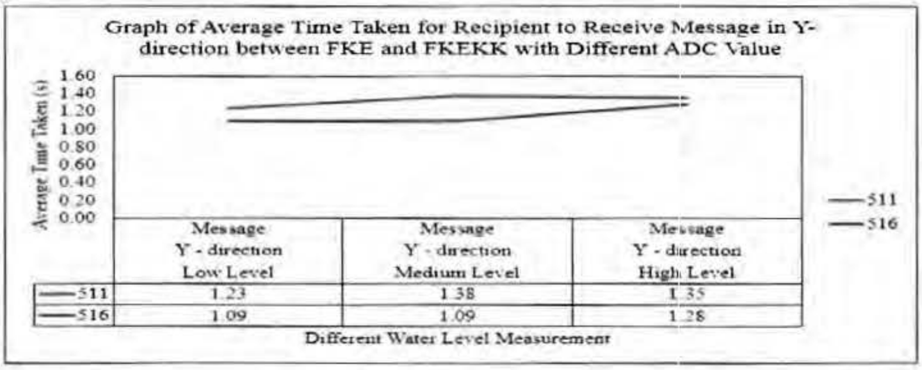


Figure 4.11: Average time taken for recipient to receive message in Y-direction between FKE and FKEKK with different ADC value.

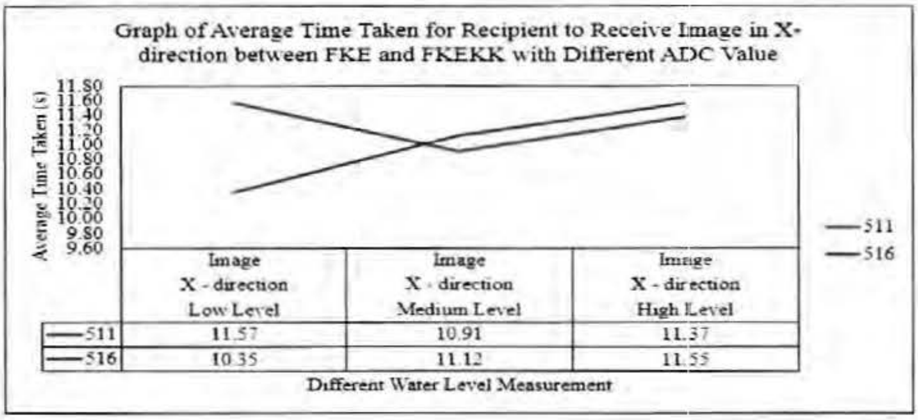


Figure 4.12: Average time taken for recipient to receive image in X-direction between FKE and FKEKK with different ADC value.

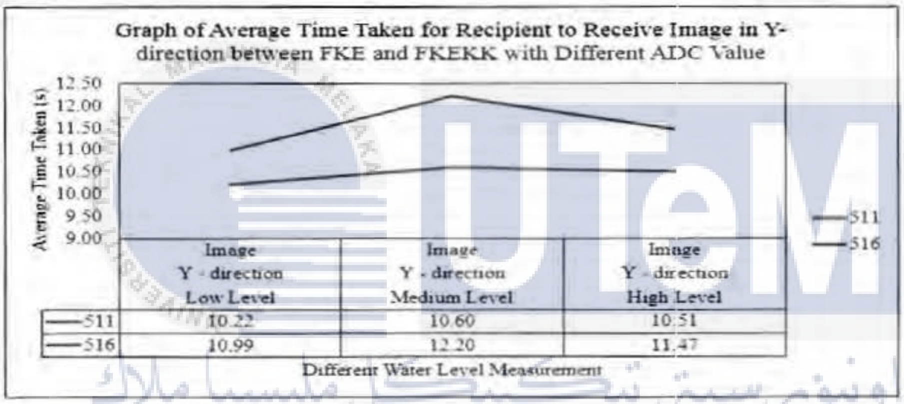


Figure 4.13: Average time taken for recipient to receive image in Y-direction between FKE and FKEKK with different ADC value.

Table 4.8 and Table 4.9 show time taken for recipient to receive message and image at 511 and 516 ADC value which are 3.5 and 5.4 magnitude scale respectively for 10 trials at outdoor test, where the distance is between FKE and FKEKK. The sensing system is placed at FKE while the recipient is located at FKEKK as shown in Figure 4.9. The system is using Digi data plan to send and receive the message and image as the Wi-Fi connection in UTeM is unable to connect to the Raspberry Pi. The average time taken and the standard deviation are calculated by using the formula stated in procedures of Experiment 7.

From Figure 4.10, when the shaking test was conducted in X-direction, the average time taken for recipient to receive message decreased steadily from low level to medium level, which is from 1.70 seconds to 1.26 seconds, and increased to 1.45 seconds at high level with 3.5 Richter scale whereas the average time taken for recipient to receive message with 5.4 Richter scale at low level is 1.14 seconds, decreased to 1.12 seconds at medium level, and then increased to 1.39 seconds at high level.

From Figure 4.11, where the shaking test was conducted in Y-direction, the average time taken for receiving the message increased insignificantly from low level to medium level, which is from 1.23 seconds to 1.38 seconds, and decreased insignificantly to 1.35 seconds at high level with 3.5 Richter scale while the average time taken with 5.4 Richter scale at low level and medium level are the same which is 1.09 seconds, and then increased steadily to 1.39 seconds at high level.

From Figure 4.12, for the recipient to receive image at 3.5 Richter scale and when the shaking test was conducted in X-direction, the average time taken at low level is 11.57 seconds decreased to 10.91 seconds at medium level, and increased to 11.37 seconds at high level. For 5.4 Richter scale, the average time taken for recipient to receive image takes 10.35 seconds to reach the recipient at low level, and increased to 11.12 seconds at medium level, and then increased again to 11.55 seconds at high level.

From Figure 4.13, where the container is shaking in Y-direction, the average time taken to receive image at low level is 10.22 seconds increased insignificantly to 10.60 seconds at medium level, and decreased to 10.51 seconds at high level with 3.5 Richter scale while for 5.4 Richter scale, the average time taken for receiving the image at low level is 10.99 seconds, increased to 12.20 seconds at medium level, and decreased to 11.47 seconds at high level.

4.9.2 Result between FKE and FKM

Figure 4.14: Recipient receives message and image at FKM.

Table 4.10: Time taken for recipient to receive message and image at 3.5 Richter scale at outdoor test between FKE and FKM.

Number of Trials	Time Taken for Recipient to Receive Message and Image at 511 ADC Value between FKE and FKM (s)											
	Low Level				Medium Level				High Level			
	X - direction		Y - direction		X - direction		Y - direction		X - direction		Y - direction	
	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image
1	1.2	11.3	1.4	13.0	1.8	12.6	1.2	12.0	2.8	14.5	1.5	11.3
2	1.8	11.8	1.0	11.9	1.0	12.7	1.0	10.8	1.5	12.4	2.1	10.8
3	1.1	11.4	1.7	10.4	1.0	12.9	0.7	12.2	2.1	11.3	1.0	10.9
4	1.4	10.5	0.8	12.0	0.9	13.2	1.0	11.2	1.4	10.5	1.4	11.2
5	1.5	12.0	1.3	10.3	1.1	11.5	1.1	12.0	1.3	11.0	1.1	11.5
6	1.6	11.5	1.1	11.4	0.8	11.1	1.6	12.7	1.0	10.0	1.8	11.0
7	1.2	14.0	1.5	11.8	0.9	12.9	1.3	11.3	1.4	12.2	1.2	11.3
8	1.1	10.9	1.0	11.2	1.2	11.6	1.4	12.7	1.9	10.7	1.2	12.1
9	0.8	13.4	1.0	12.3	1.1	11.2	1.0	11.2	1.1	10.8	1.6	10.8
10	1.2	11.4	1.1	11.3	1.5	11.8	1.2	12.0	1.5	11.3	1.5	10.4
Average	**1.29**	**11.82**	**1.19**	**11.56**	**1.13**	**12.15**	**1.15**	**11.81**	**1.60**	**11.47**	**1.44**	**11.13**
Standard Deviation	**0.29**	**1.09**	**0.28**	**0.83**	**0.31**	**0.79**	**0.25**	**0.66**	**0.54**	**1.29**	**0.34**	**0.47**

Table 4.11: Time taken for recipient to receive message and image at 5.4 Richter scale at outdoor test between FKE and FKM.

Number of Trials	Time Taken for Recipient to Receive Message and Image at 516 ADC Value between FKE and FKM (s)											
	Low Level				Medium Level				High Level			
	X - direction		Y - direction		X - direction		Y - direction		X - direction		Y - direction	
	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image	Message	Image
1	1.1	12.8	2.2	11.2	0.9	14.2	1.3	12.1	2.3	12.4	1.7	12.4
2	1.9	10.8	1.7	12.8	1.2	14.0	1.0	10.9	1.5	14.5	1.1	12.5
3	1.3	12.0	1.1	11.4	0.9	12.1	1.2	11.2	1.9	14.0	1.3	11.5
4	0.9	12.6	1.3	10.0	0.8	11.0	1.0	11.7	1.3	11.2	1.0	10.3
5	1.2	11.2	1.4	12.8	1.0	12.2	0.9	12.0	1.1	13.7	1.1	10.8
6	1.1	11.8	1.8	12.3	1.3	11.6	1.5	12.9	1.1	11.6	0.9	10.0
7	2.1	10.2	0.9	10.9	1.1	10.8	1.1	11.9	0.9	12.4	0.9	10.8
8	1.5	12.3	1.0	11.0	1.1	10.7	1.8	11.7	1.7	11.0	1.5	11.0
9	1.0	11.9	1.3	12.1	1.0	11.5	1.3	11.9	1.4	11.8	1.1	10.9
10	1.3	12.7	1.5	11.5	1.4	12.1	1.0	11.6	1.2	10.6	1.3	14.1
Average	**1.34**	**11.83**	**1.42**	**11.60**	**1.07**	**12.02**	**1.21**	**11.79**	**1.44**	**12.32**	**1.19**	**11.43**
Standard Deviation	**0.39**	**0.86**	**0.40**	**0.90**	**0.19**	**1.22**	**0.28**	**0.54**	**0.42**	**1.34**	**0.26**	**1.24**

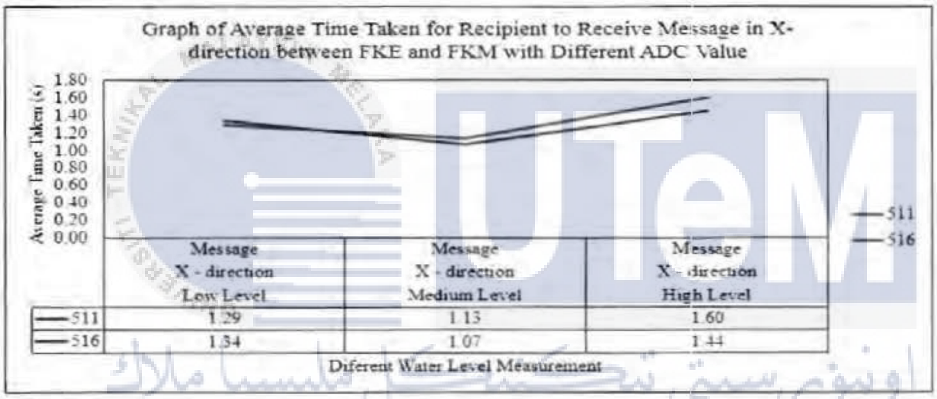


Figure 4.15: Average time taken for recipient to receive message in X-direction between FKE and FKM with different ADC value.

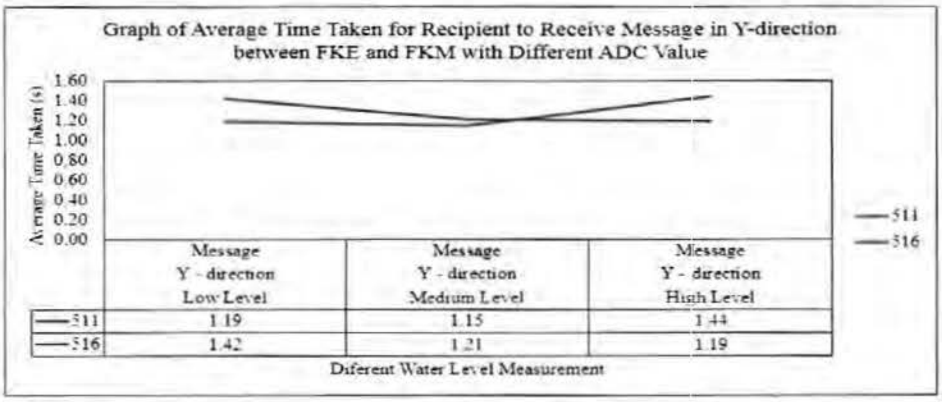


Figure 4.16: Average time taken for recipient to receive message in Y-direction between FKE and FKM with different ADC value.

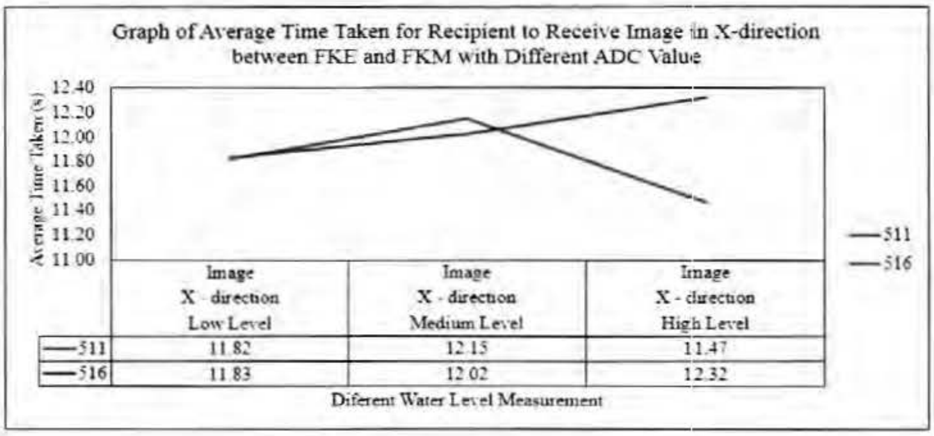


Figure 4.17: Average time taken for recipient to receive image in X-direction between FKE and FKM with different ADC value.

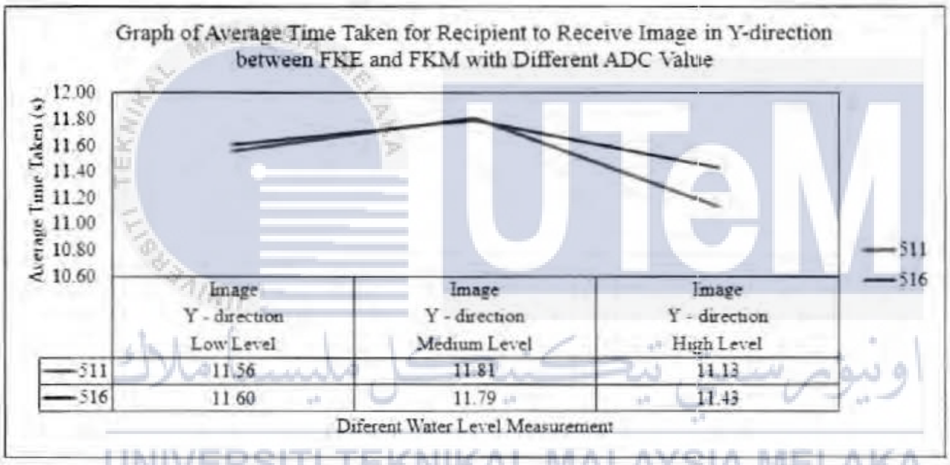


Figure 4.18: Average time taken for recipient to receive image in Y-direction between FKE and FKM with different ADC value.

Table 4.10 and Table 4.11 show time taken for recipient to receive message and image at 3.5 and 5.4 Rochter scale respectively for 10 trials at outdoor test, where the distance is between FKE and FKM. The sensing system is placed at FKE while the recipient is located at FKM as shown in Figure 4.14. The internet plan used is the same as the one used for testing the distance between FKE and FKEKK which is Digi data plan. The average time taken and standard deviation are also calculated.

From Figure 4.15, for 3.5 Richter scale, the average time taken for recipient to receive the message decreased steadily from low level to medium level, which is from 1.29 seconds to 1.13 seconds, and then increased to 1.60 seconds at high level when the shaking test conducted in X-direction while the average time taken for recipient to receive message at 5.4 Richter scale is 1.34 seconds at low level, then decreased to 1.07 seconds at medium level and increased to 1.44 seconds at high level.

From Figure 4.16, when the shaking test was conducted in Y-direction, the average time taken for receiving the message decreased insignificantly from low level to medium level, which is from 1.19 seconds to 1.15 seconds, and increased to 1.44 seconds at high level with 3.5 Richter scale whereas the average time taken for receiving the message for 5.4 Richter scale at low level is 1.42 seconds, then decreased to 1.21 seconds at medium level, and decreased again to 1.19 seconds at high level.

From Figure 4.17, for the recipient to receive image where the shaking test was conducted in X-direction and 3.5 Richter scale, the average time taken at low level is 11.82 seconds, then increased to 12.15 seconds at medium level, and then decreased to 11.47 seconds at high level. On the other hand, which is 5.4 Richter scale, the average time taken for recipient to receive image at low level is 11.83 seconds, then increased to 12.02 seconds at medium level, and then increased again to 12.32 seconds at high level.

From Figure 4.18, where the shaking test was conducted in Y-direction, the average time taken to receive image at low level is 11.56 seconds increased gradually to 11.81 seconds at medium level, and then decreased to 11.13 seconds at high level with 3.5 Richter scale whereas the average time taken to receive the image with 5.4 Richter scale is 11.60 seconds at low level, then increased to 11.79 seconds at medium level, and then decreased to 11.43 seconds at high level.

4.9.3 Discussion on Experiment 7

From Figure 4.10 and Figure 4.11, the overall average time taken for the recipient to receive the message is within 1 to 2 seconds when the experiment was conducted between FKE and FKEKK, and the results is also similar for the experiment conducted between FKE and FKM as shown in Figure 4.15 and Figure 4.16. These two results show a similarity with the experiment done at indoor environment. Hence, the system is well functioning and it gave a faster response of sending the message to the recipient.

From Figure 4.12 and Figure 4.13, the overall average time taken for the recipient to receive the image is within 10 to 13 seconds when the experiment was conducted between FKE and FKEKK, whereas the average time taken for the recipient to receive the image between FKE and FKM is within 11 to 13 seconds as shown in Figure 4.17 and Figure 4.18. These two results also indicated that this Disaster Alert System works efficiently compared to previous research, where the recipient took more than 20 seconds to receive the alert message.

Since the result at indoor shows that the time taken for receiving message and image were not affected by different threshold value and different water level measurement, hence the overall results taken at outdoor also shows that distance is not a factor affecting the time taken for the recipient to receive alert message and image. For instances, the average time taken for recipient to receive the message at low water level measurement, 3.5 Richter scale, and shaking test conducted in X-direction between FKEKK and FKM is 1.70 seconds and 1.29 seconds respectively. FKM receives 0.41 seconds faster than FKEKK while FKEKK is 210 meter away from the sensing system (FKE) whereas FKM is 6.45 kilometre away from the sensing system (FKE), where FKM is 6.24 kilometre away from FKEKK. Hence, it shows that the distance does not affect the time for delivering and receiving the alert message and image. This can be related to the real earthquake situation, where the people that are further away from epicentre will also receive the alert message and image same as the people that near to the epicentre when earthquake is happening.

Moreover, from Table 4.8, where the experiment was conducted between FKE and FKEKK, the time taken for the recipient to receive the image at low water level measurement and shaking test in X-direction with 511 ADC value shows the biggest standard deviation which is 2.16 seconds and the mean value is 11.57 seconds, which means that the image will be received by the recipient in the range of 9.41 to 13.73 seconds. From Table 4.9, it shows that the biggest standard deviation is 2.67 seconds and the mean value is 11.12 seconds, which falls in the medium water level measurement and shaking test in X-direction with 5.4 Richter scale. This means that the recipient will receive the image in the range of 8.45 to 13.79 seconds. Both results show that the system is well-functioning. Even though it has biggest deviation value, it still falls in the range mentioned.

Furthermore, the biggest standard deviation values for both Table 4.10 and Table 4.11 fall in the same conditions, which are high water level measurement and shaking test in X-direction between FKE and FKM for both 511 and 516 ADC values, where the values are 1.29 seconds and 1.34 seconds respectively and the mean values are 11.47 seconds and 12.32 seconds respectively. This means that the recipient will receive the image in the range of 10.18 to 12.76 seconds for 3.5 Richter scale whereas in the range of 10.98 to 13.66 seconds for 5.4 Richter scale. Both results also show that the system is well-performing. Even though it has biggest deviation value, it still falls in the range mentioned.

Hence, it can be concluded that the Disaster Alert System is not affected by distance, different water level measurement and different threshold value. The system worked efficiently since the time taken for receiving the message and image for every trials is less than 15 seconds, which improved about 5 seconds from that previous research.

4.10 Results of Experiment 8

Table 4.12: Reliability test for 3.5 Richter scale with different water level at indoor test.

No. of Trials	3.5 Richter scale (511 ADC value)											
	Low Level				Medium Level				High Level			
	X-direction		Y-direction		X-direction		Y-direction		X-direction		Y-direction	
	Msg	Img	Msg	Img	Msg	Img	Msg	Img	Msg	Img	Msg	Img
1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1

1 = Sent; 0 = Was not sent

Table 4.13: Reliability test for 5.4 Richter scale with different water level at indoor test.

No. of Trials	**5.4 Richter scale (516 ADC Value)**											
	Low Level				**Medium Level**				**High Level**			
	X-direction		**Y-direction**		**X-direction**		**Y-direction**		**X-direction**		**Y-direction**	
	Msg	**Img**	**Msg**	**Img**	**Msg**	**Img**	**Msg**	**Img**	**Msg**	**Img**	**Msg**	**Img**
1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1

1 = Sent; 0 = Was not sent

4.10.1 Discussion on Experiment 8

From Table 4.12 and Table 4.13, it can be clearly seen that this Disaster Alert System shows 100 percent reliable for 3.5 and 5.4 Richter scale at indoor test. The system is functioning everytime the threshold value and the water level are surpassed. It was not affected by any other factor such as distance in a house or lab since the internet connection is worked perfectly in the coverage area. This system could save a lot of lives that stay at indoor by alerting them about the potential of earthquake and flood through the alert message and image at the very first time. Hence, earlier precautions cab be taken and this could prevent the situation from being chaos.

4.11 Results of Experiment 9

Table 4.14: Reliability test for 3.5 Richter scale with different water level at outdoor test.

No. of Trials	**3.5 Richter scale (511 ADC Value) between FKE and FKEKK, FKM**											
	Low Level				**Medium Level**				**High Level**			
	X-direction		**Y-direction**		**X-direction**		**Y-direction**		**X-direction**		**Y-direction**	
	Msg	**Img**	**Msg**	**Img**	**Msg**	**Img**	**Msg**	**Img**	**Msg**	**Img**	**Msg**	**Img**
1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	0	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1

1 = Sent; 0 = Was not sent

Table 4.15: Reliability test for 5.4 Richter scale with different water level at outdoor test.

No. of Trials	**5.4 Richter scale (516 ADC Value) between FKE and FKEKK, FKM**											
	Low Level				**Medium Level**				**High Level**			
	X-direction		**Y-direction**		**X-direction**		**Y-direction**		**X-direction**		**Y-direction**	
	Msg	**Img**	**Msg**	**Img**	**Msg**	**Img**	**Msg**	**Img**	**Msg**	**Img**	**Msg**	**Img**
1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	0
7	1	1	1	1	1	0	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1

1 = Sent; 0 = Was not sent

4.11.1 Discussion on Experiment 9

From Table 4.14, it shows that the system is only 99.2 percent reliable for 3.5 Richter scale and from Table 4.15, it shows that the system is only 98.3 percent reliable for 5.4 Richter scale at outdoor test. The system is not working perfectly everytime the water level and threshold value are surpass. Since the system used internet as communication medium, hence the internet connection for some mediums are not stable occasionally. Although the system is not affected by the distance, but the system is affected by the internet connection. If the internet is disconnected either happened in the sender or receiver, this will affect the time of sending and receiving the alert message and image. However, as long as the internet is available and well-functioning, then the system is working perfectly no matter in what conditions. This could help to reduce the loss of lives and damage on property.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In a nutshell, all of the objectives have been achieved throughout this project. First of all, ultrasonic sensor is chosen to detect the water level due to its accuracy and fast response than infrared sensor. Next, previous studied shown that accelerometer and Raspberry Pi were more suitable in this project compared to Arduino vibration sensor and Arduino respectively. Therefore, the accelerometer is combined with ultrasonic sensor in order to test the functionality of detecting flood and earthquake simultaneously, and the Raspberry Pi is chosen as a controller in this project. The result shows the integration of both sensors is well-functioned.

Since smartphones are highly demanded nowadays, and a lot of free applications are available to let the user to communicate with others or receive important news from others, hence Telegram application is chosen for this project due to its free of charge, faster than any other messenger, and most importantly it opens an API and protocol free for everyone. The Bot API allows people to easily create programs that use Telegram messages for an interface, such as in this project. By using smartphone application, a better, smarter, and efficient way to alert people are more suitable for this Disaster Alert System. At first, a Telegram application is successfully installed in a mobile phone and a bot is created. The process of echoing messages show that the sending and receiving of message is worked. Next, a picture with a better resolution, which is 640x480 is successfully to capture by using USB camera and save in JPED format. Furthermore, a combination of sending message and image automatically from the controller is the most essential part in this Disaster Alert System. This process took quite a long time in the coding part before start the sending process. However, the process of sending and receiving message and image automatically is successfully functioned after finished typing program code. This Disaster Alert System uses embedded system of Raspberry Pi as a life saver, which is capable of sending free message and image to notify the users when there are happening earthquake and flood.

Furthermore, a simple and budget Disaster Alert System is completely developed by interfacing the sensor part and messaging part. Experiment 6 to Experiment 9 are conducted in order to test for its efficiency and reliability at different conditions and situations. The system is tested with different water level measurement for flood, different threshold value as magnitude scale for earthquake, different direction of shaking the container, and different places with different distances. After testing the system at different conditions and situations, the results show that the system works efficiently when compared to previous research. The time taken for recipient to receive message and image is less than 15 seconds, which is 5 seconds shorter than previous research. Besides that, the system is working 100 percent reliable at indoor environment. However, the system does not work perfectly for outdoor test due to the speed and availability of the internet connection. This shows that the system is not affected by any other factors, but only affected by the internet speed.

In spite of that, the system still well-functioned where the sensors, controller and medium used are all in real time. The message and image were delivered and displayed within few seconds when the earthquake and flood disaster strike. The message and image received may help to alert people and this could reduce the number of casualties and property damage, since the people will not get panic and know what the next precaution steps in this chaos situation are. Hence, this Disaster Alert System can be a better warning system.

5.2 Recommendation

In order to improve this Disaster Alert System, a better and flexible sensor, such as water level sensor is recommended to use for detecting the flood instead of ultrasonic sensor even though it is expensive. Besides that, flood sensor can also be used to replace the ultrasonic sensor due to its availability to detect moisture levels and also monitor the temperature.

Moreover, the system is recommended to add a GPS modem in order to send the alert message and image with the exact location of earthquake and flood happen in the case of many sensors are install at other different places. Hence, calculation on the time for the earthquake and flood to reach the recipient area can be done. This may help the recipients to take safety measurement as soon as possible.

Furthermore, the system is also recommended to further develop by detecting various type of disaster through different type of sensors. For instances, by adding a gas sensor at potential wildfire places could help to detect the presence of fire. Besides that, an Ultrasonic Thru-Beam Sensor can also be used to detect haze. Since Raspberry Pi has a higher processor, therefore it is able to solve various disaster effect and real time messaging system can be develop.

Last but not least, it is recommended that the calculation of time taken for receiving alert message and image should be done automatically by typing formula in program code instead of calculating manually. This may increase the accuracy and efficiency of time taken.

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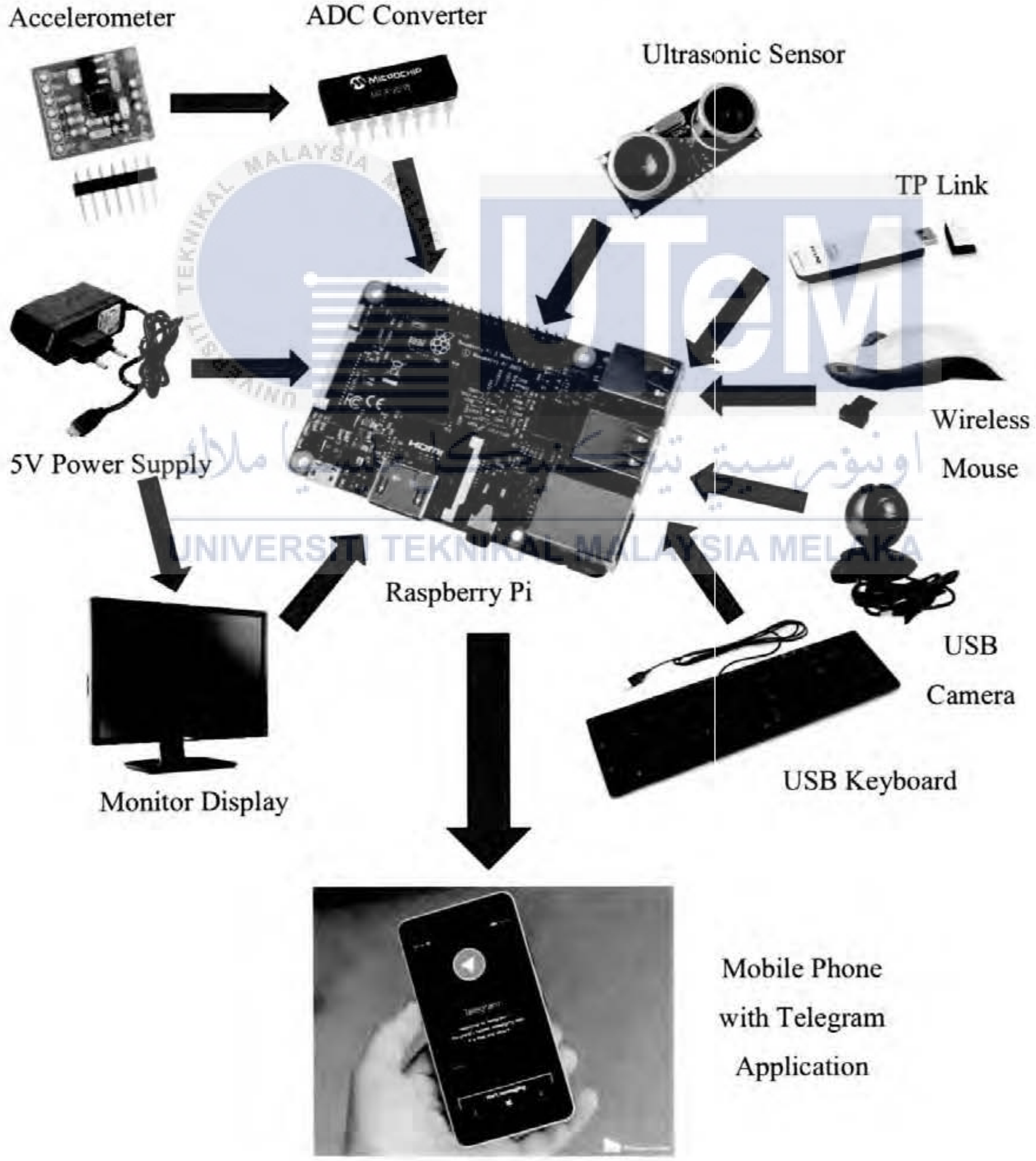
APPENDICES

APPENDICES A: Overall Circuit Diagram



APPENDICES B: Gantt Chart for Final Year Project 1

Project Activity	**Sept-16**				**Oct-16**				**Nov-16**				**Dec-16**			
FYP 1	**Weeks**															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Title Discussion and Selection	■	■	■													
Journal Finding and Literature Review		■	■	■	■	■	■	■	■	■	■	■				
Set the Objectives and Scope				■	■	■										
Selection of Components						■	■	■								
Experiments Design and Procedures								■	■	■	■	■				
Preliminary Result and Discussion										■	■	■	■			
First Draft of Report Compiling											■	■	■	■		
Submission of First Draft Report														■		
FYP 1 Presentation															■	
Submission of Final FYP 1 Report													■	■	■	■

APPENDICES C: Gantt Chart for Final Year Project 2

Project Activity	Feb-17				Mar-17				Apr-17				May & June-17			
	Weeks															
FYP 2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Hardware and Software Development	■	■	■	■	■	■	■	■	■							
1. Sensors connect with Raspberry Pi	■	■	■													
2. Coding for sensors used			■	■	■											
3. Coding for sending message and image through Telegram				■	■	■	■									
4. Interface sensors with Telegram coding						■	■	■								
5. Coding for Raspberry Pi to send and receive message							■	■	■							
System Implementation and Interface				■	■	■	■	■	■							
System Testing and Data Collection									■	■	■	■				
1. Efficiency Test										■	■					
2. Reliability Test											■	■				
Final Draft of Report Compiling									■	■	■	■	■	■		
Submission of Final Draft Report														■		
FYP 2 Presentation															■	
Submission of Final FYP 2 Report													■	■	■	■

APPENDICES D: Calculation of Gravitational Force. R_x for Different Acceleration

1. For 0.01m/s^2 (3.5 magnitude scale)

$$R_x = \frac{1g * 0.01\ \left(\frac{m}{s^2}\right)}{9.81\ \left(\frac{m}{s^2}\right)}$$

$$= 0.00102g$$

2. For 0.025m/s^2 (4.2 magnitude scale)

$$R_x = \frac{1g * 0.025\ \left(\frac{m}{s^2}\right)}{9.81\ \left(\frac{m}{s^2}\right)}$$

$$= 0.00259g$$

3. For 0.25m/s^2 (4.8 magnitude scale)

$$R_x = \frac{1g * 0.25\ \left(\frac{m}{s^2}\right)}{9.81\ \left(\frac{m}{s^2}\right)}$$

$$= 0.0259g$$

4. For 0.5m/s^2 (5.4 magnitude scale)

$$R_x = \frac{1g * 0.5\ \left(\frac{m}{s^2}\right)}{9.81\ \left(\frac{m}{s^2}\right)}$$

$$= 0.05097g$$

5. For 1.5m/s^2 (6.0 magnitude scale)

$$R_x = \frac{1g * 1.5\ \left(\frac{m}{s^2}\right)}{9.81\ \left(\frac{m}{s^2}\right)}$$

$$= 0.15291g$$

APPENDICES E: Calculation of Threshold Value (ADC Value) for Different Gravitational Force

1. For 0.00102g (0.01m/s^2, 3.5 magnitude scale)

$$adc = \frac{[(R_x \; x \; Sensitivity) + V_{0g}] \; x \; 1023}{V_{ref}}$$

$$= \frac{[(0.00102 \; x \; 0.33) + 1.65] x \; 1023}{3.3}$$

$$= 511.6$$

2. For 0.00259g (0.025m/s^2, 4.2 magnitude scale)

$$adc = \frac{[(R_x \; x \; Sensitivity) + V_{0g}] \; x \; 1023}{V_{ref}}$$

$$= \frac{[(0.0259 \; x \; 0.33) + 1.65] x \; 1023}{3.3}$$

$$= 511.76$$

3. For 0.0259g (0.25m/s^2, 4.8 magnitude scale)

$$adc = \frac{[(R_x \; x \; Sensitivity) + V_{0g}] \; x \; 1023}{V_{ref}}$$

$$= \frac{[(0.0259 \; x \; 0.33) + 1.65] x \; 1023}{3.3}$$

$$= 514.11$$

4. For 0.g (0.05097m/s^2, 5.4 magnitude scale)

$$adc = \frac{[(R_x \; x \; Sensitivity) + V_{0g}] \; x \; 1023}{V_{ref}}$$

$$= \frac{[(0.05097 \; x \; 0.33) + 1.65] x \; 1023}{3.3}$$

$$= 516.11$$

5. For 0.15291g (0.01m/s^2, 6.0 magnitude scale)

$$adc = \frac{[(R_x \; x \; Sensitivity) + V_{0g}] \; x \; 1023}{V_{ref}}$$

$$= \frac{[(0.15291 \; x \; 0.33) + 1.65] x \; 1023}{3.3}$$

$$= 527.14$$

APPENDICES F: Coding for Detecting Level of Water by Using Ultrasonic Sensor and Infrared Sensor

```
#!/usr/bin/python
import spidev
import time
import os
import math
import RPi.GPIO as GPIO

# Open SPI bus
spi = spidev.SpiDev()
spi.open(0,0)

# Function to read SPI data from MCP3008 chip
# Channel must be an integer 0-7
def ReadChannel(channel):
        adc = spi.xfer2([1,(8+channel)<<4,0])
        data = ((adc[1]&3) << 8) + adc[2]
        return data

# Function to convert data to voltage level,
# rounded to specified number of decimal places.
def ConvertVolts(data,places):
        volts = (data * 3.3) / float(1024)
        volts = round(volts,places)
        return volts

# Function to convert voltage level to distance
def ConvertDistance1(volts,places):
        distance1 = (27.86* math.pow(volts, -1.15))-9
        distance1 = round(distance1,places)
        return distance1
```

```
while GPIO.input(ECHO)==1:
        pulse_end = time.time()

pulse_duration = pulse_end - pulse_start
distance= pulse_duration * 17150
distance = round(distance, 1)

#Read ir sensor data
ir_level = ReadChannel(ir_channel)
ir_volts = ConvertVolts(ir_level,2)
ir_distance1 = ConvertDistance1(ir_volts,2)
distance1 = round(ir_distance1,1)

#print out results
print ("US_Distance:"), distance, ("cm")
print ("IR_Distance:"), distance1, ("cm")

if distance <=10:
        print ("LED High Level on")
        GPIO.output(17,GPIO.HIGH)
else:
        print ("LED off")
        GPIO.output(17,GPIO.LOW)

if distance1 <=10:
        print ("LED High Level on")
        GPIO.output(5,GPIO.HIGH)
else:
        print ("LED off")
        GPIO.output(5,GPIO.LOW)
```

```
    if 14.5 <= distance <= 15.5:
        print ("LED Medium Level on")
        GPIO.output(18,GPIO.HIGH)
    else:
        print ("LED off")
        GPIO.output(18,GPIO.LOW)

    if 14.5 <= distance1 <= 15.5:
        print ("LED Medium Level on")
        GPIO.output(6,GPIO.HIGH)
    else:
        print ("LED off")
        GPIO.output(6,GPIO.LOW)

     if 19.5 <= distance <= 20.5:
        print ("LED Low Level on")
        GPIO.output(27,GPIO.HIGH)
    else:
        print ("LED off")
        GPIO.output(27,GPIO.LOW)

    if 19.5 <= distance1 <= 20.5:
        print ("LED Low Level on")
        GPIO.output(13,GPIO.HIGH)
    else:
        print ("LED off")
        GPIO.output(13,GPIO.LOW)

GPIO.cleanup()
```

APPENDICES G: Coding for Echoing Message Only

```
import sys
import time
import random
import datetime
import telepot

def handle(msg):
        chat_id = msg['chat']['id']
        command = msg['text']
        print 'Got command: %s' % command
        print chat_id

        if command == 'Hello!':
                bot.sendMessage(chat_id, 'Hello^^')
        elif command == 'How are you?':
                bot.sendMessage(chat_id, 'I am fine!^^')
        elif command == 'What is the time now?':
                bot.sendMessage(chat_id, str(datetime.datetime.now()))
        elif command == 'Okay, thank you!':
                bot.sendMessage(chat_id, 'You are welcome!:)')
        elif command =='Goodbye!':
                bot.sendMessage(chat_id, 'Goodbye!!!')

bot = telepot.Bot('318595317:AAG5p2pyZBMO3hghT48ejAea7_plKdPoZV0')
bot.message_loop(handle)
print 'I am listening...'
while 1:
        time.sleep(10)
```

APPENDICES H: Coding for Capturing the Image by Calling another File

```
import sys
import time
import random
import datetime
import subprocess

subprocess.call('/home/pi/webcam.sh')
```

APPENDICES I: Coding for Sending Message and Image Automatically

```
import sys
import time
import random
import teleport
import subprocess

bot = teleport.Bot(‘318595317:AAG5p2pyZBM03hghT48ejAea7_plKdPoZV0’)
print ‘Initiating broadcast.’
bot.sendMessage(‘@fyptbp’, ‘Hi, testing!’)
subprocess.call(‘/home/pi/webcam.sh’)
time.sleep(1)
bot.sendPhoto(chat_id = ‘@fyptbp’, photo = open(‘/home/pi/Dekstop/image.jpg’),
caption = ‘Done!’)
```

APPENDICES J: Disaster Alert System Coding

```
#!/usr/bin/python
import spidev
import time
import os
import RPi.GPIO as GPIO
import sys
import random
import telepot
import subprocess

# Open SPI bus
spi = spidev.SpiDev()
spi.open(0,0)

#Define LEDs
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
GPIO.setup(17,GPIO.OUT)
GPIO.setup(18,GPIO.OUT)
GPIO.setup(27,GPIO.OUT)

#Define US sensor
TRIG = 23
ECHO = 24

#Function to read SPI data from MCP3008 chip
#Channel must be an integer 0-7
def ReadChannel(channel):
    adc = spi.xfer2([1,(8+channel)<<4,0])
    data = ((adc[1]&3) << 8) + adc[2]
    return data
```

```
# Function to convert data to voltage level,
# rounded to specified number of decimal places.
def ConvertVolts(data,places):
    volts = (data * 3.3) / float(1023)
    volts = round(volts,places)
    return volts

#Function to calculate acceleration
def ConvertAcc(data, places):
     Acc = (data*3.3/float(1023)-1.65)/0.33*9.81
     Acc = round(Acc,places)
     return Acc

#Function to calculate acceleration
def ConvertAcc1(data, places):
    Acc1 = (data*3.3/float(1023)-1.65)/0.33*9.81
    Acc1 = round(Acc,places)
    return Acc1

#Define sensor channels
X_channel=0
Y_channel=1

while True:

    #Read the X sensor data
    X_level = ReadChannel(X_channel)
    X_volts = ConvertVolts(X_level,2)
    Acc = ConvertAcc(X_level,2)

    #Read the Y sensor data
    Y_level = ReadChannel(Y_channel)
```

```
Y_volts = ConvertVolts(Y_level,2)
Acc1 = ConvertAcc1(Y_level,2)

#Print out results
print("------------------------------------")
print("X-direction:{}({}V){}m/s2").format(X_level, X_volts, Acc)
print("Y-direction:{}({}V){}m/s2").format(Y_level, Y_volts, Acc1)

print ("Distance Measurement In Progress")
GPIO.setup(TRIG,GPIO.OUT)
GPIO.setup(ECHO,GPIO.IN)

GPIO.output(TRIG, False)
print ("Waiting For Sensor To Settle")
time.sleep(0.5)

GPIO.output(TRIG, True)
time.sleep(0.00001)
GPIO.output(TRIG, False)

while GPIO.input(ECHO)==0:
    pulse_start = time.time()
while GPIO.input(ECHO)==1:
    pulse_end = time.time()
pulse_duration = pulse_end - pulse_start
distance = pulse_duration * 17150
distance = round(distance, 1)
print ("Distance:"), distance, ("cm")

if distance <=10 and X_level>511:
   print ("LED High Level on")
   GPIO.output(17,GPIO.HIGH)
```

```
    bot = telepot.Bot('318595317:AAG5p2pyZBMO3hghT48ejAea7_plKdPoZV0')
    print 'Initiating broadcast.'
    bot.sendMessage('@fyptbp','Earthquake is more than 3.5 magnitudes and water
    level measurement is below 10cm. Danger!!! Please evacuate now!!!')
    subprocess.call('/home/pi/webcam.sh')
    time.sleep(1)
    bot.sendPhoto(chat_id='@fyptbp', photo=open('/home/pi/Desktop/image.jpg'),
    caption='Flood condition: Water level is below 10cm!!!')

else:
    print ("LED off")
    GPIO.output(17,GPIO.LOW)

if 14.5 <= distance <= 15.5 and X_level>511:
    print ("LED Medium Level on")
    GPIO.output(18,GPIO.HIGH)
    bot = telepot.Bot('318595317:AAG5p2pyZBMO3hghT48ejAea7_plKdPoZV0')
    print 'Initiating broadcast.'
    bot.sendMessage('@fyptbp','Earthquake is more than 3.5 magnitudes and water
    level measurement is between 14.5 cm and 15.5 cm. Please evacuate quickly!!')
    subprocess.call('/home/pi/webcam.sh')
    time.sleep(1)
    bot.sendPhoto(chat_id='@fyptbp', photo=open('/home/pi/Desktop/image.jpg'),
    caption='Flood condition: Water level is between 14.5 cm and 15.5 cm!!')

else:
    print ("LED off")
    GPIO.output(18,GPIO.LOW)
```

```
    if 19.5 <= distance <= 20.5 and X_level>511:
        print ("LED Low Level on")
        GPIO.output(27,GPIO.HIGH)
        bot = telepot.Bot('318595317:AAG5p2pyZBMO3hghT48ejAea7_plKdPoZV0')
        print 'Initiating broadcast.'
        bot.sendMessage('@fyptbp','Earthquake is more than 3.5 magnitudes and water
        level measurement is between 19.5 cm and 20.5 cm. Please get ready to
        evacuate!')
        subprocess.call('/home/pi/webcam.sh')
        time.sleep(1)
        bot.sendPhoto(chat_id='@fyptbp', photo=open('/home/pi/Desktop/image.jpg'),
        caption='Flood condition: Water level is between 19.5 cm and 20.5 cm!')

    else:
        print ("LED off")
        GPIO.output(27,GPIO.LOW)

#Wait before repeating loop
time.sleep(0.1)

GPIO.cleanup()
```