CERTIFICATION OF APPROVAL

FREQUENCY BASED FLY REPELLENT

by

Selbi Melayeva

15726

A project dissertation submitted to the
Information and Communication Technology Programme
Universiti Teknologi PETRONAS
In partial fulfillment of the requirement for the
BACHELOR OF TECHNOLOGY (Hons)
(INFORMATION AND COMMUNICATION TECHNOLOGY)

Approved by,

____
(Dr. Izzatdin Bin Abdul Aziz)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

MAY 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

____

SELBI MELAYEVA

ABSTRACT

This project presented the application of ultrasonic sound in repelling flies. Pest insects are well known threat to human and agriculture. Getting rid the pest using alternative ways to conventional pesticides is considered crucial and strategically important step to the future.

The objective of this project is to be able to repel insects without the use of chemical pesticides by producing ultrasound. The majority of the insects are sensitive to ultrasound and they have a tendency to keep away from the territory covered by the ultrasound. The specific frequency ranges of the ultrasonic sound are used to study on the insects’ behaviour and response. In this thesis, data from theoretical, simulation and experimental are collected and analyzed.

This pest control device is designed to be low cost and effective solution, is powered by solar panels to make it applicable over the large fields. The project is one of the most ideal approaches to reduce the harm of pesticides making the consumption of fruits safer to the general public.

ACKNOWLEDGEMENT

In the name of ALLAH, The Most Gracious and Most Merciful

The greatest pleasure is to acknowledge the efforts of many people who are directly or indirectly gave their support, guidance, motivation, cooperation, friendship and understanding to carry out this project. Without their support, completing this project would be difficult.

Most deepest appreciation to Universiti Teknologi PETRONAS (UTP) and Computer and Information Sciences (CIS) department for providing state-of-the-art infrastructure and gadgetries, which stand crucial to the development of the product.

Utmost appreciation goes to Dr. Izzatdin Abdul Aziz for his guidance, support, ideas, motivation and patience throughout the project. His supervision and taught has nurtured those under him once step forward than time.

In addition to that, I would like to thank my family and friends for their encouragement and contributions along the process of completing my Final Year Project.

Thank You.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF GRAPHS AND CHARTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Fruit fly

The continuing growth of fly population has encountered mankind with numerous issues, including the significant one of imminent starvation. To adapt to this problem, aggressive agriculture was started upon at the turn of 19th century. Mechanization of agriculture prompted the production of more products for the masses. Storage programs were intensively carried out in order to avoid the loss of surpluses. By then was presentation of pest infestation that additionally experienced population explosion to be a formidable opponent, and the risk to food sufficiency. World pests are undesirable creatures that hinder with the domesticated plants and animals [1]. Those are birds, insects or rodents that cause harm to sown seeds, fruits, seedlings, blossoms, seeds, buds, roots, leaves and tubers of harvests either in the plantation field or in storage. It is estimated that pests consume 33% of the crops that grown in the United States. Globally, pests consume about 35% of crops. This annual loss to pests around $18.2 billion in United States alone [2], while the assessment of annual losses of grain to red billed quelea in the range of at least $1,000,000 in Somalia to $6,300,000 in Sudan.

In order to develop effective means of controlling different pests, that take heavy toll of our crops, pesticides were designed. Pesticides are chemicals intended to combat the attacks of different pests in agricultural and horticultural crops. It is believed that they affect the pest's central nervous system that results in their death. As for today, the production of pesticide is approximately $32 billion with its use that stands at more than 5 billion pounds yearly [3].

Preferably, a pesticide must be fatal to the target pests, but not to non - target species, including human. Unfortunately, this is not the situation. Their use is causing chaos on human and other forms of life [4]. There is currently strong evidence that few of these chemicals do represent a potential danger to people and other forms of life and undesirable side effects to the nature [5, 6]. Pesticides, as is known, is the transition from the treated area by drift during use, and then released into the atmosphere or in soil [7]. Soil contamination in this way caused significant changes in the populace of non-target creatures. The economic effect of pesticides in non - target species (counting people) has been evaluated at about $8 billion every year in developing countries. For instance, the number of worms has been diminished to more than 60% after applying benony. This potential risk of contamination from pesticides was advanced by Carson (1963) slightly above half a century of their use. The surface water pollution, ground water tainting, air pollution and soil contamination were the significant essential link of toxicity. The consequences of this pollution on target and non-target creatures of eco-systems involve resistance to chemicals [8], biological and chemical degradation, the accumulation along the food chain [9], the impact on fish, birds and, at last, possible toxicity to humans. A record of death and sickness because of pesticide harming is around 1 million every year.

Methods of non-chemical pest control have been put forward as the most ideal approach to lessen pesticide contamination in our surroundings [7]. These alternatives to raising food without pesticides include genetic control, biological control, physical control, social practices and the broad-based IPM or integrated pest management. All of these strategies have their own particular issues, such as being ineffective or too complicated, but the physical control of pests is most convenient. Therefore, other approach that is much safer to individuals as well as cost-saving is needed to repel pests away from our plants.

House fly

Another similar problem concerned with the human exists and not only in the fields, but in our surroundings, such as home places and offices. Despite the fact that flies seem to have no immediate impact on production, they may cause public health problems that can result in poor community relations.

In large numbers house flies can be an important nuisance by disturbing people during work and at leisure. Flies soil the outside as well as inside of buildings with their feces. They can likewise have a negative psychological effect because their presence is a sign of unsanitary.

House flies can transmit over 100 animal and human disease-causing organisms, including bacteria, protozoa, rickettsiae, viruses, worms and fungi. Insects feed on human food and wastes where they can get and transport a variety of pathogens. In addition to the house fly, various other fly species have adjusted to life in human settlements, where they introduce comparative issues.

In this project, the ultrasound was chosen to overcome these two problems. This project is to study, propose a conceptual design and implement ultrasound repelling system, which can repel fruit insects effectively without pollution and no effect to the environment. The propose design is self-powered using solar panels.

1.2 PROBLEM STATEMENT

1. Fruit insects became a major problem for farmers and consumers whose yearly harvests inquire losses. To overcome that, pesticides are widely used. Even though it helps to reduce the damage, there is always the side effect and unfortunately it is not the good one. It is well known that chemical pesticides are directly and indirectly harmful to human health and is a lethal weapon in a long run.

2.House flies and mosquitoes can convey numerous diseases and infections. House flies carry the disease on their feet and the little hairs that cover their body. It takes just a matter of seconds to pass these pathogens to nourishment or touched surfaces. Illnesses carried by house flies incorporate typhoid, diarrhea and cholera.

There are a scope of different products available in the marketplace that offer solutions to repel them, such as traps, smoke repellents, creams and some others. But those strategies oblige utilization of items on the skin; these could turn out to be harmful to the skin. The rest create foul odours and smoke that people do not like.

So there is an industrial and safety requirement to have an alternative method to avoid the use of chemical pesticides.

1.3 OBJECTIVES

- To perform a small scale study on the existing ultrasound insect repelling system.
- To design and develop a prototype of a frequency based insect repellent.
- To validate the proposed frequency based insect repellentusing house flies through lab scale experimentation.

1.4 SCOPE OF STUDY:

- Focusing flies.
- Using an Ultrasonic sensor for generating a high wing beat frequencies of fruit flies and measure echo that is received back by sensor
- Using Arduino as a hardware / software to accept input signals from ultrasonic sensor and send the information to the GSM modem.
- SMS implementation as a general telecommunication instrument using GSM modem as a medium for transmitting a warning message to the person.
- A programming language, such as the open-source Arduino (device specific language) used to develop software with the ability to control, monitor, sense, and perform measurements and alerts.
- Using solar energy to power up Arduino board.

CHAPTER 2

LITERATURE REVIEW

Chapter 2 discusses the best method to repel insects in agriculture that will bring no damage to human and trees. This chapter is divided into five sub chapters, where section2.1 discusses the focus area of this project.Section2.2 provides reviews on pesticides and the devices used to repel insects.Section2.3presents studies from various types of sensors to be used for this project. Section2.4 examines two types of microcontrollers, such as Arduino and Raspberry Pi. Section 2.5presents our comparison study between different ways to notify a person.

2.1 OVERVIEW

Ultrasonic Sound

Sound is characterized as a type of electromagnetic energy created by the mechanical vibration and spreads through air as waves. Frequency and sound of wave propagation are measured as Hertz and Decibel, respectively. Sound waves between 20 Hz and 20 kHz are in the audible range, and human can only hear audible portion of sound waves. Sound waves beneath 20 Hz are called infrasonic sound and more than 20 kHz is Ultrasonic sound. Human cannot hear ultrasonic and infrasonic sound vibrations because human tympanum vibrates just to react to sound vibrations inside the range of 20 Hz to20 kHz as shown in Figure 2.1.

The Ultrasonic sound is present in the antennae of flies. Ultrasonic sound emitted by Repellent will startle pests and confuse them. Ultrasound creates stress on the nervous system of insects and jams their natural ultrasound frequency. This immobilizes the insects to hurry away from the ultrasound source.

"Ultrasound and Arthropod Pest Control" (2001), a broad Kansas State University study [10], affirmed that ultrasonic sound gadgets have both a repellent impact and in addition decreases mating and the reproduction of insects.

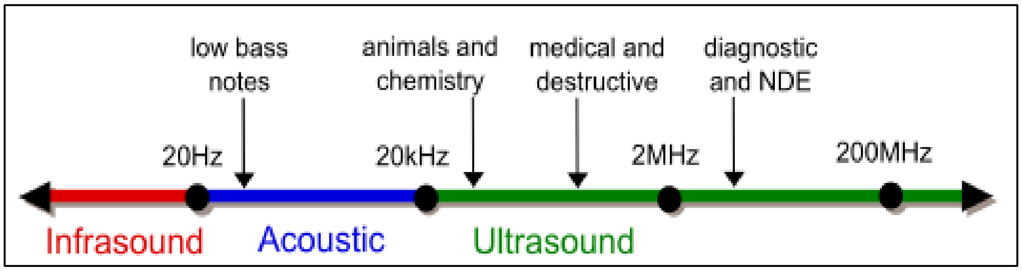


Figure 2.1: The approximate frequency that ranges corresponding to ultrasound

2.2 COMPARATIVE STUDY BETWEEN CHEMICAL BASED PESTICIDE AND REPELLENT DEVICES

Chemical pesticide use in pest control is harmful to the general public even at lower dosage. People are worried about the impact of the continued usage of chemical pesticide on the earth and its effect on human well-being.

Table 2.1: Comparison between chemical pesticides and repellent devices

Area of Difference	Pesticide Products	Repellent Devices
Hazard level	high	very low
Response time	quick	medium
Effectiveness	very effective	low
Cost	cheap (economical)	cheap

Table 2.1 presents the comparison between chemical pesticides and repellent devices. Pest control devices have an important advantage of being environmentally friendly and pose no danger to human health.

Electronic refers to different methods of repelling pests with the use of electrically powered devices. They are part of the physical methods of pest control that have recently become popular because of their environmentally friendly nature as compared to traditional pesticides. There are two main types of electronic devices widely available for pest control: Ultrasonic devices and Electromagnetic types [13].

Ultrasonic devices work by transmitting high-frequency sound waves more than 20,000 Hz. The human ear fails to possess the ability to hear such sound. Ultrasonic devices are planned and developed to emit the sound of that frequency when it focuses on pests; they make them uncomfortable in the coverage area, accordingly repulsing them far from the territory without affecting the environment and non-target life forms, including human. The preferences of this technique over other pest control systems includes the fact that they are environmentally friendly, eco-system friendly, cheap and have no known danger to people.

2.3 FEASIBILITY STUDY ON DIFFERENT TYPE OF SENSORS

All sensors provide insight into the environment (odometry, contact, sensitivity to light, to heat and to sound). Ultrasound sensors are ordinarily used for the detection of moving objects and measure the distance because they are cheap and simple to handle. Other than ultrasounds, two other technologies used to do such estimations are as follows:

- Infrared
- Laser

The following table summarizes main advantages and disadvantages of the different alternatives in terms of solutions for this project:

Table 2.2: Comparative feasibility study on different type of sensors [14]

Area of difference	**Ultrasonic sensor**	**PIR (Passive Infrared)**	**Laser**
Implementation	- senses the presence of a moving object by sending ultrasound waves into space and measures the speed at which they return	- detects the presence of occupants by sensing the difference between the heat emitted by moving people and the background heat	- allows long-range detection for difficult applications by maintaining a focused beam spot
Range	- 2cm - 400cm	- 5cm- 80 cm	- few meters to tens of meters, depending on the model
Directivity	- cone of approx. 30°	- cone of approx. 5°	- the most focused (about 1 degree or even half a degree)
Accuracy	- relatively accurate, but accuracy reduces with the distance from the angle measurement, temperature and pressure	- relatively accurate, but accuracy decreases with distance	- accurate up to a few centimetres, compared to the measurements of several meters
The sensitivity	- it is sensitive to pressure - sensitive to temperature	- it is prone to false positives because of being sensitive to the environmental changes, such as hot / cold air and sunlight	- it is sensitive to temperature
The sensitivity to interference	- covers entire space and doesn't need direct line of sight (new row)	- oblige direct line of sight between sensor and object in a space	- unable to detect objects reflecting the laser (windows, chrome plated objects)
Cost	- inexpensive	- inexpensive	- relatively expensive

From the comparison study in Table 2.2 [14], Ultrasonic sensor is the best sensor to use for insect repelling system. It gives accurate, non-contact measurement of the distance within 2 cm to 4 m range, while others provide a lower measuring range. The operating angle is approximately 30° (degree), which is large in comparison with the acoustic sensor and laser. Therefore, the measurement will be more accurate inside the focal cone of 30°, and less precise towards the sides. Ultrasonic sensor does not require direct line of sight and can detect moving objects behind the obstacles. The device is cheaper than other types of sensor, which is an advantage, since the user want to buy cheaper and more effective device for controlling insects.

2.4 COMPARATIVE STUDY ON DIFFERENT TYPES OF MICROCONTROLLER

To lower the design and implementation cost, open source computer microcontroller boards are used. We are going to highlight the differences between two most prevalent boards: Raspberry Pi Model-B and Arduino Uno. Each of them has its own particular qualities and shortcoming, and some platforms are better for specific projects more than others.

Table 2.3: Table of comparison between Arduno and Raspberry Pi [15]

	Devices	
	Arduino	**Raspberry Pi**
Platform	Uno	Model-B
Software		
Operating system	None	Linux, RISC OS
Integrated development environment	Arduino IDE, Eclipse	OpenEmbedded, QEMU, Scratchbox, Eclipse
Programming language	Writing based C++	Python, C, BASIC
Architecture	8Bit	32Bit
Hardware		
Processor	ATMEGA328	BCM2835 (ARM)
Clock Speed	16MHz	700MHz
RAM	2Kbyte (0.002MB)	512MB

ROM	32Kbyte	SD Card (2 to 16G)
I/O(several protocols)	14	8
USB	One (input only)	Two
On Board Network	None	10/100 wired Ethernet RJ45
Cost	$30	$35

Based on the table 2.3, each of these two types of hardware has their own objectives. The Arduino Uno is suitable for this project because it is built specifically for beginners; it is an open source, easy to set up, consumes little power and can be powered by solar panel, which gives a user full control over their technology. In addition, Arduino can be connected with GSM modem to send SMS notifications. With the use of Arduino IDE, it is possible to write programs that will interface with a lot of hardware, such as sensors, switches, internet and other microcontrollers.

As for Raspberry Pi, it is intended to function on a higher level. It is built for more complex projects, because it can deal with things like Ethernet, audio and video processing; it has an extensive memory and it is basically a little PC that runs Linux from a SD card. The main disadvantage of this device is that it doesn't have many ways for interaction with the outer sensors. As in this project we require hardware capable of interacting with different electronics, the Raspberry Pi isn't exactly as strong of an alternative.

2.5 COMMUNICATION CHANNELS USED TO NOTIFY A USER

Few types of communication channels may be used to notify a user in case where flies are detected. For this project a notification through SMS is needed only in case if the device is used in the field. The purpose of notification is that flies don't come alone, and in case when a farmer knows that there are flies, he can immediately take some actions to prevent the other areas of the field from these creators. The following table shows the benefits and drawbacks of the communication channels:

Table2.4: Tableofcomparisonbetweenthechannelsofcommunicationusedtonotify a person

Channels	Benefits	Challenges
Sirens	-can be used at night - good in rural areas	- maintenance of the system - cannot distribute a detailed message
Internet/Email	- communication speed - interactive	-not widespread -cost of Internet connection
SMS	- quick - messages can be sent to the group at the same time - low cost	- congestion - cannot notify a person if he/she does not have a signal

Based on the table 2.4, SMS is the best tool to notify a user. A person can get a text message even with a bad network connection, as SMS is the low bandwidth channel. Approximately 95% of SMS messages are read in 2 minutes, where the push notices can be turned off. It is a very popular mobile service, which is available on almost all digital mobile phones.

2.6 CONCLUSION

It is clear that way forward to safer and healthier environment is to develop and use pest repellent devices. We are living in 21st century with advanced electronics and IT infrastructure. Nevertheless, simple, cost and performance effective solution should be the main objective.

Few options on the communication method and hardware were discussed in the feasibility study and most effective ones were chosen as below:

- Sensor type: ultrasonic sensor - covers fair range and inexpensive
- Microcontroller: Arduino Uno – simple, easy to set up, fit for purpose
- Communication channel: SMS – broadly used, easy to set up, inexpensive

CHAPTER 3

METHODOLOGY

3.1 RESEARCH METHODOLOGY

Figure 3.1 below shows the basic methodology and overall processes for this project.

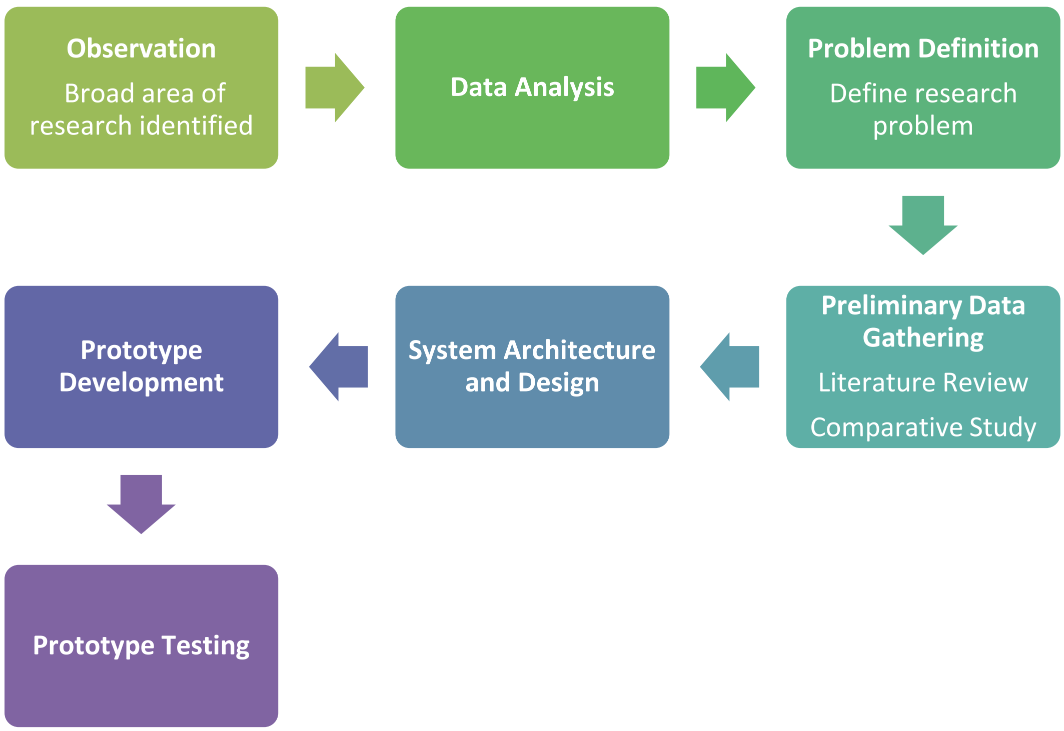


Figure 3.1: System development lifecycle for Frequency based pesticide

Observation

Through research, it was observed that there are only limited pest repelling systems used in agriculture industry. Although though the electronic pest repelling devices have been available for at least 20 years, only recently they become popular and generally promoted, presumably because they have no risk to environment. Usage of pest control devices in agriculture is well known in some developed countries, such as United States, where they use it in organic farming systems as well.

The observation was concentrated fundamentally on how to keep away insects from fruit trees using advanced technologies that use frequencies as a repellent and also using wireless technology authorized with SMS for information dissemination.

Data Analysis

By using sensor the high frequency sound waves will be generated thus detecting flying insects and measuring their distance. Flies can be repelled or killed in case when they are irradiated with the powerful ultrasound.

The frequency required to repel insects relies on the physical characteristics of the flying insects. One way to do this would be to create the ultrasonic field that will sweep over a range of frequencies, such as 20 kHz to 200 kHz.

Problem Definition

This stage is the place where the problem is determined to narrow down the project scope. The primary objective is to build and test a working prototype of the pest repellent device. Secondary objective is to analyse the performance of the hardware and effectiveness of the device, if it does serve the purpose. Traditionally, farmers (user) have to use chemical pesticides in their fields to control insects. This technique can be considered as healthy, with no harm to environment, trees and people. Furthermore, the system will warn the farmers when flies in the field are detected, so they can take precautions to prevent damage to fruit trees.

Preliminary Data Gathering

Study for this project was conducted using research from internet, reading progressing papers, articles, books and journals with respect to remote technologies and how they are used in various fields.

A comparative study between various hardware and communication tools was done in order to ensure the best and least price realization. At first, the comparative study was done between pesticide products and pesticide devices, following by different types of sensor to be used in the device, such as Ultrasonic sensor, Passive Infrared sensor and Laser, then Arduino Uno and Raspberry pi microcontroller comparison was done, and at last but not least was to identify the communication channel to user: Sirens, Internet/Email and SMS.

To move ahead with the project, the information about every component included in the development of the device and operating system needs to be gathered and well-studied. The study revealed the need for the three main stages to be focused, which are data acquisition, followed by data communication and alert notification.

System Architecture and Design

Data acquisition is the most important element of the system, which will help to detect the fruit flies (pests)and house flies and trigger the generation of the ultrasound to repel them. From the study, it was decided to use the Ultrasonic sensor that detects the existence of moving objects. For information processing, the Arduino Uno will be used. It will be powered by solar panels.

In the data communication stage, GSM modem is used as communication medium. It is used to transmit alert notification in form of SMS. The functionality of the system will be programmed using Arduino compiler and editor.

Prototype Development

The prototype development of this project requires the integration of its hardware and software. All the details of the configuration of hardware and software we will discuss in Chapter 4.

Prototype Testing

Before prototype testing can be done, testing technique should be designed to guarantee efficient and effective testing to be done on the system. Testing shall incorporate utilization of prepared input data with an arrangement of possible results and also with the use of new information that have never been inputted previously. The system must be tested by developer and end user.

Testing process will be divided into three phases. In the first phase, sample data of recorded movements will be tested to guarantee its consistency. The second phase includes the testing of the application to ensure whether it is effective in supporting the system by testing the accuracy of the coding. In the third phase, the real environment will be used to test the system; we shall call it “field test”.

3.2 KEY MILESTONE

Key milestones of this project are presented in the graphs below:

Figure 3.2a: Milestone for the FYP I

No	Details/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Title														
2	Preliminary Research Work														
3	Design project outcome														
4	Submission of Interim Report														
5	Project work continues														
6	Proposal Defence														

Figure 3.2b: Milestone for the FYP II

No	Details/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project work continues														
2	System testing														
3	Pre-SEDEX														
4	Submission of Technical Paper														
5	Submission of Dissertation (soft bound)														
6	Oral Presentation														
7	Submission of Project Dissertation (Hard Bound)														

CHAPTER 4

RESULTS AND DISCUSSION

4.1 SYSTEM MODEL

Figure 4.1 provides the overview of the system's framework. The system's framework illustrates the how each components of the proposed system are integrated and interact.

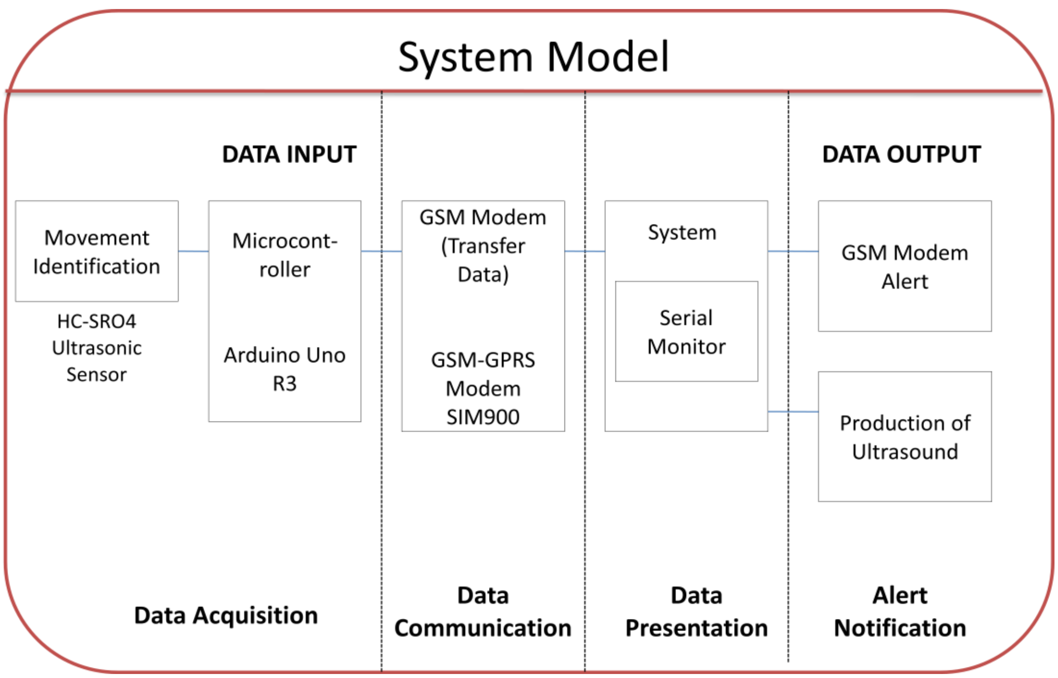


Figure 4.1: System framework for Frequency Based Fly Repellent

4.2 SYSTEM COMPONENTS

4.2.1 Hardware

Figure 4.2: Ultrasonic Sensor HC - SR04

Figure 4.2 shows the Ultrasonic Sensor - module HC - SR04that offers 2cm to 4 m non-contact measurement function with the accuracy that can reach up to 3mm. The module comprises of transmitters, control circuit and receiver. This sensor will be connected to breadboard and Arduino board.

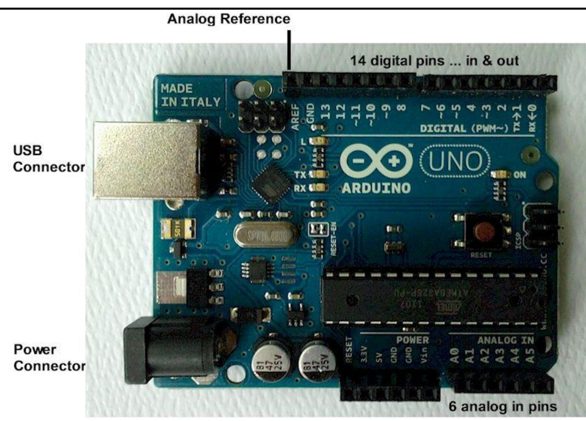


Figure 4.3: Arduino UNO R3

Figure 4.3 shows the microcontroller board called the Arduino Uno R3, which is based on the ATmega328 and with additional components which facilitate programming, as well as incorporation into other circuits. Arduino Uno has 20 digital I/O pins, 16 MHz crystal oscillator, 6 analog inputs, a power connector, USB connection, ICSP header and reset button. It includes everything needed to maintain the microcontroller.

Arduino is an open source gadgets prototyping platform in view of adaptable, simple to-utilize equipment and programming. It is like a little PC that we can program to do things, and it communicates with the world through engines, electronic sensors and lights.

Figure 4.4:GSM-GPRS Modem SIM900 KIT

GSM Modem is utilized to send SMS, make and get calls, and make other GSM operations by AT commands via the serial interface from microcontrollers and PCs. The modem utilizes the exceptionally prevalent SIM900A module for all of its GSM operations. It is issued with a standard interface RS232, which can be utilized to effectively interface the modem to computers and microcontrollers.

Figure 4.5: Solar Cell

The solar cell will be used to supply power to the Arduino board. This is an electrical appliance that transforms light energy into electricity using the photoelectric effect.

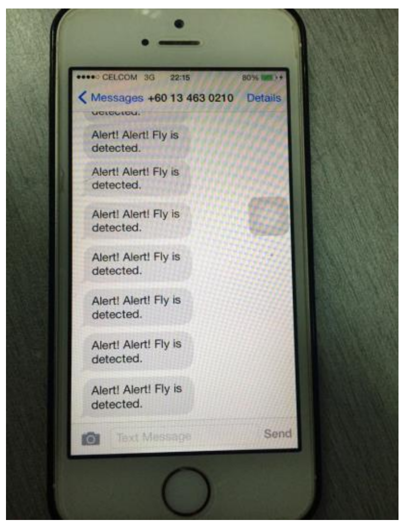


Figure 4.6: Mobile Phone

Figure 4.6 shows the mobile phone that was used to receive SMS alert from the system.

4.2.2 Software

Arduino Software

Different devices may be connected and controlled by Arduino, then writing a code will create new smart devices. The open sources Arduino Software (IDE) allows simply write code and transfer it to the board. ARDUINO 1.6.1version is used for this project.

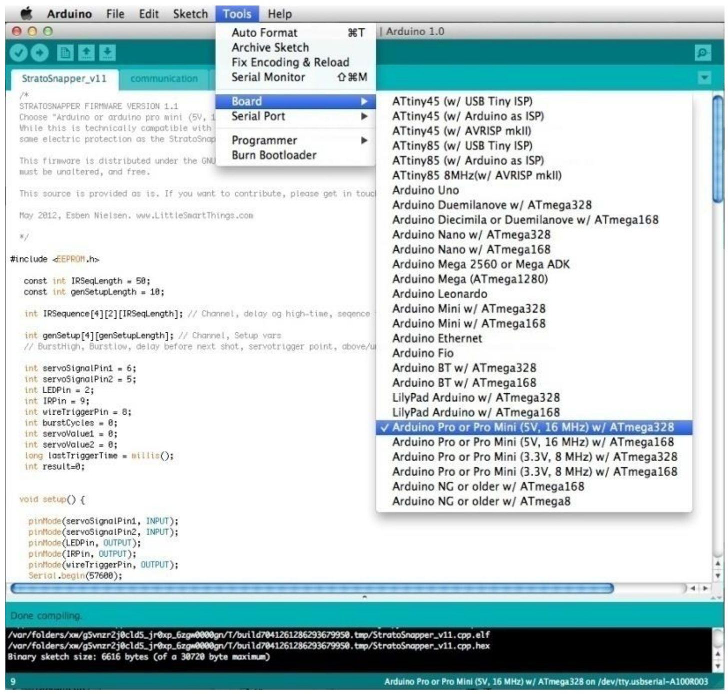


Figure 4.7:ARDUINO 1.6.1 (IDE)

4.2.3 Integrated version of components

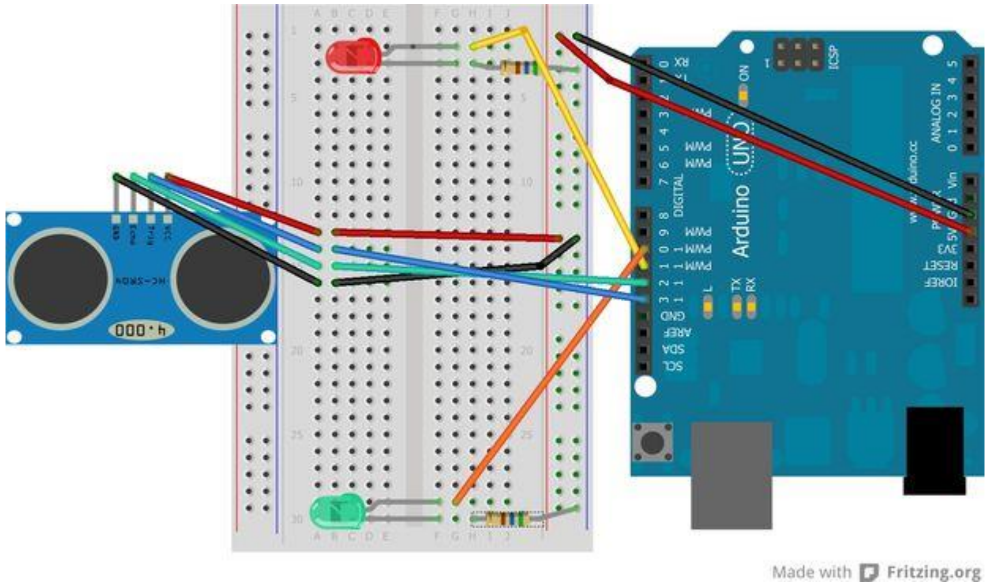


Figure 4.8: Ultrasonic Sensor, Arduino Uno and breadboard connection ports

Figure 4.8 shows the connection of Arduino board with the Ultrasonic sensor and breadboard. The operation is simple. As we approach object the sensor LEDs light up depending on distance of the object. The green LED is switched on when we are far away and red in case if it is close. The LEDs sensing distances are programmable.

4.3SYSTEM ARCHITECTURE

The system architecture in Figure 4.9 comprises of three stages, which are the movement identification and production of ultrasound, data communication and SMS notification.

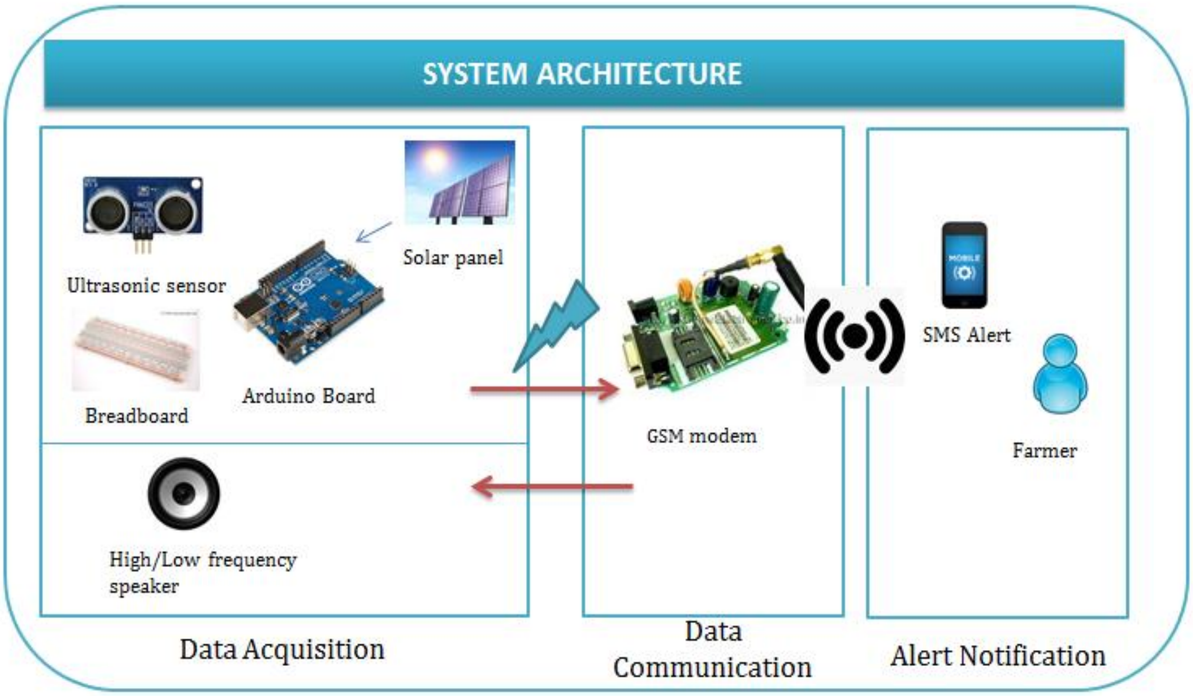


Figure 4.9: System Architecture of Frequency Based Fly Repellent

Each station transmits its data in real time. The repeater stations are connected to the main station where the information from all basins are obtained and processed, and the desired ultrasound at the desired frequency range is produced. At the point when this happens the Receiver will be informed through SMS.

Changes detected by the ultrasonic sensor will be sent to the Arduino board. From the Arduino microcontroller, the data will be sent to the GSM modem, which later sends an SMS notification to an individual. After that the required ultrasound frequency will be produced in order to get rid of flies.

Figure 4.10 shows the process flow of the proposed system.

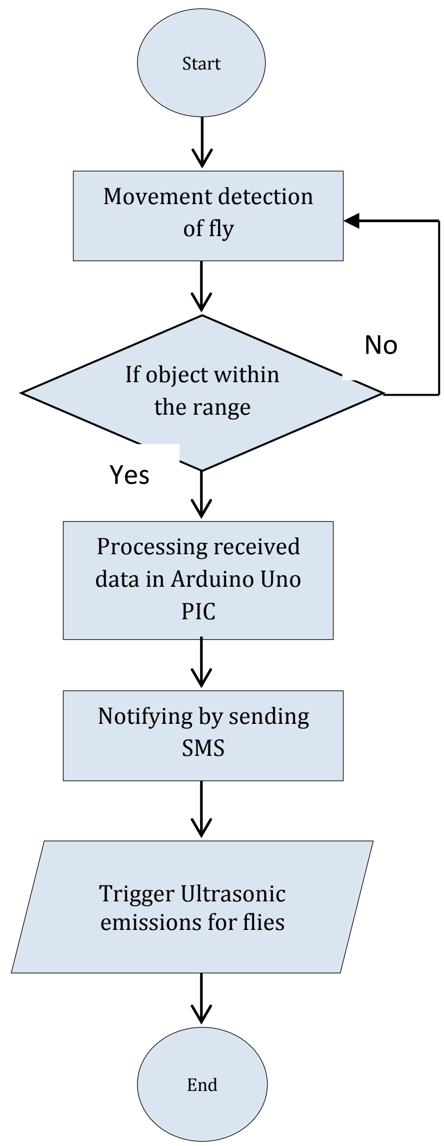


Figure 4.10: Flowchart diagram for Frequency based fly repellent

4.4TESTING

4.4.1 Hardware Setup

1. Connect Ultrasonic sensor and Arduino Uno with wires for detection of flying object.
    - Set a distance or range to detect fly or insect. Parameter: centimeter (cm).
2. Connect ultrasonic speaker to Arduino Uno and to signal generator to produce accurate range of frequency.
    - Set a frequency range to generate. Parameter: Frequency (KHz).
3. Insert SIM card and connect the Antenna to GSM modem. Attach GSM Modem to Arduino Uno.
    - Parameter: time (seconds)
4. Put flies into a container with the Sensor, Arduino board and speaker.
5. Then, connect Arduino USB cable to the laptop.
6. Copy the code, verify it and upload it to Arduino UNO.
7. Set complete device in the laboratory and test.

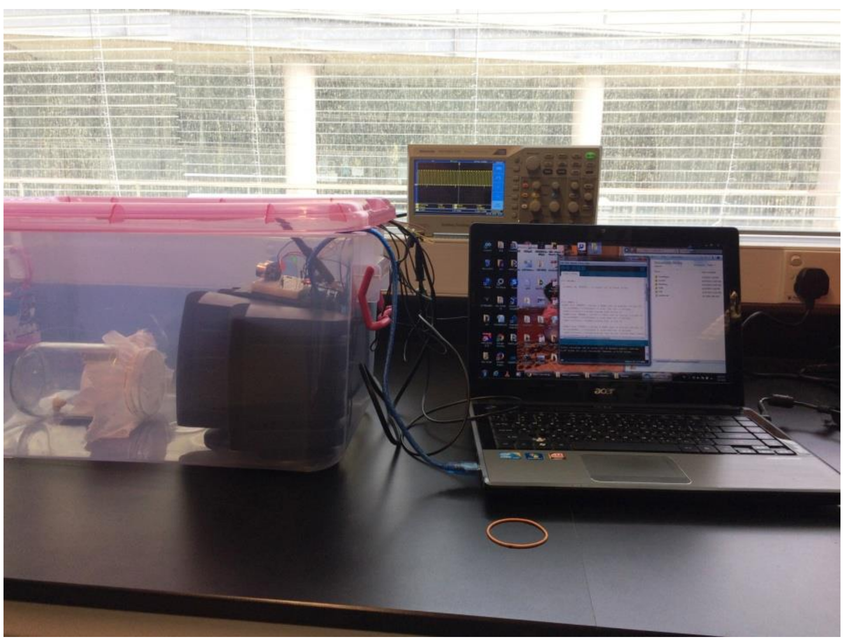


Figure 4.11: Illustration of Actual Experiment

4.4.2.Software

Code for the system

```
#include "SIM900.h"
#include <SoftwareSerial.h>
#include "sms.h"
#include <TonePlayer.h>
#include <NewPing.h>
SMSGSM sms;
boolean started=false;

 #define TRIGGER_PIN  13  // Arduino pin tied to trigger pin on the ultrasonic
sensor.
 #define ECHO_PIN     12  // Arduino pin tied to echo pin on the ultrasonic
sensor.
 #define MAX_DISTANCE 200 // Maximum distance we want to ping for (in
centimeters). Maximum sensor distance is rated at 400-500cm.
 #define led 11
 #define led2 10
/*-----( Declare objects )-----*/
NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE); // NewPing setup of pins
and maximum distance.
/*-----( Declare Variables )-----*/
intDistanceCm;
 long randNumber;
TonePlayer tone1 (TCCR1A, TCCR1B, OCR1AH, OCR1AL, TCNT1H, TCNT1L);

void setup()
{
Serial.begin(9600);
Serial.println("UltraSonic Distance Measurement");
pinMode(led, OUTPUT);
pinMode(led2, OUTPUT);
  //Serial connection.
Serial.begin(9600);
Serial.println("GSM Shield testing.");

pinMode (9, OUTPUT);  // output pin is fixed (OC1A)

  if (gsm.begin(2400)){
Serial.println("\nstatus=READY");
    started=true;
  }
  else Serial.println("\nstatus=IDLE");
Serial.println("Distance:");
  };

void loop()
{
delay(400);// Wait 100ms between pings (about 10 pings/sec). 29ms should be
the shortest delay between pings.
DistanceCm = sonar.ping_cm();
Serial.print("Ping: ");
Serial.print(DistanceCm);
Serial.println(" cm");

  if ( (DistanceCm<= 23) && (DistanceCm != 0) )
  {
digitalWrite(led,HIGH); // When the Red condition is met, the Green LED should
turn off
digitalWrite(led2,LOW);
```

```
Serial.println("found! ");

  if(started){
    if (sms.SendSMS("+60134332801", "Alert! Alert! Fly is detected.")){

Serial.println("\nSMS sent OK");
  }}

  tone1.tone (38000); //plays a 38kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 5 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (38500); //plays a 38.5kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 5 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (39000); //plays a 39kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 5 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (39500); //plays a 39.5kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 5 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (40000); //plays a 40kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 5 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (40500); //plays a 40.5kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 5 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (41000); //plays a 41kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 5 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (41500); //plays a 41.5kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 5 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (42000); //plays a 42kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 5 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (42500); //plays a 42.5kHz tone on digital I/O pin 13
  delay (5000); //continues to play tone for 5 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (43000); //plays a 43kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 10 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (43500); //plays a 43.5kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 10 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (44000); //plays a 44kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 10 seconds
  tone1.noTone(); //stops playing tone on pin 13

  tone1.tone (44500); //plays a 44.5kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 10 seconds
  tone1.noTone(); //stops playing tone on pin 13
```

```
tone1.tone (45000); //plays a 45kHz tone on digital I/O pin 13
  delay(5000); //continues to play tone for 10 seconds
  tone1.noTone(); //stops playing tone on pin 13

 }
  else {
digitalWrite(led,LOW);
digitalWrite(led2,HIGH);

  }
}
```

Basically the device is programmed to continuously sense 4-5 m range radius for moving objects (flies or pests). Upon detection it shall send an SMS to user with notification and start playing tones from 38kHz to 45kHz frequency for 100 seconds. Once done it shall continue sensing and detecting, until there are no flies or pests in the range.

4.4.3 Testing the range of frequency required to repel flies

Abstract

- Test was done to study flies' flight behavior and their response to different frequency ranges.

Objective

- To test the behavior of flies in three different frequency ranges.
- To test for the repellency.

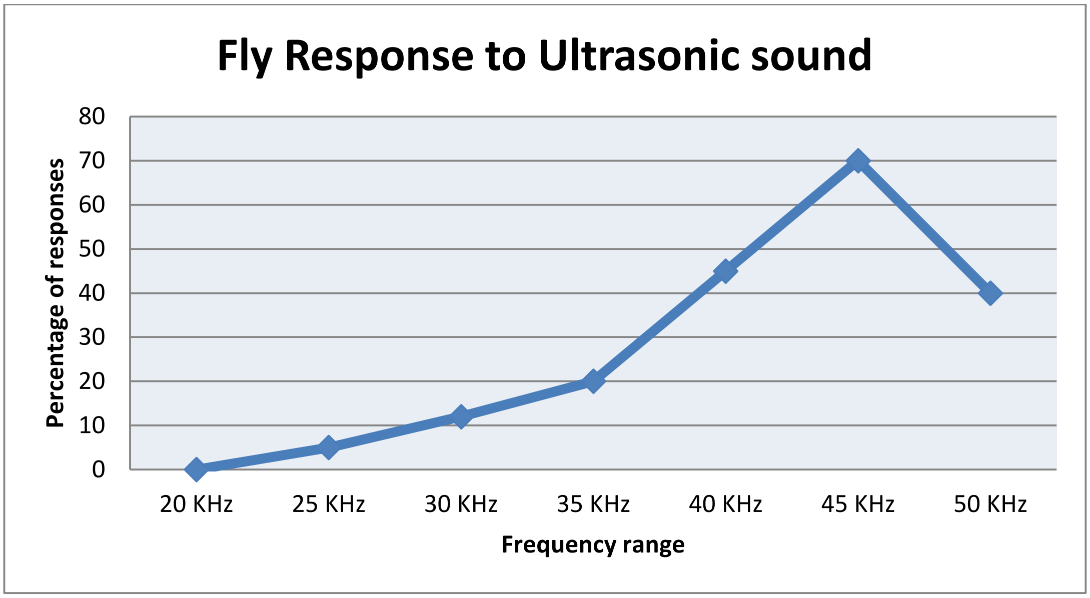


Figure 4.12: Fly Response to Ultrasonic sound.

The test was conducted first, with the device is turned off, and then with the device is turned on. Ten trials were performed with house flies.

The result of the frequency studies give different outcome. All three frequency ranges (20 kHz - 30kHz, 30 kHz - 40kHz, 40 kHz – 50 kHz) that we tested had a significant impact on the flies' flight behavior compared to the control situation without sound. In addition, the frequency ranges from38 kHz to 45kHz affected flies flight behavior at all distances. At this frequency, the houseflies early flight behaviors were affected much more than at the other frequencies and they become more active.

Based on the Figure 4.12, over 70% of flies response to sound waves of 45 kHz, as they become more energetic and active. As the experiment was carried out in a container due to the difficulty of observing the flying insects in an open area, we could only observe the behaviour of flies to the high frequency sound waves. Therefore, it can be concluded that frequency range of 38 kHz to 45kHz can be used to repel flies.

4.4.4 Testing fly behavior

Abstract

- Test was carried out to investigate the behavior and the reaction of flies in the frequency range between38 kHz to 45 kHz.

Objective

- To test the behavior of flies in the frequency range of 38 kHz to 45 kHz.
- To check the system for the repellency.

Results

Table 4.1: Test on the flies behavior

Number of experiment trial	Number of flies	Avoid	Die	Active	No response
1	3	1	0	2	0
2	5	2	0	2	1
3	4	1	0	2	1
4	2	1	0	1	0
5	4	0	0	3	1
6	2	1	0	1	0
7	3	2	0	1	0
8	2	0	0	2	0
9	3	1	0	2	0
10	2	1	0	1	0

Ten experiment trials were performed for this test. For each experiment, it took about 2-5 flies to study resulting in a total of 30 flies.

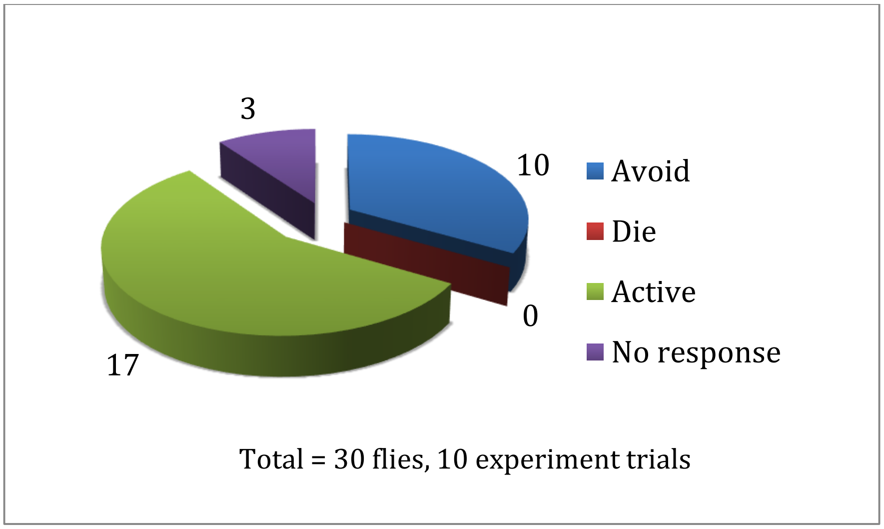


Figure 4.13: Flies behavior test

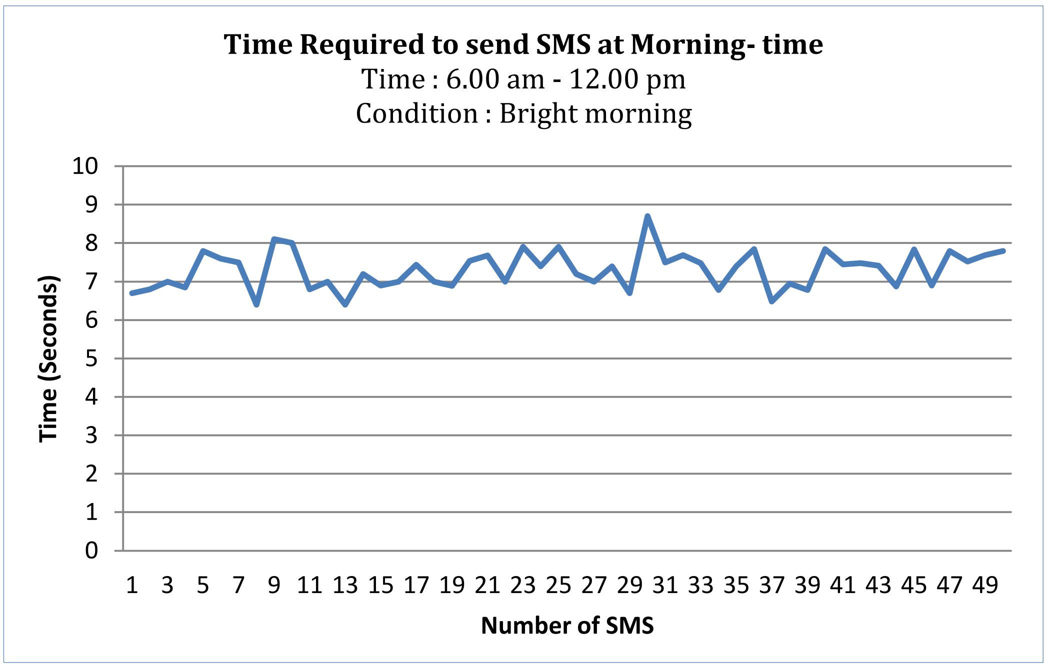
Figure 4.13illustrates the overall result of the 10 experiment trials. 17 flies were active at the time of the high frequency sound waves between38 kHz to 45 kHz, while 10 were avoiding the sound and hiding behind the speaker. There are three flies that had no response at all. Throughout the experiment none of the flies died.

4.4.5Latency test for sending alert

Objective

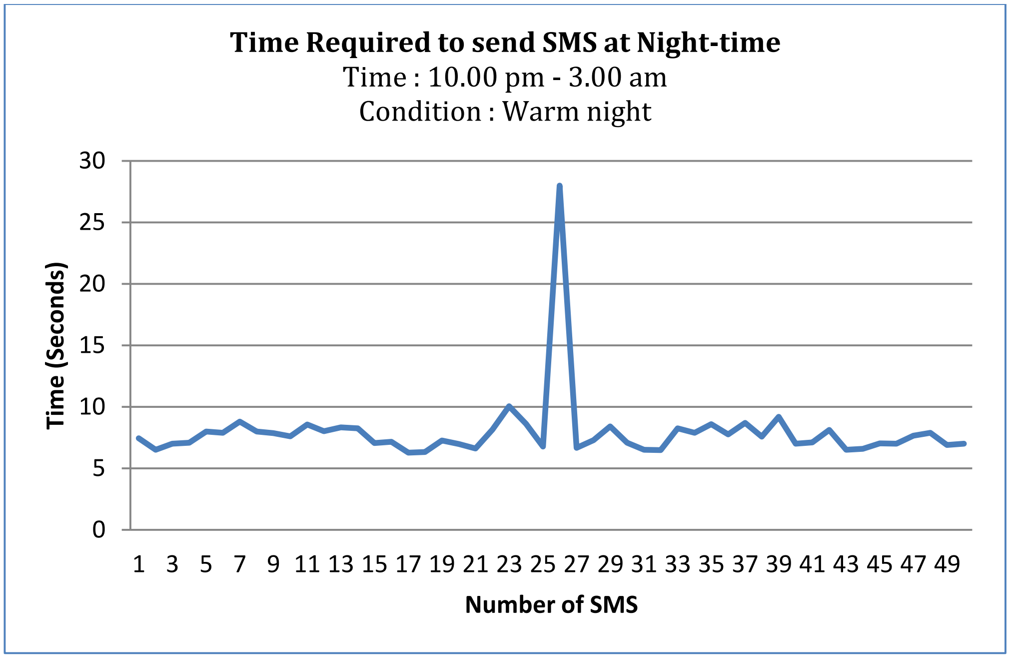
- The purpose of performing these tests was to study the time taken for SMS to be sent to the person. For each condition 50 SMS was sent. Three different conditions were examined which resulted in a total of 150 SMS that were transmitted to the receiver.

Results



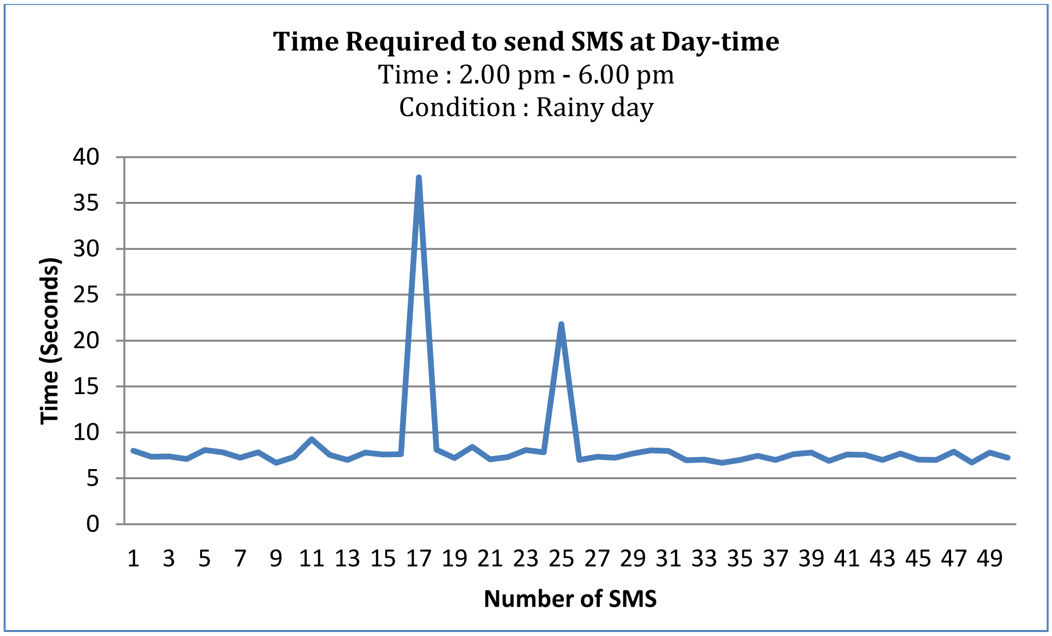
Graph 4.1: Bright morning testing condition

The initial condition was tried early in the morning from 6.00 am to 12.00 pm, as indicated in the Graph 4.1. It shows a time range when flies are most active at temperatures of 80 to 90°F and become inactive during night hours at temperatures below 45°F [17]. The graph demonstrates that the longest time required to send SMS in the morning was 8.8 seconds at the 31st sample.



Graph 4.2: Night hour testing condition

Graph 4.2 indicates second condition that was examined during night time from 10.00 pm to 3.00 am. For the field, this time span is also critical to the fruits because the temperature may drop radically which could likewise ripen the fruits. In this case, on the 26 trial the duration of 28 seconds was recorded. This may possibly due to retransmission activity. However, the result does not endanger the reliability since the data was received successfully.



Graph 4.3: Rainy day testing condition

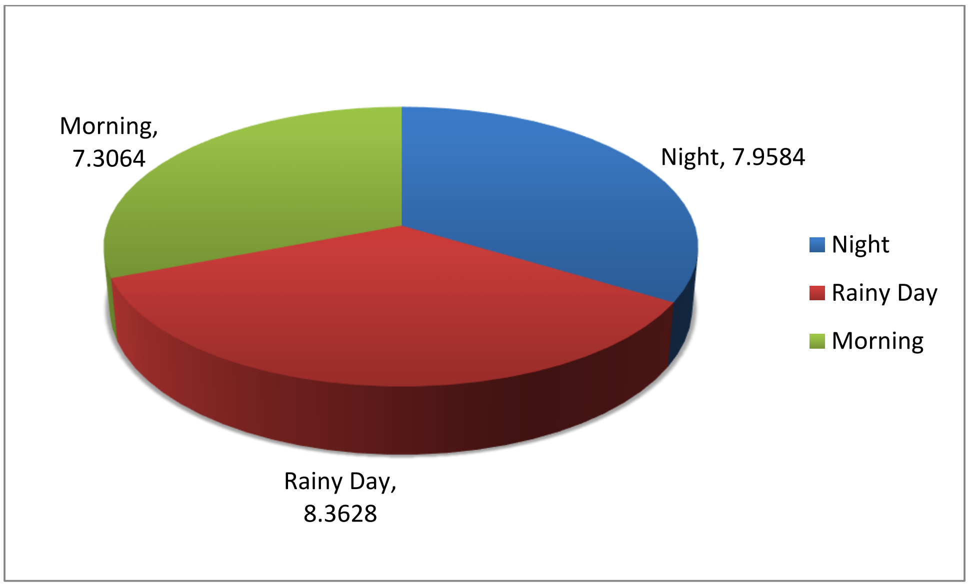
Graph 4.3 demonstrates the third condition that was tried during rain. This test was very important for the analysis of the wireless transmission reliability because of atmospheric absorption.

Water vapour and drops are already known to absorb the wireless transmission, thereby reducing the reliability of signal[18]. Rain and fog cause scattering of radio waves which result in attenuation. It may be a significant cause of signal loss. Time needed for the transmission of SMS in this test is fairly extensive when contrasted with the first and second test. It is possible to see from test number 17 and 25 that reaches up to 37 seconds.

To conclude for all the tests carried out, each SMS sent to the receiver changes distinctively in time, however, falls in the scope of 7 to 8 seconds. There has not been a serious problem occurred because SMS alert was transmitted in expectable time duration, thus allowing farmers to take immediate response.

Weather condition test

Condition test was performed to see the system performance during 3 different conditions that was during the morning, at night and rainy day. These 3 conditions were chosen to consider the utilization of telecom in a specific region, whether it would impacts the execution of the system. This test resulted in a total of 150 SMS that were transmitted. For all this tests performed, every SMS alert sent to the individual not fluctuates contrastingly in time however falls in the scope of 7 to 8.5 seconds.



Pie Chart 4.4: Average time required for sending 150 SMS

All conditions have been examined demonstrating no critical impact to the system. Time required for the framework to transmit SMS has been recorded to be almost the same for every one of the three unique conditions. Hence either day or night and also during rainy day, the framework use is recorded to be almost the same.

SMS Reliability Test

This test was directed to examine the reliability of SMS as a communication medium. The study examines the framework's reliability to send SMS notification to the person.

Table 4.2: SMS Reliability Test

	Total transmitted data	Percentage
Accuracy of transmission	194/200	97%
Retransmission rate	3/200	1.5%
Total data loss rate	3/200	1.5%

Table 4.2shows the result obtained from the reliability test conducted. Accuracy of data transmission was 97%. Out of 200 SMS sent by the system, only 3 retransmissions occurred during this test. Approximately 2 minutes were taken for the framework to retransmit the SMS to the person. Out of the total number of SMS sent 3 were lost and 197 were received by the receiver.

4.4.6 Summary

Three experiments have been tried for this project:

1.Testing the range required to repel of frequency flies;

2. Testing fly behavior in the frequency range between 38 kHz to 45 kHz;

3. Latency test for sending alert.

All this tests have been done in a real environment using completed prototype. From the results of testing it can be concluded that a high frequency sound waves of 38 kHz to 45kHz can be used to repel flies and alarm notification can be received within 7 to 8 seconds.

All these tests helped to achieve the project's main objective as to validate the proposed insect repellent through lab scale experimentation using house flies. The purpose of this tests was to verify the effectiveness of the proposed system.

CHAPTER 5

CONCLUSION

In general, frequency based insect repellent in agriculture is expected to reduce the risk of attacks by fruit flies in the fields and house flies at home. It should be able to reduce losses in the long run, so that user (such as farmers, gardeners, country folk and etc.) will be able to save time and effort to protect the fruit trees.

In addition, the device will simply chase flies away without having to kill them, as it is a pest repellent. It can be used in a small or large scale, with the proper modifications applied to the system.

Main objectives have been successfully implemented for this phase of the project:

1. A small scale study was conducted on existing methods of repelling insects. Devices needed to use for implementation of the project have been identified by conducting comparison study between different types of technologies.
2. The conceptual model and the working system of the frequency based pest repellent device have been developed.
3. Successful testing of the device in a real environment with a proven frequency of 38-45 KHz to repel house flies.

RECOMMENDATION

Few recommendations to further develop the device and its application:

- Better sensors could be used to cover bigger radius of land
- Different frequencies could be tested on various pests living on and/or underground
- Device could be complemented not only with ultrasonic sound but micro-vibrators to repel underground pests
- Research could be done to have the device to use continuous most effective frequency and tone at particular hours (peak hours) of pests presence
- Feedback from device could be programmed on sensor or tone to notify on device failure.

REFERENCES

[1] Kurma, R.(1999). Insect Pest Control, *Arnold Ltd*, United Kingdom, 15.

[2] U.S EPA, Report on the Environment: 2007 Science Report.

[3] Webster, J.P.G., Bowles, R.G.& Williams, N.T. Estimating the Economic Benefits of Alternative.

[4] Steven, E.S., Zhen, L. & David, Z. (2007).The Economics of Pesticides and Pest Control. *International Review of Environmental and Resource Economics*, 1, 271–326.

[5] Aktar, M.W., Sengupta, G. & Chowdhury, A. (2009). Impact of Pesticides use in Agriculture: Their Benefit and Hazards. *Interdisciplinary Toxicology*, 2(1), 1–12.

[6] Kole, R.K., Banerjee, H., Bhattacharyya, A., Chowdhury, A. & Aditya Chaudhury, N. (1999). Photo Transformation of some Pesticides. *J Indian Chem Soc.*, 76, 595–600.

[7] Igbedioh, S.O. Effects of Agricultural Pesticides on Humans, *Animals and Higher Plants in Developing.*

[8] U.S EPA (1999). Spray Drift of Pesticides, Office of Pesticide Programs, Washington, DC.

[9] Palumbi, S.R.(2001).Humans as the World’s Greatest Evolutionary Force, *Science*,293, 1786–1790.

[10] Bhadriraju Subramanyam (Subi) (2001). "Ultrasound and Arthropod Pest Control: Hearing is Believing!" (PDF). Kansas State University.

[11] Oyedum, O.D., Ibrahim, A.G., Okeke, S.S.N. & Awojoyogbe, O.B. (2013). Electronic Pest Control Devices: A Review of their Necessity, Controversies and a submission of Design Considerations. *The International Journal Of Engineering And Science (IJES)*, 2 (9), 26-30.

[12] Bayrak, N. &Hayat, R. (2012). [Tephritidae (Diptera) species of Turkey]. *Türk Bilimsel Derlemeler Dergisi*, 5(2), 49-55 (in Turkish).

[13] Kushiar, K.F. (2011). *Pest Repeller System.* Universiti Teknikal Malaysia Melaka.

[14] Generation Robots. *The different ways of determining position of a robot using a signal.* Retrieved from: http://www.generationrobots.com/en/content/65-ultrasonic-sonar-sensors-for-robots.

[15] Orsini, L. (2014, May 7). *Arduino Vs. Raspberry Pi: Which Is The Right DIY Platform For You?* Retrieved from: http://readwrite.com/2014/05/07/arduino-vs-raspberry-pi-projects-diy-platform.

[16] Ovezov, B.A. (2009). Frequency based pesticide. Universiti Teknologi PETRONAS, Malaysia.

[17] House Flies, Cornell University, College of Agriculture and Life Sciences. Retrieved from: http://vet.entomology.cals.cornell.edu/arthropod-identification/chicken-recommendations/house-flies

[18] Stallings, W. (2002), 'WIRELESS Communication and Networks' InternationalEdition, New Jersey, Prentice Hall.

[19] Kushiar, K.F. (2011). Pest repeller system. Faculty of Electronic and Computer Engineering. Universiti Teknikal Malaysia Melaka.

[20] Simeon M. I., Mohammed A.S., Adebayo S. E. (2013). Development and preliminary testing of an electronic pest repeller with automatic frequency variation. *International Journal of Engineering Science Invention*, 2-1.