THE POTENTIAL OF H'FRES V:1.0 (HIGH SUPERSONIC FREQUENCY) FOR LOCUST ELIMINATION

NAAGASURUNE A/P ARUMUGAM

BACHELOR OF CIVIL ENGINEERING TECHNOLOGY

(ENERGY & ENVIRONMENT)

UNIVERSITI MALAYSIA PAHANG

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NAAGASURUNE A/P ARUMUGAM

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ABSTRAK

Ciri-ciri penilaian pembangunan mampan sedang dibangunkan dalam konteks teknologi hijau. Memandangkan pertanian terus dihukum kerana kesan negatif alam sekitar, kecekapan sumber dan penggunaan teknologi bersih menjadi semakin kritikal. Tambahan pula, terdapat beberapa penyelesaian teknikal yang tersedia untuk membantu pertanian "hijau" menyelesaikan kesukarannya, sama ada dengan mengurangkan input, menjana tenaga boleh diperbaharui atau mengekalkan ekosistem. Disebabkan oleh pelbagai pilihan, kesukaran dalam analisis kos-faedah, dan potensi pertukaran dalam kemampanan, teknologi bersih dan pemilihan pembangunan mampan kekal rumit. Sudah tiba masanya untuk menggunakan teknologi semasa untuk mengatasi isu alam sekitar (Fraser, A,2019). Di banyak bahagian dunia, wabak belalang padang pasir mungkin menjadi penyumbang utama kepada kebuluran dan bahaya kepada keselamatan makanan. Wabak Desert Locust 1986–1989, serta peningkatan lain dalam tempoh dua dekad yang lalu, menunjukkan keupayaan berterusan perosak purba itu untuk membahayakan pertanian dan mata pencarian di seluruh kawasan luas di Afrika, Timur Dekat dan Asia Barat Daya. Peningkatan yang kukuh pada tahun 2004–2005 mengakibatkan kehilangan tanaman secara besar-besaran di Afrika Barat, meletakkan keselamatan makanan di rantau itu dalam risiko. Belalang adalah salah satu daripada perosak yang paling berbahaya dalam pertanian. Mereka adalah kumpulan hemimetabolous belalang bertanduk pendek kepunyaan keluarga Acrididae. Apabila segerombolan belalang berkumpul, mereka mempunyai kecenderungan unik untuk mengubah tabiat dan tingkah laku, yang dirangsang oleh banyak keadaan persekitaran (FAO, 2016). Matlamat kajian ini adalah untuk menilai teknik penderia bunyi yang canggih dan kemajuan teknologi untuk pengesanan autonomi dan pemantauan serangga perosak. Daripada menggunakan racun perosak, kerajaan harus menyokong penggunaan agen biologi dan serangga tertentu, antara kaedah pengurusan serangga perosak yang lain. Belalang berkilauan yang dicadangkan memusnahkan rangka kerja sambil tidak membahayakan orang ramai. Individu tidak terjejas oleh rangka kerja ini kerana ia menghasilkan gelombang bunyi frekuensi supersonik yang tinggi. Gelombang bunyi frekuensi supersonik tinggi dengan skop pengulangan melebihi 20 kHz tidak dapat didengari oleh manusia. Apabila belalang dan merangkak menyeramkan yang lain berkumpul, mereka sentiasa menyedari gelombang bunyi frekuensi supersonik tinggi, yang memburukkan mereka dan memaksa mereka untuk meninggalkan kawasan itu. Tujuan kajian ini adalah untuk menentukan keberkesanan H'FRES V:1.0 dalam mengurangkan populasi belalang dan sejauh mana bateri 12-volt boleh menyalakan lampu jalur LED. H'FRES V:1.0 ialah peranti kawalan racun perosak berjentera yang merupakan penyelesaian inovatif yang menghapuskan pencemaran racun perosak dan boleh menyumbang kepada pertumbuhan jangka panjang produk pertanian. H'FRES V:1.0 menggunakan teknologi mikroelektronik kontemporari untuk bertindak secara langsung pada sistem saraf pendengaran serangga belalang, menyebabkan sistem fisiologi mereka menjadi terganggu, jengkel, hilang selera makan dan akhirnya mati. Dengan pelbagai julat, potensi frekuensi supersonik tinggi untuk penyingkiran serangga belalang akan dinilai. Sensor bunyi dengan Arduino terus menjana gelombang bunyi dalam pelbagai jalur frekuensi, menghalang belalang daripada menyesuaikan diri dengan habitat hidup mereka, yang boleh menyebabkan mereka pening dan meningkatkan peluang mereka untuk dibunuh. Sel suria 20-watt membekalkan tenaga elektrik kepada mekanisme pengecasan bateri untuk digunakan pada waktu malam. Tambahan pula, mentol LED akan mematikan lampu malam secara automatik pada waktu subuh dan menghidupkannya semula pada waktu senja. Pada siang

hari, bagaimanapun, serangga akan terbang ke arah produk kerana mereka percaya ia adalah pemangsa mereka. Apabila tiada cahaya matahari, reka bentuk H'FRES V:1.0 ini mempunyai sistem kawalan automatik yang menarik perosak serangga dan mati apabila matahari bersinar. H'FRES V:1.0 yang dicadangkan mungkin menarik pelbagai perosak belalang dalam pertanian, menurut penemuan ujian pemasangan sistem. Sistem H'FRES V:1.0 yang dicadangkan menggunakan kurang tenaga sambil mengekalkan kos, ketersediaan dan fleksibiliti yang berpatutan. IDE Arduino, yang digunakan untuk menulis kod terbenam untuk papan Arduino, telah digunakan sebagai alat perisian. Alat yang direka bentuk menggunakan kuasa yang sangat sedikit dan berpotensi untuk menghalau belalang di rumput dan persekitaran lain dengan berkesan. Sebagai kesimpulan, H'FRES V:1.0 boleh digunakan dalam industri pertanian, racun perosak dan sains semula jadi, dengan penekanan pada R&D, pembuatan dan pengedaran. Sistem yang dicadangkan akan dilaksanakan.

ABSTRACT

The characteristics of a sustainable development evaluation are being developed within the context of green technology. As agriculture continues to be chastised for its negative environmental impact, resource efficiency and clean technology adoption become increasingly critical. Furthermore, there are several technical solutions available to help "green" agriculture to solve its difficulties, whether by reducing inputs, generating renewable energy, or maintaining ecosystems. Due to the wide range of options, difficulty in cost-benefit analyses, and potential trade-offs in sustainability, clean technology and sustainable development selections remain complicated. It is time to utilize current technology to overcome environmental issue (Fraser, A, 2019). In many parts of the world, desert locust plagues may be a major contributor to famines and a danger to food security. The 1986–1989 Desert Locust epidemic, as well as other upsurges over the last two decades, indicate the ancient pest's continued ability to endanger agriculture and livelihoods throughout wide swaths of Africa, the Near East, and South West Asia. A strong rise in 2004–2005 resulted in massive crop losses in West Africa, putting the region's food security at risk. Locusts are one of the most harmful pests in agriculture. They are a hemimetabolous group of short-horned grasshoppers belonging to the Acrididae family. When a swarm of grasshoppers congregates, they have a unique tendency of altering habits and behaviours, which is stimulated by many environmental conditions (FAO, 2016). The goal of this study is to assess sophisticated sound sensor techniques and technology advancement for autonomous detection and monitoring of insect pests. Instead of using pesticides, the government should support the use of biological agents and specific insects, among other means of insect pest management. The proposed sparkling locusts destroy the framework while causing no harm to people. Individuals are unaffected by this framework because it creates high supersonic frequency sound waves. High supersonic frequency sound waves with a repetition scope of over 20 kHz are inaudible to humans. When locusts and other creepy crawlies congregate, they are continually aware of high supersonic frequency sound waves, which aggravates them and forces them to flee the area. The purpose of this study was to determine as effective H'FRES V:1.0 was in reducing locust populations and how well a 12-volt battery could power an LED strip light. The H'FRES V:1.0 is a mechanised pesticide control device that is an innovative solution that eliminates pesticide contamination and can contribute to the long-term growth of agricultural products. H'FRES V:1.0 employs contemporary microelectronics technology to act directly on the auditory neural system of locust's insects, causing their physiological system to become disturbed, irritated, lose appetite, and eventually die. With various ranges, the potential of high supersonic frequency for locust insect removal has been assessed. The sound sensor with Arduino continually generates sound waves in various frequency bands, preventing locusts from adapting to their living habitat, which may cause them to get dizzy and increase their chances of being killed. A 20-watt solar cell provides electrical energy to the battery charging mechanism for use at night. Furthermore, the LED bulb will automatically turn off the night light at dawn and turn it on again at dusk. During the day, however, the insects will fly towards the product because they believe it is their predator. When there is no sunlight, this designed H'FRES V:1.0 has an automatic control system that attracts insect pests and shuts off when the sun shines. The suggested H'FRES V:1.0 attracted a variety of locust pests in agriculture, according to the findings of the system installation test. The suggested H'FRES V:1.0 system consumes less energy while maintaining reasonable cost, availability, and flexibility. The Arduino IDE, which is used

to write embedded code for the Arduino board, was utilised as the software tool. The designed gadget uses very little power and has the potential to effectively repel locusts in lawns and other environments. As a conclusion, H'FRES V:1.0 may be employed in the agricultural, pesticide, and natural science industries, with an emphasis on R&D, manufacturing, and distribution. The proposed system will be implemented.

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LIST OF SYMBOLS

%	Percent
km	Kilometre
cm	Centimetre
g	Gram
V	Voltage
°C	Degree Celsius
Hz	Hertz

LIST OF ABBREVIATIONS

UN	United Nations
FAO	Food and Agriculture Organizations United Nations
WHO	World Health Organizations

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Locusts are subspecies of the grasshopper family Acrididae, which includes the vast majority of short-horned grasshoppers that can cause damage to crops and natural systems (see Figure 1.1). While grasshoppers are typically viewed as individuals, they can congregate in large groups and devastate vegetation. Grasshoppers swarm in both the nymph and adult stages, and when they reach the adult stage, they can swarm in the air (Saremi, 2017). Guo (2006) investigated whether they are extremely diverse, estimating that there are approximately 130 grasshopper species in Inner Mongolia alone. These species differ depending on the regional environmental subzones. Dasyhippus barbipes in the early season, Oedaleus asiaticus in the middle season, and Chorthippus in the late season are the three most common species among the 130. Because of the high diversity, it is difficult to identify individual species.

Figure 1.1 Chorthippu Brunneus

Locusts are essentially harmless, however, when they meet suitable environmental conditions, they start breeding. In certain nations, locust outbreaks are also a major concern for farmers and the general public. The latest desert locust outbreak could have had unanticipated consequences, potentially caused widespread crop damage and risked food security. According to the FAO Desert Locust Situation Update, desert locust invasions, which were observed for thousands of years, can occur on a regular basis if no intervening control measures are in place. In general, recessions are brief, whereas invasions can last a decade or more. Desert locust outbreaks have been better controlled since the 1960s, and they are often shorter in duration and have less impact. However, upsurges continue to occur, most often as a result of resource cuts during recessions or insecurity in key areas where preventive control should be implemented. The role of climate change in such outbreaks is still being debated.

According to the United Nations (UN) Food and Agriculture Organization (FAO), the key to mitigating the degree to which Desert Locust can impact agricultural areas is early warning and early response. It is critical that countries conduct the requisite field surveys and sustain them on a regular basis after extremely heavy rainfall to track breeding conditions and locust infestations.

The purpose of this dissertation is to study the elimination of Locusts are divisions of the grasshopper species Acrididae by the H'FRES V:1.0 is a mechanised equipment technology of pesticide control as an innovative measure that avoids environment pollution caused by pesticide, and can be propitious to sustainable development of agriculture produce. In this technology, H'FRES V:1.0 uses modern microelectronics technology to directly use special supersonic frequency and electromagnetic waves to act on the auditory nervous system of green insects, causing their physiological system to become disordered, irritable, lose appetite, and then gradually die. The potential of high supersonic frequency for Locusts are divisions of the grasshopper species Acrididae elimination will be evaluated with different ranges.

It is also, H'FRES V:1.0 involved Dual-wave frequency conversion. The use of electromagnetic waves + supersonic waves, dual sound wave intelligent dynamic frequency conversion technology, so that green insects cannot adapt and it will directly hit the weakness of green insects.

1.2 Problem Statement

Locust population reaches a certain density, and eradicate beauty of environment. When the critical point is reached, turn savage and swarm and try to eat the world. The Locust has the potential to damage the livelihoods of one tenth of the world’s population. After becoming airborne, swarms of tens of millions of locusts can fly up to 150km a day with the wind. Female locusts can lay 300 eggs within their lifetime while a Locust adult can consume roughly its own weight in fresh food per day about two grams every day (Yurtonglu, 2018). A very small swarm eats the same amount of food in one day as about 35,000 people. This entirely damaged the agriculture sector within a day.

In current situation, Chemical insecticides used for locust control are insecticides, which means they kill not only just locusts but also other insects and arthropods present in the environment, some of which could be beneficial ones such as honeybees, other pollinators or natural enemies of locusts. Therefore, pesticides are commonly used in most sectors of agricultural production to avoid or mitigate locust elimination, which can thereby increase yield and quality of produce, including cosmetic appeal, which is also essential to consumers. The chemical pesticides also can be sporulation of the fungus takes a long time and necessitates high humidity levels, which are not necessarily present in the field (Abdelatti, 2020). Chemical pesticides and the additives in their formulations may have unexpected consequences for plant-associated microbes. All the chemical pesticides that are used in locust control pose some risks to human health, although certain products are less hazardous than others.

There are so many amazing things occurring in the realm of science and technology, yet there is no efficient electronic insect repellent. The numerous pest control methods are discussed, as well as the electronic pest controller based on frequency generation technology. Pesticides, herbicides, and other repellents are all poisonous and dangerous to human health. Ultrasonic frequency device possible to produce acoustic signal to pests such as rabbits, birds, and insects. Pests are irritated by the sound of this frequency (10 - 100 kHz) and migrate away from the device as a result of the extreme auditory stress. The technology may be used by the general people to repel mosquitos, as well as by farms to repel rodents, insects, and other pests.

1.3 Objectives

This study aims to:

i. To investigate the effectiveness of H'FRES V:1.0 (High Supersonic Frequency) in eliminating locust and populations.
ii. To evaluate the repellence effects of H'FRES V:1.0 on biological control of locust.

iii. To develop Solar Energy-Based H'FRES V:1.0 (High Supersonic Frequency) system.

1.4 Research Scope

The research's aim is to find way farmers and the general public can solve the problem stated in the problem statement. To show that the H'FRES V:1.0 system can effectively and efficiently replace harmful chemical repellents for agriculture and the environment. The main advantage of this system is that it only uses a small amount of electricity from the solar panel, which runs 24 hours a day. The first experiment was carried out on campus to test the efficiency of H'FRES V:1.0 (High Supersonic Frequency) in removing locusts and populations. The repellent effects of H'FRES V:1.0 on biological locust control are then investigated in the second process. Finally, a Solar Energy-Based H'FRES V:1.0 (High Supersonic Frequency) system created. The body component of the product is designed using scrap metal items and system components such as Arduino Uno, jumper wires, sound sensor, breadboard, LED strip light, LDR, resistor (330 and 220 ohm), trimmer, rotary potentiometer (10k ohm), buzzer, and RGB backlight positive LCD 16x2 which all of the components are purchased from the Arduino shop. This initiative is primarily focused on eradicating locusts in an efficient and cost-effective manner.

1.5 Signification of Study

During dry spells, solitary locusts are forced together in the patchy areas of land with remaining vegetation. A small swarm of locusts contains thousands of individuals that spread over several hundred square meters, but large swarms contain up to 80 million individuals per km2 and can infest more than 1000km2. Since a swarm can cover a distance of 100km per day, farmers regard gregarious locusts as one of the most destructive plagues on earth. When the locusts start attacking crops and thereby destroy the entire agricultural economy, it is referred to as locust plague/locust invasion. Plagues of locusts have devastated societies since they still wreak havoc today. This study identifies several methods to eliminate locusts.

The intensity-response characteristics, the frequency sensitivity and the two-tone suppression of the avoidance behaviour are discussed with respect to the auditory physiology of Locust. The involvement of some identified auditory ascending interneurons in the avoidance behaviour is considered (J Exp Biol, 1989). H'FRES V:1.0

considers as non-chemical methods for controlling pests known as the locusts. Utilizing the biopesticide in the agriculture field, it can enhance the growth of the plants where it can contribute to the economic increase. The H’FRES V:1.0 emit high-frequency sounds claim to eliminate the locusts. This high frequency supersonic does not affect the human health or auditory system.

CHAPTER 2

LITERATURE REVIEW

2.1 Green Technology Solutions

The United Nations Sustainable Development Goals (SDGs) for 2030 pose a special challenge to global agriculture (United Nations,2015). While, agriculture should contribute to SDGs 1, 2, and 3 (no poverty, zero hunger, and excellent health and well-being), it must also support SDGs 12, 13, 14, and 15 (responsible consumption and production, climate action, life below water, and life on land). Agriculture, in particular, is one of the most major industries in terms of climate and energy usage. Over the last four decades, as the environmental protection agenda has evolved into the more inclusive objective of sustainable development, clean technologies (CT) have become a significant instrument, especially in agriculture. For example, integrated pest management (Veisi, H ,2012) is a cleaner production method that was developed in the 1970s for pollution prevention and control in agriculture (Robertson, G.P ,2005).Since then, its use has been proved in the majority of nations, with cost reductions ranging from 37% to 53% in South Africa (Urquhart, P ,1999).

2.2 Locusts

Locusts are large insectivorous insects that, because of their ability to create thick and rapidly mobile swarms, can be serious agricultural pests. They are short-horned grasshoppers that form large colonies in dense migration groups on a regular basis, with individuals differing in many ways from those living separately (Simpson & Sword, 2009; Cabej, 2019). It is critical that countries conduct the requisite field surveys and sustain them on a regular basis after extremely heavy rainfall to track breeding conditions and locust infestations. The discovery of large infestations necessitates control operations to prevent a further increase in locust numbers. In order to establish effective strategies for controlling harm, an integrated approach to understanding the conditions that lead to locust build-up and migration is needed (Anstey et al., 2009). The growth and mitigation of locust occur due to 3 factors that are wind, rainfall and temperature.

Controlling locusts is complicated by a number of factors (World Meteorological Organization and Food and Agriculture Organization of the United Nations, 2016):

i. The swarm is highly mobile, migrating from 50 to more than 100 km in a day;
ii. The total invasion period frequently occurs in a relatively brief time, sometimes as short as a month but rarely longer than three months;
iii. The swarms are unevenly distributed in time, so that very large swarms may be available for only a few days, followed by relatively long periods when none is present;
iv. Swarms are variable in size and can extend up to thousands of hectares;
v. Campaign experience, funds and supplies are often lacking in locust-affected countries because of the irregular occurrence of locust upsurges and plagues.

2.2.1 Locusts Life Cycle

A Desert Locust can live for three to five months, but this is highly unpredictable and mostly dependent on weather and environmental factors. There are three stages of the life cycle: embryo, hopper (nymph), and adult (Figure 2.1). The lifetime of a Desert Locust is about three months but this can be extended to up to six months under cold conditions. Depending on the temperature, eggs hatch in around two weeks (the range is 10–65 days). Hoppers shed their skins five to six times, increasing in size each time. This is known as moulting, and the stage between moults is known as an instar. Hoppers mature in about three weeks to nine months, but more often in two to four months, depending on environmental conditions, especially temperature. Adults will stay immature for up to six months if the weather is dry and cold. Adults do not moult, so they do not rise in bulk, but they do gain weight steadily. Any day, an adult locust will consume 2.5 g of its own body weight. Adults that can fly are sexually immature at first, but they mature over time and can copulate and lay eggs. Solitary individuals are still present in the desert, waiting for the right circumstances to mate (World Meteorological Organization and Food and Agriculture Organization of the United Nations, 2016).

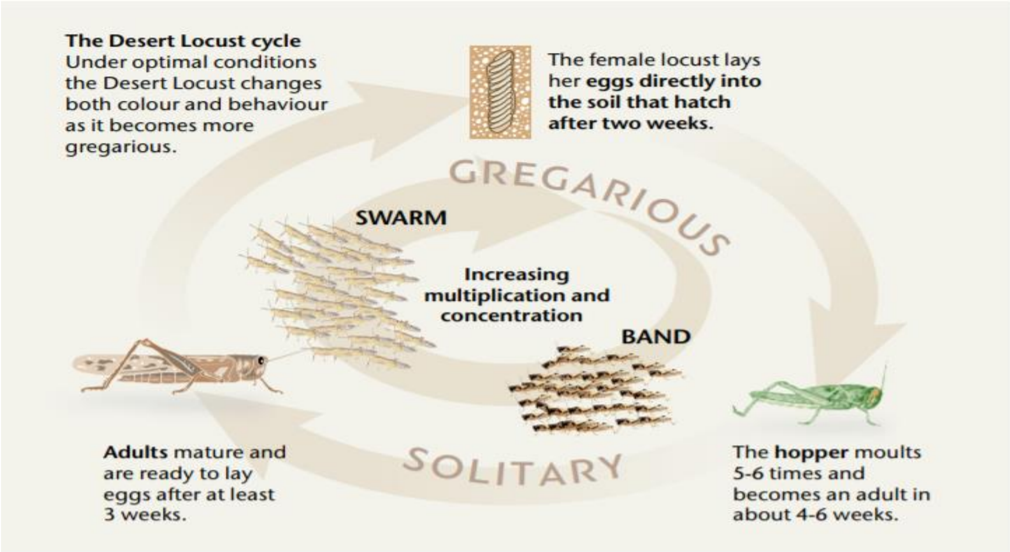

Figure 2.1 Desert Locust life cycle.

Sources: World Meteorological Organization and Food and Agriculture Organization of the United Nations (2016)

2.2.2 Locust Swarm Data

The Locust Hub platform gives users access to location-based data on Hoppers, Bands, Adults, Swarms, ecological environments, and specifics of control operations carried out in different countries (Locust Hub, 2020). Date-time stamp, geolocation metadata, place name, and area affected are all included in the swarm's dataset. The transit routes used by swarms were analysed using locust attack incidents recorded in the news media. The Locust Hub portal was used to retrieve a subset of data about the swarms that oscillated in the Indian subcontinent during the pre, live, and post Amphan cyclonic events.

Region of locust oscillations	Time Period	No. of locust swarms reported
Indo-Pak border and the scheduled Thar desert region	1 Jan to 09 May, 2020	2192
Scheduled Thar desert region in India	10 May to 15 May, 2020	54
Swarms transited through the first conduit	16 May to 21 May, 2020	36
Entry of fresh swarms into the Thar desert region from Pakistan during the living period of Amphan	16 May to 21 May, 2020	22
Swarms transited through the second conduit	22 May, to 28 May, 2020	49

Figure 2.2 Details of swarm sightings at various time periods along Indo-Pak border and the scheduled Thar desert region of India

Sources: Locust Hub (2020)

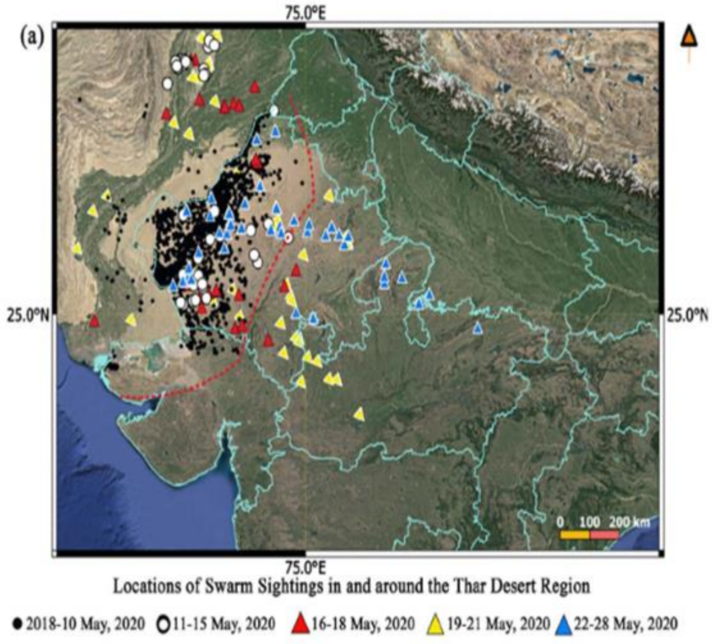

Figure 2.3 Map of Locust swarms in and around the Thar Desert

Sources: Locust Hub (2020)

Figure 2.3 Map showing locations of Locust swarms in and around the Thar Desert during various phases of Amphan cyclone. In this map, archival sightings of the Desert locust till the period of Amphan Cyclone are shown in black dots. Note the movement of swarms towards the Southeast direction during the living period of the Amphan cyclone and towards the Eastern side after the cyclonic episode.

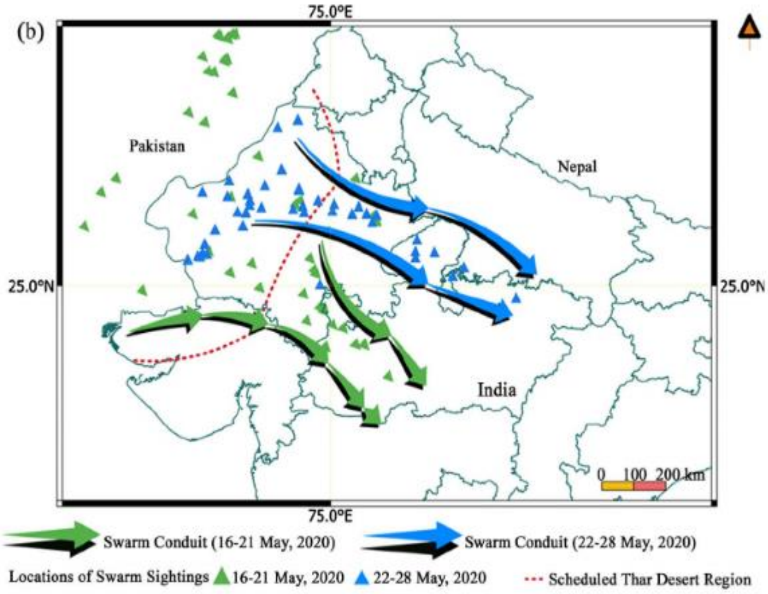

Figure 2.4 Map of swarm conduits

Sources: Locust Hub (2020)

Figure 2.4 Map showing the swarm conduits formed during the living period of Amphan cyclone (green colour conduit) and post cyclonic episode (blue colour conduit). The first conduit favoured the migration of swarms to the south-central parts of India and second conduit favoured migration of swarms to the Indo-Gangetic plane.

2.3 Locust Auditory System

The hearing system of locusts is highly integrated and tiny, with little similarity to either the human ear or an electronic microphone. For survival, locusts must discriminate between low-frequency sound from other locusts and high-frequency sound from predators such as bats (Nanomaterials, 2013).

The desert locust Schistocerca gregaria has significant phenotypic plasticity, exhibiting a trans-generational accumulation of phenotypic change driven by population density fluctuations, and is therefore a well-known example of various morphologies caused by epigenetics (Pener MP,2009). The solitarious and gregarious phases are two extreme phenotypes that differ greatly in behaviour, physiology, and anatomy. Locusts tend to exist in the solitarious phase at low population densities. They have a mysterious appearance and behaviour, moving slowly and with a crawling pace. They deliberately avoid other locusts in most situations, scattering themselves extensively around the habitat. When they fly long distances, they do it at night under the cover of darkness. The gregarious phase is triggered by an increase in population density, which leads to forced interaction with other locusts. Gregarious locusts are very active, with aposematic hue as larvae, and are noticeable in both appearance and behaviour (Sword GA,1999). Most significantly, they actively congregate into vast migratory swarms that might eventually number in the billions. Phase change in the locust happens across a variety of timescales: certain essential behavioural changes happen in a matter of hours, colour changes happen throughout the course of a locust's lifespan, while full morphological change takes numerous generations.

Locust hearing ranges from 1 to 30 kHz (Gopfert MC, Robert D, 2005). Between 4 and 8 kHz, the most tympanal movement and electrophysiological response was seen. We discovered a considerable change in the membrane width between phases in the form of the tympana, which is the initial receiver of sound, with solitarious locusts having broader membranes (table 2.1). The travelling wave occurs in the breadth axis (electronic supplementary material, movies S1–S3). Because tympanal width varied with phase but not length, we assume the membrane's width is preserved with phase and contributes to the travelling wave's higher displacement. Females are bigger than males, and solitarious locusts are larger than gregarious locusts; nevertheless, the lack of a substantial influence of sex on tympanum width implies that this difference is not just a result of the respective body proportions of the two phases. Females have a substantially longer tympanal membrane than men, which we attribute to their bigger stature, which does not appear to be reflected in their hearing capacity. Furthermore, no significant variations in membrane mobility or electrical response were found between the sexes. Finally, the electrophysiological response of the auditory receptor neuron is caused by the membrane's displacement from the travelling wave (Shira D. Gordon,2014).

Both the long-term development of body morphology moulding the anatomy of the tympanum and the qualities of the auditory afferents innervating it determine locust auditory ability. As a result, the features of their hearing that don't change are likewise interesting as a preserved element that isn't affected by phenotypic plasticity. The greatest sensitivity of both morphologies is about 4–8 kHz (Table 2.1), which might be significant for avoiding bird predators or for a historical role of hearing mating calls.

Table 2.1 Auditory differences between solitarious and gregarious locusts

	Solitarious	**Gregarious**
Tympanal Anatomy	7.5% wide : 1.56 ± 0.04mm Affects the travelling wave	wide : 1.45 ± 0.02mm lenghth: no significant difference
Tympanal Biomechanics	Peak displacement 4-7 kHz Larger membrane displacement (e.g.0.31±0.06 μm Pa^{-1} at 5kHz)	Peak displacement 4-7 kHz Smaller membrane displacement - Needs 6 dB louder sound to more as such as solitarious
Neurophsiology	Peak responcr 4-8 kHz Greater response at lower sound levels across frequencies	Peak responcr 4-8 kHz Shorter latency,faster response,for lower frequencies

Source: Shira D. Gordon, 2014

2.4 High Supersonic Frequency

Beyond roughly 2kHz, supersonic waves are found to be dominant, although the frequency does not indicate a cut-off for supersonic waves, nor does it represent a cut-off for sonic waves. The predominant sound speed is the typical value of 340 m/s, which was previously characterised as a "trivial" solution for membrane dynamics. The intermediate frequency spans from 500 Hz to the supersonic cut-on frequency. This is in line with the predicted finding of subsonic waves on the membrane experiencing a fast spatial fading rate. The frequency with which this singularity occurs is solely determined by the mass ratio, and the results are in good accord with experimental evidence. Waves moving at supersonic speeds behave similarly to high-order modes in a stiff duct, in which sound waves advance in a zig-zag pattern with supersonic axial wave speed (Huang, 2000). It's supersonic, meaning it's quicker than the speed of sound! Originally, supersonic meant "having to do with sound waves beyond human hearing," but by 1934, it was used to indicate movement faster than the speed of sound, with ultrasonic reverting to its original definition. Sonic is derived from the Latin word sonus, which means "sound."

Ultrasonic sound waves have a frequency more than 20,000 Hz per second, which is above the human hearing range. The velocity divided by the frequency equals the particular wavelength. Supersonic speed, often known as Mach 1, is the rate of travel that exceeds the speed of sound (Dannehl, 2020).

2.5 Proposed method is focusing on avoiding pesticides and killing the insects in harmless way by using insect killing methodology.

Table 2.2 Proposed Method

Paper/Author	Title Pest killing	Methodology	Power and Cost
Dr. Dhiraj Sunehra Solar Energy Driven	Mosquito Repeller System Using Arduino Uno	Using Oscillator for repeller system and real time clock for on/off.	Consume less power
P. Vijayakumar, C.Akshith Reddy, M.L. Sai Shivani Aahwanik, Sai Varshith,R. Krishnaprasanna, M.Tamilselvi, R. Rajashree,Xiao-Zhi Gao	IoT Based Smart Mosquito Killing System	Using a ultrasonic sensor,UV light and electric fence, DC fan and a mosquito liquidator	High cost and consume more power
A.M. Gavhande*, S.R.Kalbande and V.P.Khambalkar	Development of Eco-Friendly Solar Photovoltaic Insect Light Trap for Pest Control	Solar photovoltaic insect light trap was economically viable and could be used for controlling the insect and pest population	Low cost and consumes less power.

2.6 Arduino Uno Board

Arduino Uno is a microcontroller board based on the ATmega328P (Figure 2.4). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogy inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

2.6.1 Salient Features of Arduino Uno

The salient features of ATmega328P microcontroller are given below:

i. Advanced RISC architecture
ii. 131 powerful instructions – most single clock cycle execution
iii. 32 x 8 general purpose working registers
iv. 1Kbytes EEPROM
v. 2Kbytes internal SRAM
vi. High performance, low power AVR® 8-bit microcontroller
vii. 23 programmable I/O lines

Peripheral features:

i. Two 8-bit Timer/Counters with separate prescaler and compare mode
ii. One 16-bit Timer/Counter with separate prescaler, compare mode, and capture mode
iii. Real time counter with separate oscillator
iv. Six PWM channels

Operating voltage:

i. 2.7V to 5.5V for ATmega328P

Temperature range:

i. Automotive temperature range: –40°C to +125°C

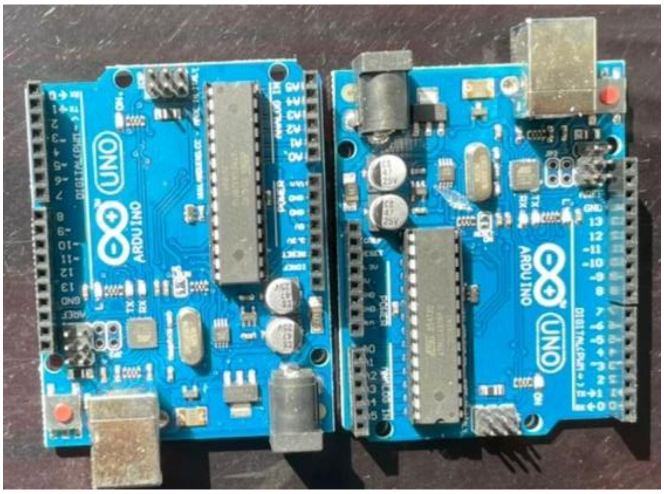

Figure 2.5 Arduino Uno Board

2.7 Solar Panel

Solar panels function as light-to-electricity converters (Figure 2.5). Because the Sun, also known as Sol by astronomers, is the most powerful source of light accessible most of the time, they are dubbed "solar" panels. Solar cells are the components of a solar panel. Photons remove electrons from their atoms when they impact a solar cell. When conductors are attached to the positive and negative sides of a cell, an electrical circuit is established. Electricity is created when electrons travel across such a circuit. A solar panel is made up of several cells, while a solar array is made up of many panels (modules). The more panels you can put up, the more energy you'll be able to produce. Photovoltaic (PV) panels are solar panels that create direct current (DC) power. Electrons move in one way around a circuit with DC power. The electrons travel from the negative side of the battery to the positive side after passing through the load.

Figure 2.6 Solar Panel

2.8 Rechargeable SMF Battery

A 12 V rechargeable sealed maintenance free (SMF) battery powers the system. For a range of applications, SMF batteries are designed to offer stable, consistent, and low-maintenance power. These batteries may be utilised for deep-cycle applications in rural and power-deficient locations and need minimum maintenance.

Figure 2.7 Rechargeable battery

2.9 Insect Sound Detector

While there are various alternative techniques for detecting flying insects, this circuit will employ a Microcontroller's computing capacity to turn on an LED when a certain frequency is identified. Flies, bees, and wasps all emit a buzz with a frequency of 150Hz to 250Hz, which may be detected by a Microcontroller. The microphone amplifier and the primary Microcontroller controller are the two essential components that make this design work. As a result, the initial step is to amplify the detected audio so that the Microcontroller can work with it easily.

2.10 Supersonic Frequency Generator

The Arduino receives the analogue data from the potentiometer and translates it to a frequency that the supersonic frequency (in the 20–2000 Hz range) can play. At lower and higher frequencies, the software gives thresholds. The frequency being played at the time is displayed on the display. I used a trimmer to modify the display contrast (it normally doesn't show much at first since the contrast is too high, so it has to be corrected). The potentiometer is a 10Kohm linear, and it works well in this range, but the initial range (0–1024) was too low, therefore It increased the scale on the software. The 16x2 display was driven by the LiquidCrystal library, while the supersonic frequency sound was generated by the Arduino Sketch built-in library "Sound." It may be used to learn how to make synth sounds or to create a real synth with additional controls for modifying the fundamental square wave and adding loops, similar to a sequencer.

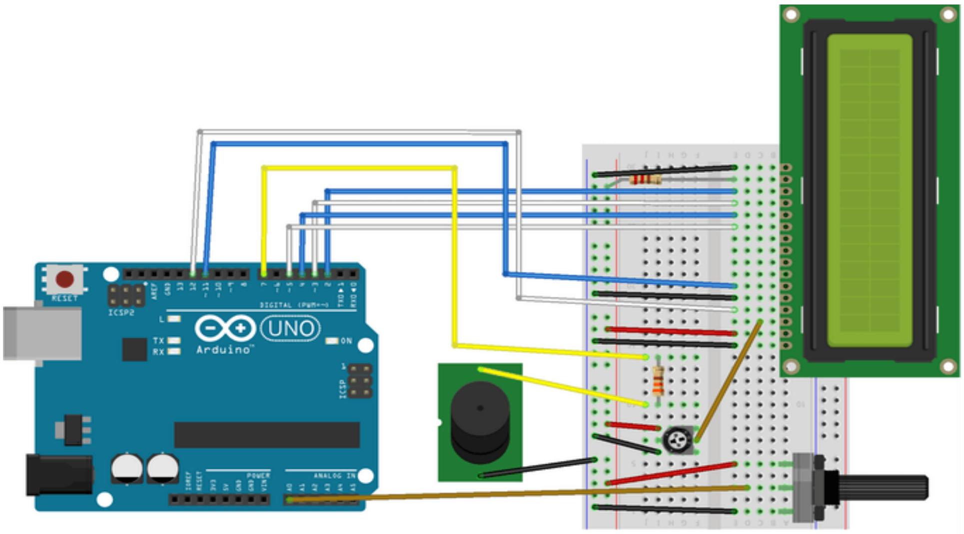

Figure 2.8 Supersonic Frequency Generator

2.11 LED Strip Light

An LED strip light is a form of electric light that uses light-emitting diodes to produce light (LEDs). LED lamps use substantially less energy than comparable incandescent bulbs and are often more efficient than fluorescent bulbs. The most efficient LED strip lights on the market have 200 lumens per watt (Lm/W) efficiency. In comparison to incandescent bulbs, commercial LED strip lights have a substantially longer lifespan.

Figure 2.9 LED Strip Light

2.12 LDR Sensor

Photoresistors are also known as Light Dependent Resistors (LDR). They're constructed of a semiconductor material with a high resistance. When light strikes the gadget, photons provide energy to electrons. They then leap into the conductive band and conduct electricity as a result. It functions on the basis of photo conductivity. Photo conductivity is an optical phenomenon in which the conductivity (and hence resistivity) of a substance decrease as light is absorbed by it.

Figure 2.10 LDR Sensor

2.13 Software Tools

2.13.1 Arduino IDE

The Arduino Integrated Development Environment (IDE) is a programme that lets us create, build, and upload code to the Arduino board. An integrated development environment (IDE) is a piece of software that helps with code editing, compilation, and debugging. The Arduino IDE is a Java-based software programme. The Arduino IDE offers built-in functions and instructions that are customised to operate on the Arduino development board while operating on the Java platform. As a result, the Arduino IDE is used to edit, build, debug, and burn code to the Arduino board.

Figure 2.11 Arduino IDE Software

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

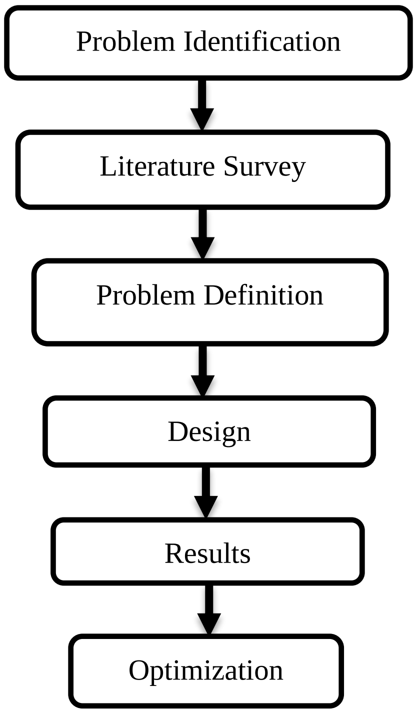

Figure 3.1 Methodology

The methodology consists of a few phases that have been encountered when developing the component prototype. The first step is to identify the problem by analysing the present condition. The primary issue is the usage of insecticides and pesticides to prevent locusts and pests from destroying crops. However, by utilising these, humans and the environment are exposed to potentially negative impacts. These pesticides are costly, and the agricultural production steadily declines, generating environmental issues such as air pollution, soil contamination, and water pollution. Nevertheless, in order to minimise some of these difficulties and find an alternative usage to prevent these locusts and pests, the next step is to look for and collect information on whether there are any substitutes accessible to manage the locusts.

Based on an exhaustive literature review of contemporary methodologies and the whole experimental effort in this study is presented in Figure 3.2. The H’FRES V:1.0 research is experimental research. The purpose is, waves the potential of high supersonic frequency for locusts’ elimination evaluated with different ranges. Therefore, H'FRES V:1.0 are combination of solar panel, rechargeable battery, supersonic frequency generator, LED strip light, sound sensor with Arduino. Solar cells are used to change solar energy to electric energy and change to battery for pest H'FRES V:1.0. The LED strip light, automatically turn off at the night light at dawn, and turn on the night light automatically at dark. However, during the daytime, the locusts will fly towards the product as the insects has the tendency to assume that the product is their predator. This attracts the locusts towards the product. The sound sensor with Arduino activates the supersonic frequency which produce sound waves emitted in 360° full surround, no dead angles when the green insects is at certain distance. This product consumes low power from solar panel which function’s 24 hours per day. After that, bring the trap to test the effectiveness and results of H'FRES V:1.0 in agricultural areas.

Following the definition of the problem, computed assisted design modelling is performed based on the dimensions and computations. Following the acquisition of the equipment's components, fabrication and assembly are finished. The final and most critical stage of the project is optimization. The completed and operational model is evaluated and adjusted by deploying it in crop fields.

3.2 Working Description

The circuit can be divided into these basic components.

3.2.1 Sound Sensor

The sound sensor is used to detect sounds in the low to high frequency range, such as those below 20Hz. When the animals emit a low-frequency sound that is close to the farm, human ears are unable to hear it. When we use a sound and ultrasonic sensor, it will detect noises below 20Hz and above that of animals, and then send a command to people via a buzzer, similar to an alert. Many agriculture farms have been afflicted by locusts, which will devastate the crops in a short period of time. When it detects the range of noises, it sends a command signal to the Arduino board, which turns on the buzzer. When Buzzer will on automatically locusts will run out of the farm because of the sound of buzzer.

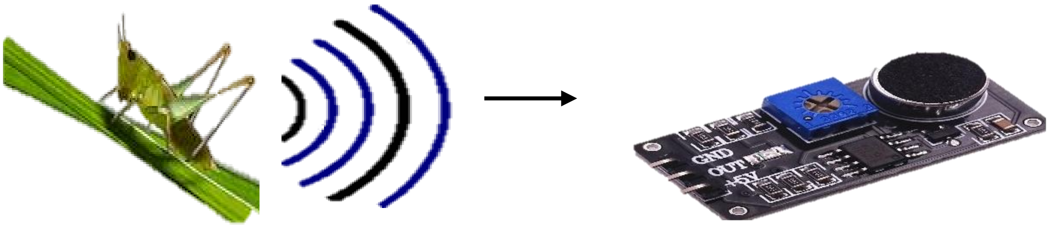

Figure 3.2 Detect sounds in the frequency range

3.2.2 Supersonic Frequency generation

When it detects the range of noises, it sends a command signal to the Arduino board, which turns on the buzzer. The Arduino receives the analogue data from the potentiometer and translates it to a frequency that the supersonic frequency (in the 20–2000 Hz range) can play. At lower and higher frequencies, the software gives thresholds.

The frequency being played at the time is displayed on the display. I used a trimmer to modify the display contrast (it normally doesn't show much at first since the contrast is too high, so it has to be corrected). The potentiometer is a 10Kohm linear, and it works well in this range, but the initial range (0–1024) was too low, therefore I increased the scale on the programme. The 16x2 display was driven by the LiquidCrystal library, while the supersonic frequency sound was generated by the Arduino Sketch built-in library "Sound." It may be used to learn synth music or to construct a full synth with additional controls for modifying the fundamental square wave and looping, similar to a sequencer. When the buzzer goes off, locusts will flee the farm and their auditory nerve system will be affected, leading their physiological system to become disorganised, irritated, lose appetite, and eventually die as a result of the buzzer's sound.

3.2.3 Flow Chart

The flowchart of the above sequence of events occurs Arduino is linked to a sound sensor that detects sounds below and above 20Hz of the locust's voice. Another Arduino is linked to an LDR-enabled LED strip lamp. When sunlight is detected, the LED light is turned off, and when dark light is detected, the LED light system is turned on.

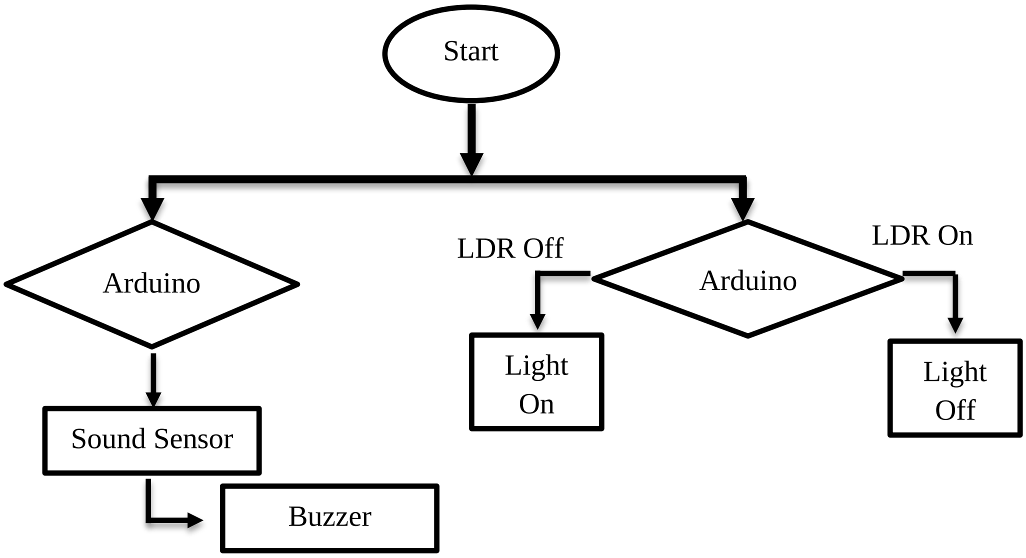

Figure 3.3 Flow chart of H’FRES V:1.0 system

A solar trap is a device that uses sun radiation to catch pest locusts in agricultural areas. The schematic illustration of a solar trap is presented in Figure 3.4 above. Solar cells are an effective technique to harness the sun's energy; they turn the sun's energy into electricity. When sunlight strikes the surface of solar panels, components of the light are absorbed by silicon and converted into electrical energy. The battery then stores the electricity created by the sunshine and discharges it using the H'FRES V:1.0 mechanism.

3.3 Locusts set up

Grasshoppers were captured in the Lorong Mawar Kampung Mahkota region of Kuantan for this investigation. In a plastic container with dimensions of 603030cm, about 100 locusts and grasshoppers are housed. Individuals for this study were captured around 2 weeks after their last moult from congested colonies. The average temperature in the terrarium is 26 2°C (mean SD) at night and 33 2°C (mean SD) during the day, with a light/dark cycle of 12:12h. It's 45–60 percent relative humidity.

Figure 3.4 Grasshopper Collection Process

3.4 Insects killing method

` Figure 3.2 shows the block diagram of a solar energy driven for H’FRES V1.0 system. It consists of a power supply unit having a solar panel and rechargeable battery which supplies power to the Arduino Uno and H’FRES V1.0 system is attached with it. The H’FRES V1.0 consists of sound generator with LCD display to design the system capable of producing sound in the selector with the ability to change the mini piezo buzzer frequency by a potentiometer and to see the result on a 16x2 display and under center with lamp.

In this technology, H'FRES V:1.0 uses modern microelectronics technology to directly use special supersonic frequency and electromagnetic waves to act on the auditory nervous system of green insects, causing their physiological system to become disordered, irritable, lose appetite, and then gradually die. The potential of high supersonic frequency for locusts’ elimination evaluated with different ranges.

By using this methodology locusts are going to be kill by applying voltage H’FRES V1.0 system. The Arduino is mainly focusing on how switching between battery to H’FRES V1.0 and LED light using Light dependent resistor is used to detect the sun light and when there is no sunlight by the time automatically LED light will activate by using this LDR sensor. Arduino provides necessary power to drive the LDR, relay driver and necessary voltage will apply on lamp.

The sound sensor is used to detect the insects sound and control will pass to Arduino and produce supersonic sound by mini piezo buzzer with sound generator with LCD display to produce the different patterns of frequencies. The sound sensor with

Arduino activates the supersonic frequency which produce sound waves emitted in 360° full surround, no dead angles when the green insects is at certain distance.

This product consumes low power from solar panel which function's 24 hours per day. LDR is mainly used to detect the light, when sunlight is detected LED light is OFF, when dark light is detected LED light system is ON.

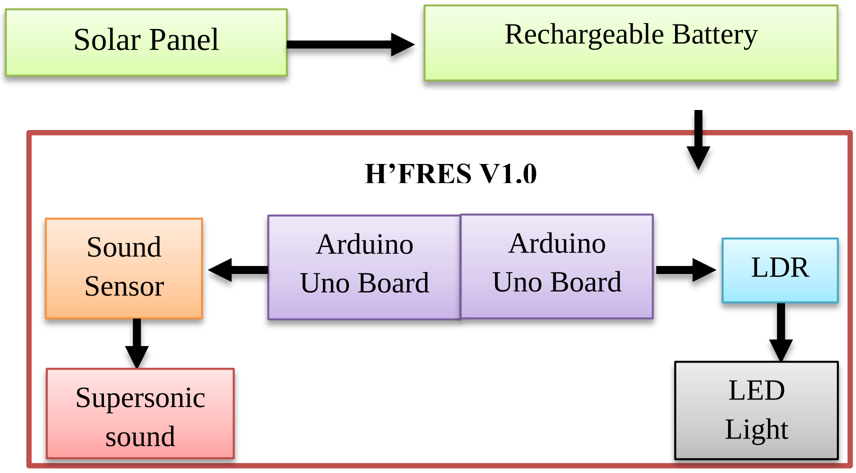

Figure 3.5 Block Diagram of H'FRES V1.0

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Implementation of H’RES V:1.0

The suggested system incorporates a supersonic frequency generator, LED strip lighting, and a sound sensor. The Arduino Uno is used to link all of these devices. This information may be examined in the Arduino Uno's terminal. The system is set up in the following manner.

i. Sound sensor

ii. Supersonic frequency generator

iii. LED strip light

Figure 4.1 H’FRES V:1.0

This section discusses the results of the H’FRES V:1.0. Figure 4.1 shows the testing of H’FRES V:1.0 in the fields.

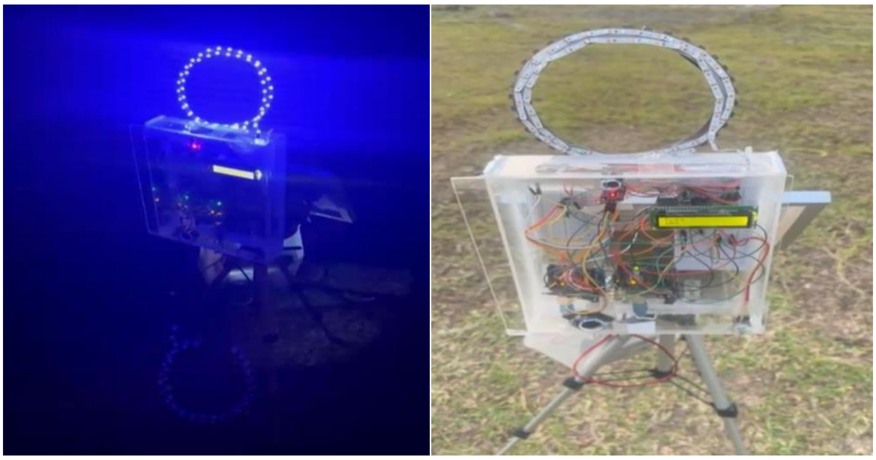

Figure 4.2 (a) Figure 4.2 (b)

Figure 4.2 (a) turn on the night light automatically at dark, (b) Automatically turn off the night light at dawn

When the LED light is turned on, the results are shown in Figure 4.1 (a). Keep in mind that if the LDR is turned on, the lamp will turn off, and if the LDR is turned off, the lamp will turn on. To test the system, a tiny tester is used to switch on and off the room light instead of automatically turning off and on the night light at dawn and dark.

The sound sensor is depicted in Figure 4.3 below. It will detect frequencies below 20Hz and above 20Hz. The sensor's working voltage is merely 5V, so it doesn't require any additional power and can be powered straight from an Arduino Uno.

Figure 4.3 Sound Sensor

Figure 4.4 demonstrates how the Arduino takes analogue input from the potentiometer and changes it to a frequency that the supersonic frequency (in the 20–2000 Hz range) can play. At lower and higher frequencies, the software gives thresholds.

When it detects the range of noises, it sends a command signal to the Arduino board, which turns on the buzzer.

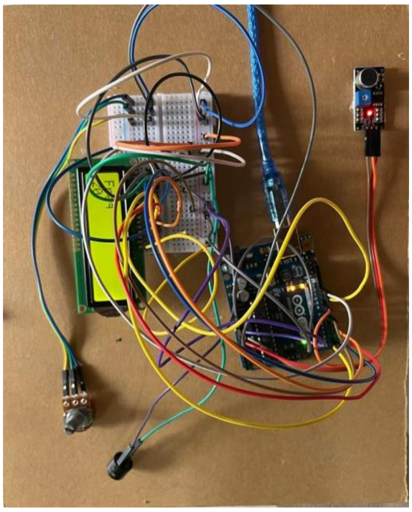

Figure 4.4 Sound sensor and supersonic frequency generator are combined in this circuit.

Figure 4.5 illustrates the Arduino Uno with system components such as an LED light, a sound sensor, and a supersonic frequency generator.

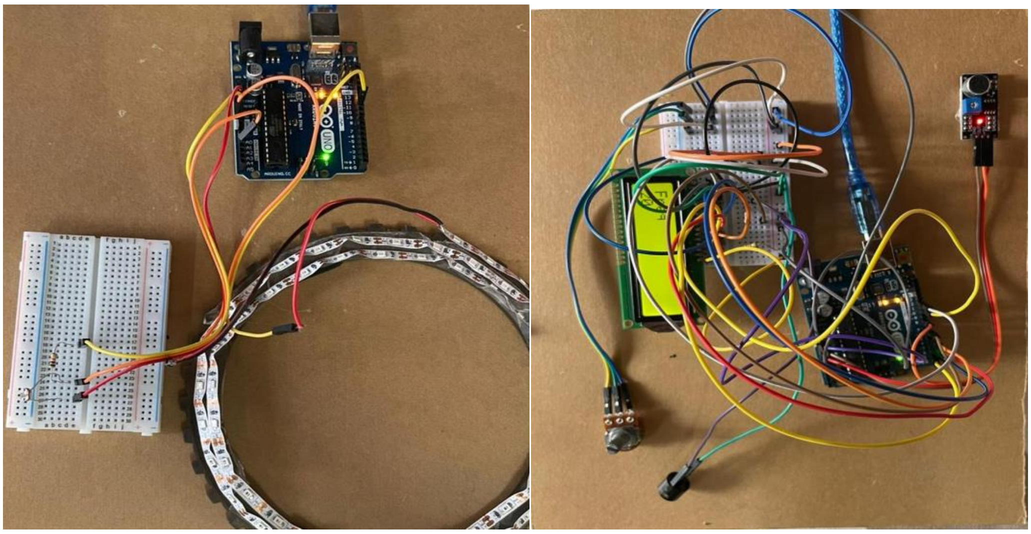

Figure 4.5 H'FRES V:1.0 System

Figure 4.6 shows the system components, which include an LED light, a sound sensor, and a supersonic frequency generator controlled by an Arduino Uno, as well as the power source, which includes a solar panel and a rechargeable battery.

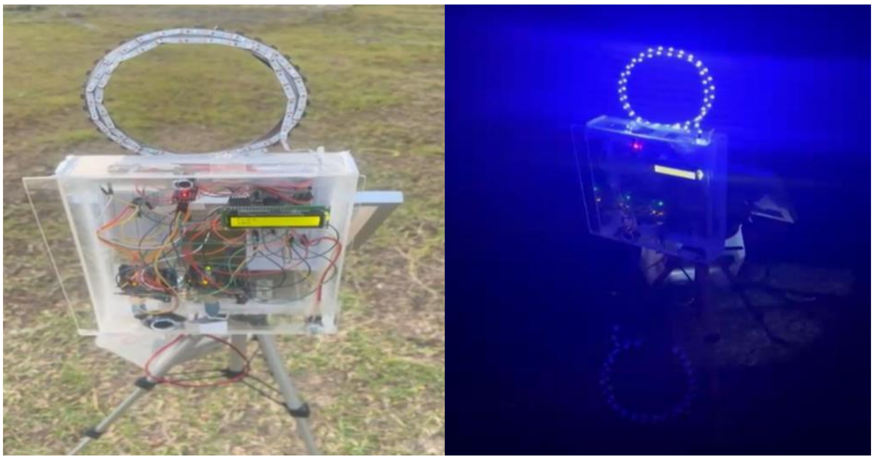

Figure 4.6 H'FRES V:1.0 System with Solar Panel

Table 4.1 Arduino pin connections in LED strip light circuit

Sensor pin	Arduino board pin
LDR pin	5V
Resistor (1k ohm)	A0, GND
Led strip light	10, GND

Table 4.2 Arduino pin connections in supersonic frequency generator and sound sensor circuit

Sensor pin	Arduino board pin
Liquid Crystal LCD	12, 11, 5, 4, 3, 2
Frequency adjust Sensor Pin	A0
Buzzer	7, GND
Sound Sensor Pin	8

The explanation of H'FRES V:1.0 system function is demonstrated in Figure 4.4. Aside from that, table 4.3 demonstrates how the H'FRES V:1.0 system functions in terms of all component attract.

Table 4.3 H'FRES V:1.0 System

LDR is OFF	Daytime bright illumination	Light is OFF	Battery charging
LDR is ON	Night-time dark illumination	Light is ON	Battery discharging

Sound Sensor	Night and day time detecting sound below and above 20hz	H'FRES V1.0 is ON	Sound detected buzzer ON

Figure 4.7 (a) shown in order to test the locust attraction capability, the LED strip light to attract locusts using light distribution patterns, the 5W LED strip light bar. Distribution curves of LED deployment are shown in Figure 4.7 (b). The results indicate that the beam divergence angle increased from 135 to 160 degrees, whereas the output light power decreased.

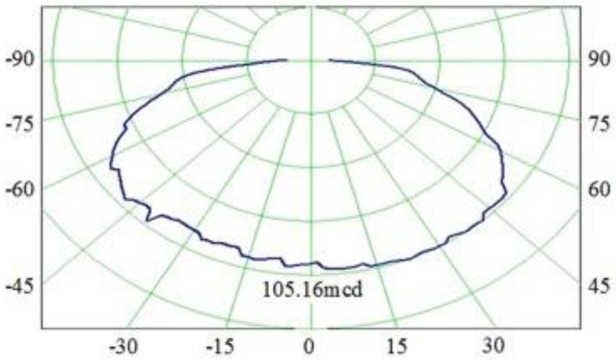

Figure 4.7 (a) Figure 4.7 (b)

Figure 4.7 (a) The module of LED light, Figure 4.7 (b) The 2D luminous intensity distribution curves of the module of LED with lens (Unit: mcd/Klm).

Figure 4.8 shows the status in the serial monitor of Arduino when the LED strip light system is ON. Observe that the turn on the night light automatically at dark and automatically turn off the night light at dawn.

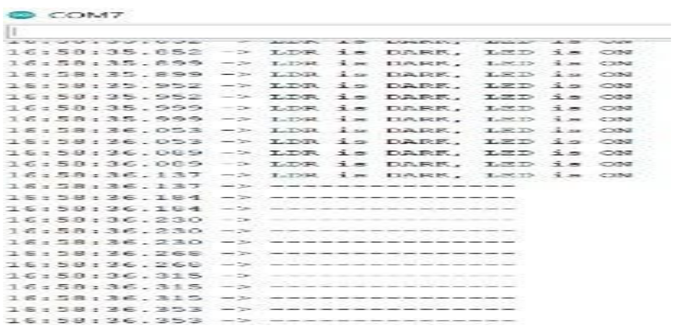

Figure 4.8 Status of LED strip light displayed in serial monitor as 'LDR is DARK, LED is ON' and '---------------'.

4.2 Analysis of Data

The trial free-flying locusts and examined reactions to sound frequencies ranging from 20 to 2000 Hz (Table 4.4 in the "Methods" section), measured at the centre of the clear container, which was situated 12.5 cm from the buzzer. Employed the highest sound level to analyse the impact of sound frequency to ensure a high potential of finding a noticeable reaction. The tests that follow look at the effect of sound pressure on the response. In addition, the reaction of locusts identified by the potential of a high supersonic frequency will be compared to different ranges (Table 4.4).

Table 4.4 Test conditions for the study of acoustic wave frequency effect on locust's flight.

Range of supersonic frequency (Hz)
20-400
401-800
801-1200
1201-1600
1600-2000

Locusts increased their flying speed across a wide range of sound frequencies between 401 and 800 Hz. At 1600 and 2000 Hz, the largest reaction was found. The flying speed rose by little over 100% for these two frequencies. The piezo behavioral reaction at these two frequencies was essentially identical within the statistical variation of our results. The reaction of locusts reached its maximum roughly 200 ms after stimulus start and thereafter decayed in the majority of cases where a meaningful increase in speed was seen. For frequencies that evoked a robust reaction, the rate of decline was slower.

Table 4.5 The primary measures of the piezo behavioral response in the current investigation are summarised.

Range of supersonic frequency (Hz)	**Most effective frequency (Hz)**	**Largest flight speed increase (%)**	**Time to maximum response (ms)**
20-400	0	0	~ 200
401-800	660-800	+ 60	~ 100
801-1200	801-1200	+ 95	~ 50
1201-1600	1201-1600	+ 95	~ 50
1600-2000	1600-2000	100	~ 50

The frequency was changed from 20 to 2000 Hz measured 12.5 cm from a centrally-located buzzer to determine the sensitivity of the piezo behavioural response to sound. The experimental design decision of 12.5 cm was influenced by the size of the facility where the studies were conducted. It may limit locust flying and chose the highest frequency to explore the effect of sound frequency to ensure a high possibility of finding a meaningful reaction. To evaluate the magnitude of sound frequency on flight response, the sound frequency level was changed between 20 and 2000 Hz. The air flow frequency conveyed by sound pressure is estimated to be roughly 0.1–7 mm/s; because this is three orders of magnitude less than the locust flying speed, the effect of sound wind gust is minimal.

One of its goals of this study was to evaluated the repellence effects of H'FRES V:1.0 on locust biological control. To make the comparison relevant, the difference frequency between the locusts in the "effect of sound supersonic frequency" research had to be chosen with the sound frequency level varying between 20 Hz to 2000 Hz. In Figure 4.9, the most effective frequency (Hz) is shown against the range of supersonic frequency (Hz).

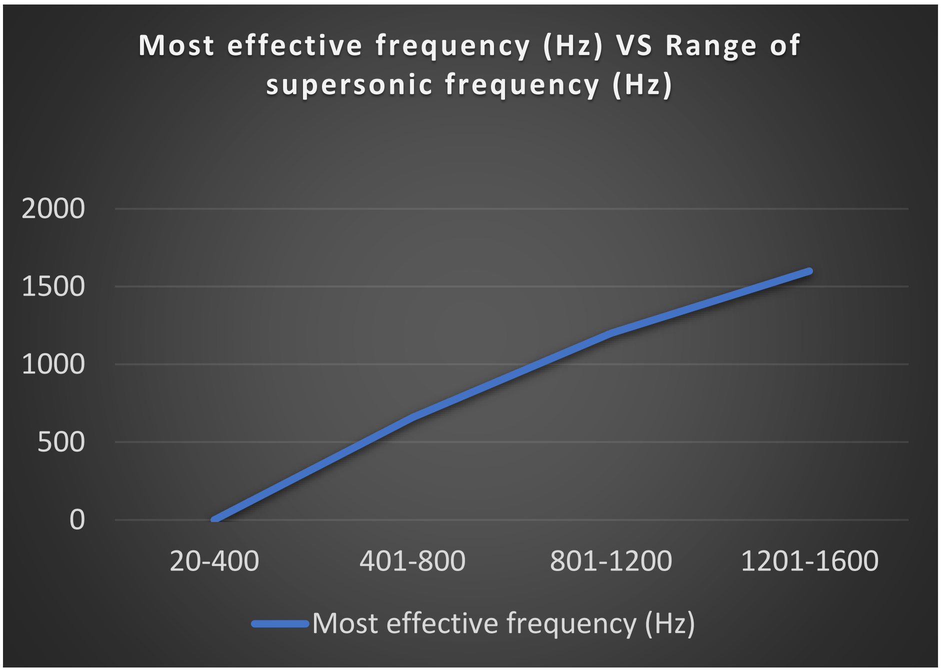

Figure 4.9 The most effective frequency (Hz) is shown against the range of supersonic frequency (Hz).

Additionally, the effectiveness of H'FRES V:1.0 (High Supersonic Frequency) in eradicating locust populations was explored, and the acoustic reaction of locusts, free-flying locusts to accidental sound was effectively proven and estimated. Quantitatively shown that locusts display piezo behavioural responses to sound frequencies, and identified the sonic frequency ranges that trigger the reaction. Similarly, 801 to 1200 Hz were chosen to investigate the influence of sound frequency on locust reaction. Independent tests were carried out in each test condition, and each batch of locusts was given ample time (=> 50 minutes). In Figure 4.10, the normalised flight speeds were plotted versus the range of supersonic frequency (Hz). In Figure 4.11, the time to maximum response (ms) was also plotted versus the range of supersonic frequency (Hz) over separate studies.

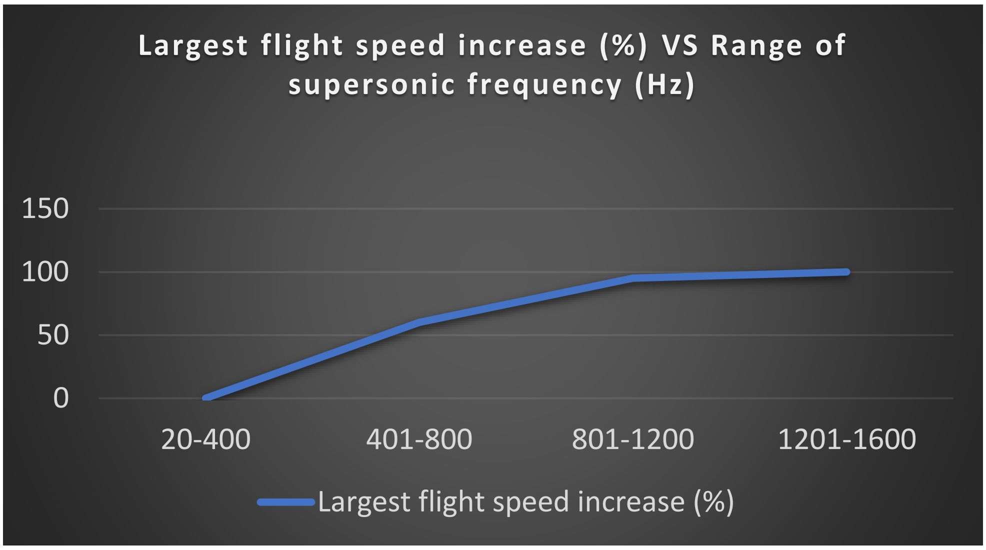

Figure 4.10 The normalized flight speeds were plotted against range of supersonic frequency (Hz).

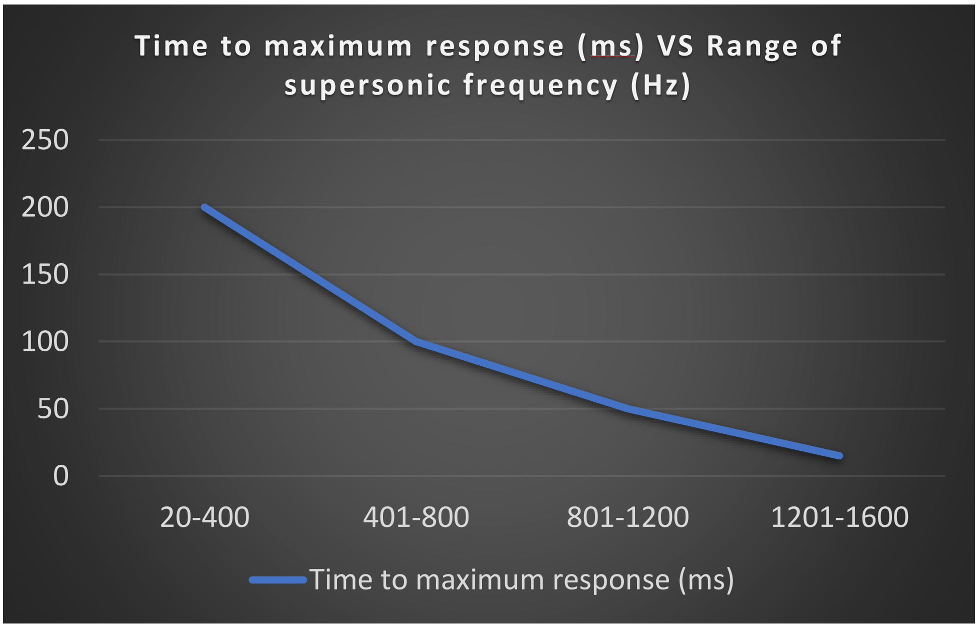

Figure 4.11 Time to maximum response (ms) against the range of supersonic frequency (Hz) over independent experiments.

Most importantly, the objective was achieved where project able to develop solar energy-based H'FRES V:1.0 (High Supersonic Frequency) system. Important results include with harnessing the solar energy using solar panel and storing the energy with the help of battery. The stored energy is used to lighting the LED strip light automatically turn off the night light at dawn, and turn on the night light automatically at dark. However, during the daytime, the locusts will fly towards the product as the locusts has the tendency to assume that the product is their predator. This attracts the locusts towards the product. The buzzer works when the sound sensor detects locust noise. Even with its eco-friendliness and low-cost engagement, it helps both farmers and agricultural professionals. The H'FRES V:1.0 system model will be extremely successful in controlling locusts, which typically cause harm to developing plants. By using green revolution technology in agriculture fields, we can provide vital safeguards to nature by delivering chemical-free nature.

Finally, the functionality of HFRES V1.0 is important for comparing the piezo behavioural reaction. These findings imply that the response observed here is an exaggerated form of the startle response, which for high sound strengths at sensitive frequencies can last for several seconds, if not longer. It would be fascinating to study locust flying, precopulatory, and mating behaviour following the auditory stimulus for an extended period of time.

CHAPTER 5

CONCLUSION

5.1 Introduction

In this study, a solar energy driven H’FRES V:1.0 system has been implemented. This system can effectively replace the chemical repellents which affect the environment. The designed system consumes very less power and can be effectively used in lawns and environment parks to repel the locusts. As a future work, this H’FRES V:1.0 system can be replaced by a highly efficient high power repeller, so that it can cover more area and can be used to repel locusts and various type of insects from farms.

5.2 Locusts Substitution

Grasshoppers are classified as single activity insects, whereas locusts are classified as swamp activity insects (group). In this experiment, grasshoppers were utilised in a variety of groups to replace the qualities of locusts in each group. As a result, the reaction of grasshoppers in the group was obtained in substitution of locusts utilising the H'FRES V:1:0.

5.3 Proposed H’FRES V:1.0 System

Proposed method is used to elimination the population of locusts by act on the auditory nervous system of locust insects, causing their physiological system to become disordered, irritable, lose appetite, and then gradually die. Here, in this system combination of solar panel, rechargeable battery, supersonic frequency generator, LED strip light, sound sensor with Arduino is used to might cause them dizziness and have higher tendency to be killed which makes the system more efficient. Using that, the system also can be controlled LED strip light by auto switching it on and off. In this, it can be supersonic frequency which produce sound waves emitted in 360° full surround, no dead angles when the green insects are at certain distance. This product consumes low power from solar panel which function’s 24 hours per day. This solar energy-based H’FRES V:1.0 research chose general materials to be adapted for pest trapping such as electronic insect trap and clear acrylic board. Then simple design was created for easily teach to farmers. The applied technology should be improved to minimize side effects on non-target species in locusts’ ecosystems. A new system for elimination locusts is developed to tackle the issues present in the current systems used in our day-to-day life. This system would help reduce problems of locusts and various types of insect pests that harm crops and result in loss of productivity each year. Future work into this system could include a better system for locusts which will be able to selectively toggle other units if any locusts is eliminated.

5.4 Status of H’FRES V1:0 Innovation

Technology Readiness Levels (TRLs) are a means for evaluating a technology's technical maturity throughout its acquisition phase, according to TWI independent research and technology organization. TRLs provide engineers with a constant point of reference for understanding the progress of technology, regardless of their technical background. TRLs assess a technology's maturity level as it progresses through the research, development, and deployment phases. TRLs are assigned on a scale of 1 to 9, with nine being the most developed technology. Due to time constraints, H'FRES V:1.0 inovation technology readiness level TRL is presently only TRL 3, which is at experimental proof of concept. H'FRES V:1.0 is a successful research and development project that began with investigations and measurements to validate analytical forecasts.

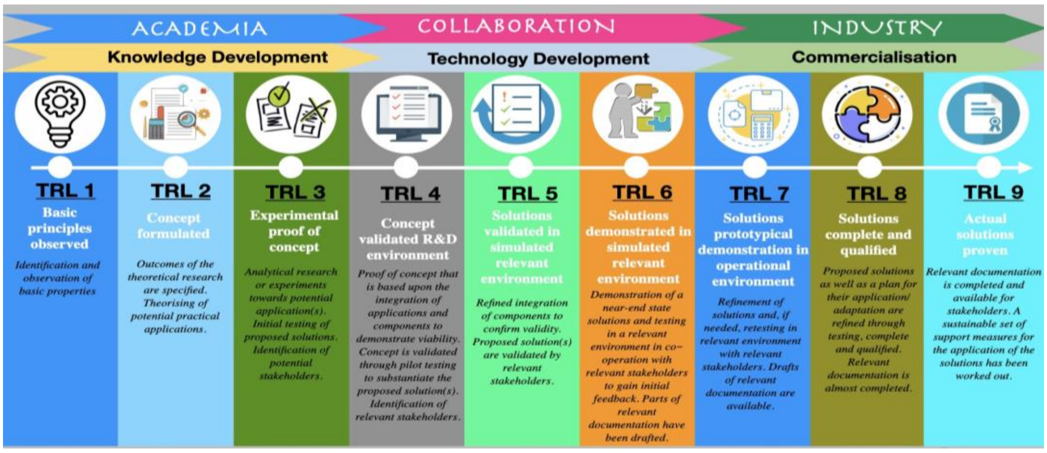

Figure 5.1 Technology Readiness Level (TRL)

Source: University Utara Malaysia

5.5 Sustainable Development Goals (SDGs)

In the nutshell, it can be concluded that H'FRES V:1.0 innovation has successfully achieved the seventh of sustainable development goal SDG that is highlighted by united nations which is affordable and clean energy. Imagine if one farmer that use H'FRES V:1.0 products give a lot of benefits to avoid agriculture continues to be chastised for its negative environmental impact, resource efficiency and clean technology adoption become increasingly critical.

Figure 5.2 The seventeen Sustainable Development Goals (SDGs)

Sources: Highlighted By United Nations

The seventeen Sustainable Development Goals (SDGs) are "our shared vision of humanity and a social contract between the world's leaders and the people," UN Secretary-General Ban Ki-moon said of the 2030 Agenda for Sustainable Development, which was adopted unanimously by 193 Heads of State and other top leaders at a summit at UN Headquarters in New York in September.

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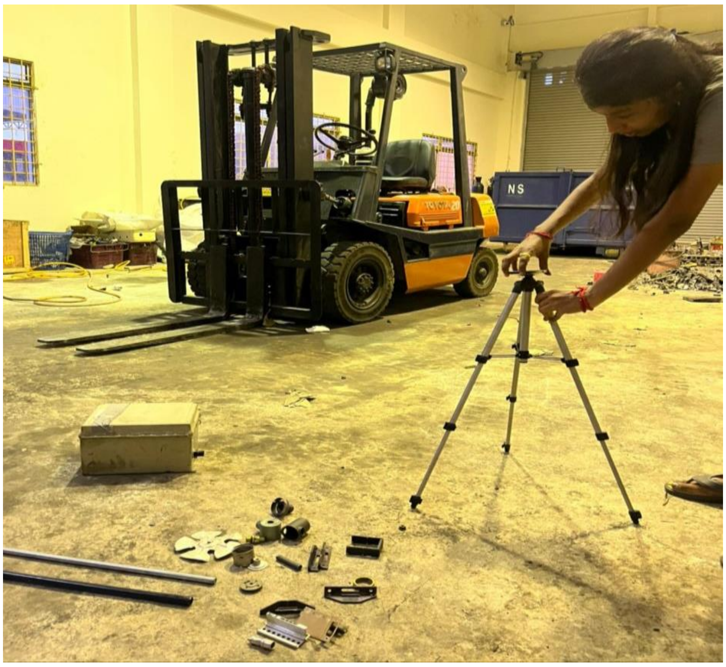
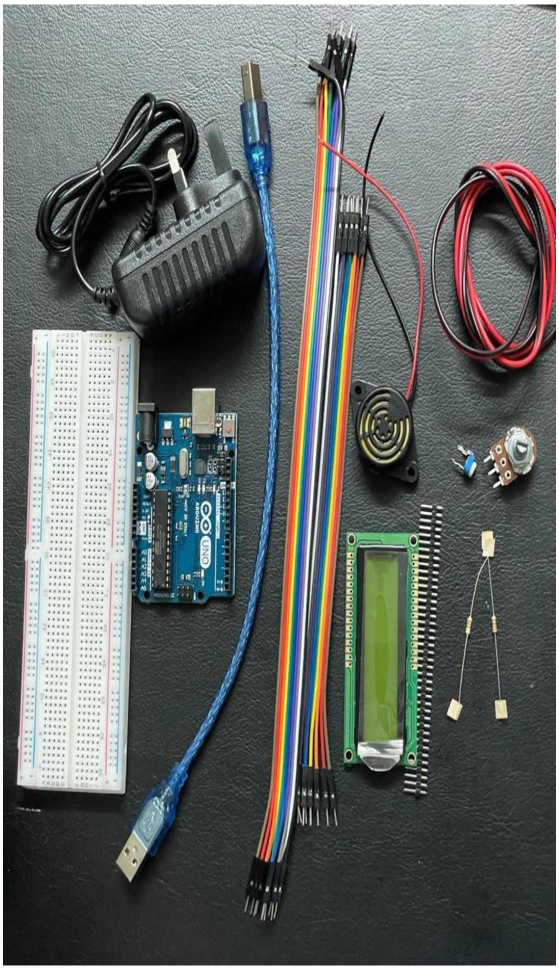
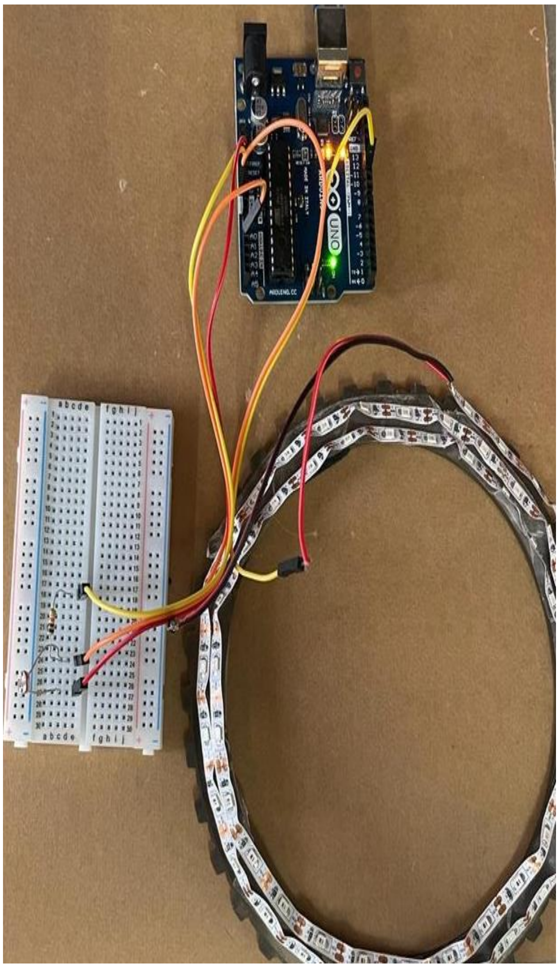
APPENDICES

Appendix A: The setup of body part by used scrap metal items.

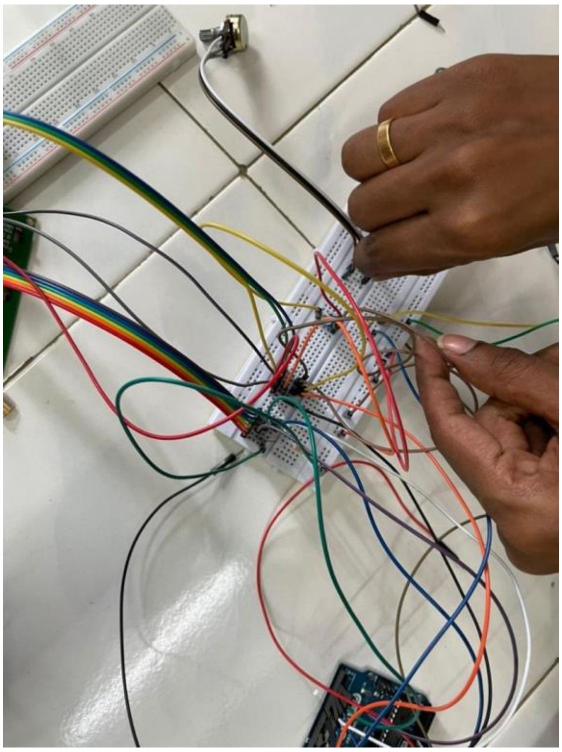


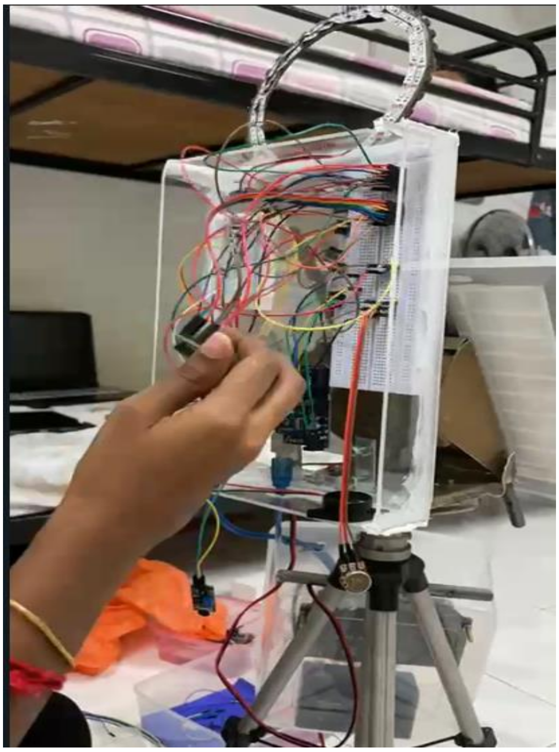
Appendix B: System components such as Arduino Uno, jumper wires, sound sensor, breadboard, LED strip light, LDR, resistor (330 and 220 ohm), trimmer, rotary potentiometer (10k ohm), buzzer, and RGB backlight positive LCD 16x2





Appendix C:The setup of system components





Appendix D**:**The Arduino Uno is used to link the body parts and system components to a power supply such as a solar panel and a rechargeable battery.