DEVELOPMENT OF IOT – BASED RODENT GUARD USING ELECTRIC SHOCK TRAP SYSTEM

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

I dedicate my bachelor’s degree to my beloved family, whose unwavering encouragement, faith in my abilities, and inspiration kept me from giving up. Their hard work, advice, and financial support were crucial in helping me complete my studies. I extend my heartfelt gratitude to my supervisor, Dr. David Ian Forsyth, for his invaluable knowledge and guidance throughout this project. I also thank my friends and everyone who helped me along the way. This project is a testament to the collective efforts that made it possible.

ABSTRACT

In areas inhabited by humans, pests, particularly rodents, are a common issue due to their encroachment on human spaces. Although rodents are not inherently malicious, their presence can lead disaster to farmers at agriculture sites and the spread of diseases. Over time, various methods, including traps and pesticides, have been employed to address pest problems. This project introduces the "IoT RODENT GUARD," designed to capture and eliminate rodents using an electric shock, preventing their escape and further nuisance. The trap, housed in a simple project enclosure, features an entry point where rodents are enticed with cheese. Positioned along the enclosure, an IR sensor detects the rodent's presence and triggers a servo to close a trapdoor, simultaneously delivering an electric shock. An immediate notification is sent to the owner's phone, preventing potential issues if the trap is forgotten. The device, safeguarded against humans, operates on a 6V battery with no safety concerns. Additionally, the versatility of the concept allows it to capture various animals beyond rodents.

ABSTRAK

Di kawasan yang dihuni oleh manusia, makhluk perosak, terutamanya tikus, adalah masalah biasa disebabkan oleh penyerbuan mereka ke ruang manusia. Walaupun tikus tidak jahat secara semula jadi, kehadirannya boleh membawa bencana kepada petani di tapak pertanian dan penyebaran penyakit.. Seiring dengan masa, pelbagai kaedah, termasuk perangkap dan racun serangga, telah digunakan untuk mengatasi masalah perosak. Projek ini memperkenalkan "IoT RODENT GUARD," direka untuk menangkap dan memusnahkan tikus menggunakan hentakan elektrik, mencegah mereka daripada terlepas dan menyebabkan gangguan lebih lanjut. Perangkap, yang diletakkan dalam penutup projek yang mudah, mempunyai titik masuk di mana tikus ditarik dengan keju. Terletak di sepanjang penutup, sensor IR mengesan kehadiran tikus dan memicu servo untuk menutup pintu perangkap, sekaligus memberikan hentakan elektrik. Notifikasi yang segera dihantar ke telefon pemilik, mencegah masalah potensi jika perangkap dilupakan. Peranti ini, dilindungi daripada manusia, beroperasi dengan bateri 6V tanpa kebimbangan keselamatan. Tambahan pula, kepelbagaian konsep membolehkannya menangkap pelbagai haiwan selain daripada tikus.

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LIST OF SYMBOLS AND ABBREVIATIONS

For examples:

CC	:	Central canal
DAB	:	3,3’-diaminobenzidine
HRP	:	Horseradish peroxidase
MS222	:	Tricaine methane sulfonate
%	:	Percentage
-	:	Negative
+	:	Positive
×	:	Multiple
=	:	Equal
>	:	Bigger than
<	:	Smaller than
/	:	Or
&	:	And
°	:	Degree
℃	:	Degree Celsius
WSN	:	Wireless sensor network
DDT	:	Dichlorodiphenyltrichloroethane
IR	:	Infrared Ray

DC	:	Direct Current
AC	:	Alternating Current
WIFI	:	Wireless Fidelity
LCD	:	Liquid Crystal Display
DDT	:	Dichlorodiphenyltrichloroethane
UK	:	United Kingdom
NB	:	New Brunswick
EU	:	European Union
LED	:	Light emitting diode
e.g.	:	Exempli Gratia (Example)
ICSP	:	In Circuit Serial Programming
TCP/IP	:	Transmission Control Protocol/Internet Protocol
GPIO	:	General-purpose input/output
ADC	:	Analog to Digital Converter
SOC	:	System On Chip
AT	:	Attention
PCB	:	printed circuit Board
USB	:	Universal Serial Bus
IDE	:	Integrated development environment
Op-Amp	:	Operational Amplifier
API	:	Application programming interface
APSD	:	Automatic Power Save Delivery

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CHAPTER 1:

INTRODUCTION

1.1 Introduction

Wherever humans are to be found, there will pests also be found. For one of the most common pests, the brown rat, it is never a malicious creature, but the fact that occasionally its habitat is impinged upon by humans makes it a pest as well as a nuisance[1]. Rodents cause tremendous destruction to agriculture, properties and can spread a lot of diseases. With an extremely high reproduction rate, this makes these species all, for practical purposes, very serious pests whose population we must control and whose invasion into our buildings we must prevent as far as possible[2].

Human beings have been pest treating differently over time. Different traps and pesticide solutions have, therefore, been picked in this scenario for a long time, not only for rodents but also for numerous other pests. However, the problem of poison lies in the way it affects nature. For example, widespread use of

Dichlorodiphenyltrichloroethane (DDT) in agriculture in the mid-20th century, DDT causes cancer, and other documented consequences as well as its staggering and utterly destructive effect on wildlife, leading to a ban on its agricultural use in most countries in the 70s[3]. The adverse environmental impact of such chemicals underlies the pressing demand to regulate and minimize them very fast in the control of rodents, a trend that by any indication is sure to only gather even more momentum in the years ahead[2].

How a greener, safer, and smarter pest control solution can be driven into practice is what needs to be inculcated[4]. Being students and developers ourselves, we believe that the change in perspective can pave the way for ingenious solutions and help in the course correction for agriculture and technology. With emerging smarter inventories for rodent control at an ecological scale, the pest problem could be effectively addressed, providing a healthier and more sustainable coexistence of humans and wildlife.

1.2 Problem Statement

In the contemporary perspective, agriculture sites areas have been inflicted with the problem of rodent infestations, which is posing seriously important challenges in terms of public health and hygiene. Rodents, due to their extremely high reproduction rates, pose a significant threat as serious pests. Most of the practices for controlling rodents are common using chemical agents or mechanical devices for trapping, and they are usually not the most effective or humane manner in solving the problem. This occasion has really demanded a leaning toward innovative smart technologies, which have been the motive for developing an "IOT RODENT GUARD."

The existing rodent control methods often lack precision and may inadvertently harm non-target species or fail to capture the intended pests. Moreover, conventional traps may not offer real-time monitoring capabilities, making it challenging to assess the effectiveness of the intervention.

Worse yet if people didn't remember to check the trap, the first indication they get is the smell. Being busy with their daily routines most of the time people place the trap in the food cabinets and they forget to check it for days until the house or farm was swarmed by flies and the cabinet has full of maggots crawling around the food cans and on the remnants of the mouse. The need for a more intelligent and adaptive approach has become apparent, leading to the development of a Smart Rodent Trap that integrates advanced sensors, electric shocks, and communication technologies.

A smart rodent trap despite its cost is the ideal solution to trap and eliminate rodents and therefore avoid all the inconvenience from putrefaction. Advocates for animal protection might also find this house appliance ideal to catch an animal.

Addressing these challenges and developing an IoT RODENT GUARD presents an opportunity to revolutionize urban pest management, offering a more sustainable, humane, and effective solution to the persistent problem of rodent infestations. By combining cutting-edge technologies and ecological considerations, this innovative approach aims to provide a new solution to the way we approach rodent control in urban environments and agriculture sites.

1.3 Objective

Main objectives: Develop an integrated automated smart rodent trap system using IoT (Internet of Things) and Smart Systems to detect and capture rodents.

i. To design a system that triggers precise commands from the Arduino to activate the relay delivering a timed electric shock.
ii. To provide real-time notifications and real-time continuous sensing of the rodent status.

1.4 Scope of the project

The design project here will be to design a safe and effective rodent trap system that senses rodents appropriately and takes them captive. It will have features that one can change at will, such as the sensitivity of the sensor, preferences for notifications, to cater to different needs. The system will effectively trap and control infestations by rodents, bringing down property destruction and health risks emanating from the pests. Moreover, since the project has connectivity provisions like Wi-Fi, the monitoring will easily be done at a distance, affording convenience to the user, and it shall provide real-time notifications on the status of the trap. Such a systemic approach makes sure that the solution is versatile and hugely effective in rodent management.

CHAPTER 2:

BACKGROUND STUDY

2.1 Introduction

This chapter was the concern on literature study and development of the whole project. Journals, papers and books from past works in relation to the project's theme can be included as primary sources on this project. This chapter will need to be scrutinized based on the principles as well as associated research applications.

2.2 Concept of IoT-Rodent Guards

There are IoT rodent traps that feature highly advanced support for the control of pests and are directed to support the age-old problem of mice infestation. While the conventional traps function by a mechanical mechanism, others are guided by attractive baits, which do not optimize these goals[5]. IoT rodent devices leverage innovative technology to increase effectiveness, reduce human intervention, and enable the real-time monitoring of rodent activities 24/7[5]. These innovative devices combine features such as sensors, connectivity features, and intelligent algorithms in the best and most effective solution for humane mouse population control.

2.3 Features of IoT Rodent Traps

2.3.1 Sensor Technology

The rodent trap usually combines infrared motion detectors, pressure sensors, and, sometimes, even cameras. These sensors achieve the activity of mouse identification so that they trigger the trap without needing the user to set up any baits and other triggers.

2.3.2 Connectivity Features

Most rodent traps of IoT have optional connectivity for wireless use with smartphones, tablets, or other intelligent home devices. This permits real-time alerts sent to users about the mice caught, their tracking activity trends and distances, and allows for trap status control from a distance.[6]

2.3.3 Automated Capture and Disposal

Unlike the traditional traps, which hence need manual checks every other time, the IoT rodent traps can automate both the capture and disposal process. Some would have mechanisms that would hold the mouse discretely, therefore reducing the idea or, rather, need for direct contact with the rodent[7].

The use of data analytics and machine learning algorithms embedded in the IoT rodent traps enables users to understand the behavior of rodents. The users can tune their alternatives for pests based on the pattern of activity, which will further enhance the efficacy of the traps with time.

2.3.4 Humane Option

Some of the IoT rodent traps are even designed with a humane philosophy in mind. Some even come with non-lethal capture and release mechanisms, ensuring the trapped mice can be transported off-premises safely.[8]

2.3.5 Energy Efficiency

Most of the IoT rodent traps are designed to achieve maximum energy efficiency, reducing environmental pollution and improving sustainability. Low-power, battery-supported versions together with standby modes ensure that the traps keep on running for considerable periods, therefore reducing the frequency of battery replacements.

2.3.6 Integration with Smart Home Ecosystems:

IoT-enabled rodent traps could be included within larger, smart home setups, allowing for comprehensive pest control management in combination with all other smart home devices. Some integration possibilities could include integration through voice commands, integration with automated routines, and integration with popular smart home platforms[9].

2.3.7 Integration with Smart Home Ecosystems:

IoT rodent traps can be integrated into larger smart home ecosystems, allowing users to manage pest control alongside other connected devices. This integration may include voice commands, automated routines, or compatibility with popular smart home platforms[9].

2.4 Application of IoT Technologies and Electric Shock in Rodent Traps

2.4.1 ELECTRONIC RAT-CONTROL DEVICES - SOLUTION OR SCAM?

The study evaluated the repellent efficacy of an electronic device, Pest X Repel (model PR-500.3), designed to repel rodents through ultrasonic signals, electromagnetic field changes, and sudden light signals. The device's features aim to prevent rodents from adapting to the stimuli. According to the manufacturer, one device can cover an area of two hundred m2, with an initial repellent effect within 1-2 weeks and maximum effectiveness after the third week.[10]

The research was conducted in two rodent-infested areas: Site №1, a cattle farm with brown rat infestation, and Site №2, a feed warehouse with roof rat infestation. The device was placed near electrical distribution boards in specific areas of each site.

To assess repellent efficiency, indicators such as the number of food sources visited, daily consumption of non-toxic food bait, visits to dusty track plates, intensity of traces left, and the number of active holes (in Site №1) were measured. Data was collected every 5 days during a 10-day pre-test period and a test period lasting 35 days in the cattle farm and 60 days in the feed warehouse.

Statistical analysis using GraphPad software and unpaired t-tests were employed to compare results between groups, with significance set at $P < 0.05$. The study aimed to determine the device's impact on rodent activity and population in real-world conditions.[10]

2.4.2 Rodent Control Strategies

The document provides a comprehensive list of rodent control strategies, acknowledging that many existing methods are labor-intensive, expensive, and have limited effectiveness. Among the strategies discussed are rodenticides, where first-generation compounds like warfarin have been replaced by second-generation compounds such as Brodifacoum, known for being odorless and tasteless. The application of rodenticides may face challenges in terrain-specific areas, affecting treatment success. Mechanical traps are considered by some as a more humane alternative to rodenticides, though they cannot discriminate between target and non-target organisms. The document suggests that traps may be used in conjunction with other control methods. Overall, the effectiveness and practicality of these rodent control strategies are highlighted, emphasizing the need for improved and efficient approaches.[11]

Biological controls involve introducing predators, parasites, or disease-causing agents to mimic natural population-limiting factors. Concerns include the potential invasiveness of introduced agents and examples of unsuccessful attempts in the past, such as the introduction of rabbits in Australia and cane toads for pest control in sugar cane fields. The cost of biological interventions varies based on the organism and control agent used. The document highlights the complexities and challenges associated with rodent control, encouraging the exploration of alternative and more efficient approaches.[11]

2.4.3 Forced running and electrical shock are stressful to mice.

The study compared the effects of manual prodding and electrical shock as methods for forcing treadmill exercise in mice. Despite both groups achieving the same level of exercise, they exhibited significantly different locomotor activity patterns in an open field assay immediately after exercise. The shock group displayed fewer vertical and horizontal movements, spent less time in the center of the chamber, and demonstrated signs of increased anxiety compared to the control and prodding groups. Corticosterone concentrations increased equally in both exercise groups after exercise[12].

The results align with previous findings that forced running is stressful for rodents, impacting physiological markers and behavior. Forced exercise, as opposed to voluntary wheel running, has been associated with decreased time in the center of an open field, increased defecation, and higher levels of faecalis corticosterone. The stress from forced exercise might override the potential benefits of exercise, as observed in rats with better motor recovery after voluntary exercise compared to forced exercise post-stroke.[12]

Although both exercise groups exerted the same effort, the shock group exhibited diminished movements, suggesting greater muscle fatigue and potential negative effects on exercise performance. The study notes that acute exercise, regardless of stress induction, increases corticosterone concentrations. The discrepancy in stress indicators and corticosterone elevation raises questions about the complex relationship between stress, exercise, and hormonal responses, emphasizing the need for further exploration in this context.[12]

2.4.4 Trends in Urban Rodent Monitoring and Mitigation

The text discusses the limited understanding of urban rodents despite their pervasive presence, attributing this to assumptions that their omnipresence implies comprehensive knowledge. The reliance on laboratory rodent studies is acknowledged as problematic due to the significant differences between wild and laboratory rodents. Barriers to progress in urban rodent research are identified, including apathy toward rodent issues, a perception of inevitability in infestations, and a lack of clear responsibility within disciplines.[13]

The unique topics issue is positioned as a global call to action, urging researchers to address gaps and barriers through innovative, multidisciplinary approaches. Contributions from diverse fields and global perspectives are emphasized. Critical themes include the complex interactions between rats and the urban environment, the impact of human intervention on rat ecology, and the continuously evolving nature of rodent populations and the pathogens they carry.[13]

Key findings include the influence of urban features on pathogen ecology, the importance of understanding rat movements in urban ecosystems, and the unpredictable consequences of lethal control programs on rat population genetics. The issue also highlights the ecological complexities of trapping rats and the context-dependent efficacy of predator scents in rodent control. The continuously changing face of rodent populations, emerging pathogens, and the implications of urbanization on rat ecology are explored.

Innovative approaches, such as a mathematical model for leptospirosis control, a hanging trap overcoming rodent neophobia, and unexpected findings during field-based research, are discussed. Serendipitous discoveries, like the impact of feral cats on rat populations, are highlighted. Overall, the issue aims to inspire fresh perspectives and comprehensive understanding of urban rodent dynamics through collaborative and innovative research.

2.4.5 Electronic Rodent Repellent Devices

The review discusses various types of pest control devices, including sonic, ultrasonic, electromagnetic, vibration, and shock devices, detailing their purposes, effectiveness, and operational principles. Sonic devices are primarily used to repel birds by emitting loud noises or distress calls, sometimes enhanced with visual cues to simulate danger. Their effectiveness in terms of intensity and repelling capabilities remains uncertain.[14]

Ultrasonic devices, which operate above the human hearing range, are marketed for rodent control in buildings. These devices generate high-intensity sound waves that supposedly repel rodents without disturbing humans. However, their effectiveness diminishes with distance and obstacles, and they are absorbed by soft materials. The devices require minimal electrical power and come with installation instructions.[14]

Electromagnetic devices, once popular in the 1970s, claimed to repel pests by altering magnetic fields. However, scientific studies found them ineffective, leading to legal actions and fines for false advertising. These devices are rarely marketed today.[14]

Vibration and shock devices have been designed to frighten or deter pests through physical discomfort or barriers. While some electrical barriers are effective in controlled areas, their high costs limit widespread use.[14]

The review also explains the technical aspects of these devices, such as frequency, pulse rate, duty cycle, intensity, and directivity. Sonic and ultrasonic devices' effectiveness is influenced by these parameters, with high-frequency sounds providing better localization for animals to avoid stimuli. Safety concerns for humans are addressed, emphasizing adherence to Occupational Safety and Health Administration (OSHA) standards to prevent hearing damage. Overall, the review highlights the varied effectiveness and practical limitations of these pest control technologies.[14]

Table 2.1: Summary of Available Protocol to Evaluate Ultrasonic Rodent Repellent Devices in Structures

Type	Simulated Field	Field	Field	Field
Rodent Activity Measures	Rolled oat consumption; paper pocket damage; photocell break counts	Tracking title counts; number of sectors distributed per tile	Tracking boards; feed consumptions; facial dropping counts	Tracking boards; feed consumptions; movement detector counts
Baseline Period (Days)	7	21	7	7
Test Period (Days)	17	21	21-42	28
Recovery Period (Days)	7	21	14	14
Re-test Period (Days)	17	21	-	28
Size of Structure (m2)	69	8.9-196.5	Not Specified	Large enough to accommodate both ultrasound and control areas; or separate buildings as control areas

[14]

2.4.6 Comparison of Trapping Efficacy Of 11 Rodent Traps in Agriculture

The study, conducted from 2010 to 2018 across various regions in northern and middle Israel, aimed to compare the efficacy of different trap types for capturing rodent species in agricultural fields and orchards. The researchers deployed 50 traps at a time in a 5 × 10 grid pattern, alternating live and lethal traps, and baited with Bamba®. A total of 648 trap-sets covering 32,029 trap-nights were utilized, with data from 1990 captured animals including mice, jirds, voles, rats, shrews, and a few other species. The study was part of a larger project exploring alternatives to poison in pest control.[15]

Statistical analysis focused on the attractiveness of different traps to specific rodent species. The attractiveness measure α was defined to compare capture rates of specific trap types within sets. Pairwise comparisons among the four most abundant traps (Victor Mouse, Sherman, Box, and Victor Rat) revealed that the Victor Mouse trap was the most effective for capturing mice, followed by Sherman, while the Victor Rat trap was the most effective for capturing jirds.[15]

Effective traps differed significantly in significant differences observed among years, regions, and crops. For example, the Victor Mouse traps were effective in the Coastal Plains more than Sherman traps. More so, in the Northern Valleys, the traps were more effective in catching more. Again, in the cereals and field crops, the Victor Mouse traps were more effective, as opposed to the orchard type. From these results, one clearly sees the need to consider the environment and species to be targeted in trapping exercises.

Such very large quantities of data collected and analyzed in the present study highlight the point that trap efficacy may be very variable under species and environmental conditions. That is, for example, the Sherman livetrap was better in other studies for larger rodents, such as the meadow vole, and varied in effectiveness in this study setting. In several similar research projects, the Victor Mouse Trap caught significantly more mice than those in the Longworth traps, thus showing that trap choice is paramount and sometimes requires adjustments to specific conditions and the targeted species.

In conclusion, the study suggests that no single trap type is universally the best. Instead, effective pest control should involve preliminary research to adjust trap types to the specific species and environmental conditions of each situation. Price and other practical considerations also play a role in selecting the most appropriate traps for effective rodent control in agricultural settings.[15]

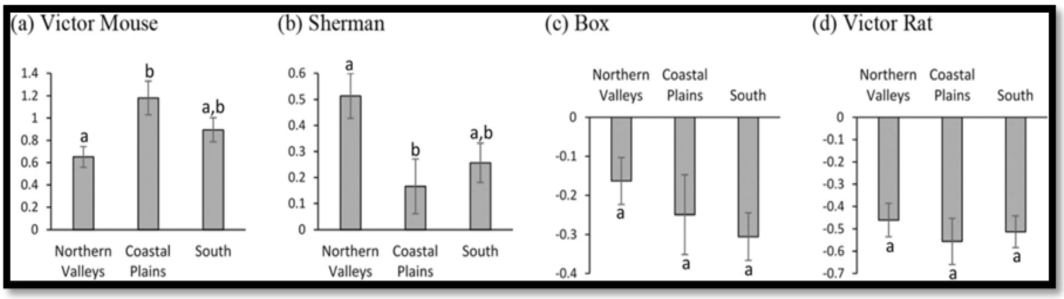


Figure 2.1: Summary of Trap Efficacy by environmental conditions.[15]

2.4.7 Rodent Control and Public Health: A Description of Local Rodent Control Programs

The study addresses the historical and contemporary challenges posed by rodents, particularly Norway rats, roof rats, and house mice, to public health and infrastructure. The research focuses on rodent control programs in large municipalities across the United States, examining their current capacity, best practices, challenges, and technical assistance needs. Key findings include:

2.4.7.1 Program Characteristics

- Majority of surveyed programs were part of comprehensive vector control programs within local health departments.
- Programs were primarily supported by local funds, with only two funded by service fees.[16]
- Funding for most programs either decreased or remained the same in the past five years, resulting in staffing and activity cuts.

2.4.7.2 Integrated Pest Management (IPM)

- All programs implemented IPM concepts in their rodent control efforts, mostly complaint based.
- Proactive activities varied, including selective baiting, inspections, and innovative projects like the Rodent Reservoir Analysis in New York City.[16]

2.4.7.3 Human Health Impact

- No confirmed human cases of rodent-borne diseases were reported among the surveyed sites.
- Rodent-related injuries/bites were reported, but not all programs had the capacity to capture rodents and test for pathogens.[16]

2.4.7.4 Challenges

- Controlling rodent populations was deemed challenging, especially in complaint-based systems.
- Lack of understanding among property/business owners and insufficient science/research on rodent control were highlighted.

2.4.7.5 Public Education and Collaboration

- Public education was a priority for all programs, emphasizing the importance of rodent control.
- Extensive collaboration with other local departments and organizations was observed, involving initiatives like Mayor's Rodent Task Force and partnerships with universities.[17]

2.4.7.6 Challenges and Solutions

- Significant challenges included a lack of funding, resources, and sustained positive outcomes.
- Collaboration among public health professionals and communities was identified as crucial for long-term and successful rodent control.[16]

In conclusion, the study emphasizes the public health implications of rodent control, calls for increased funding, resources, public education, and collaboration to address challenges, and highlights the importance of sustained efforts to control rodent populations and prevent rodent-borne diseases.

2.4.8 A “Smart” Trap Device for Detection of Crawling Insects and Other Arthropods in Urban Environments

The paper "A 'Smart' Trap Device for Detection of Crawling Insects and Other Arthropods in Urban Environments" describes the design, operation, and testing of a new advanced device for early detection and management of crawlers in urban areas within the IoT framework. The device is in a rectangular shape trap that measures 21 cm x 11 cm x 7.5 cm. It attached an electronic kit on which the pests are lured by strong attractant before being trapped on a sticky surface. The device detects the entry of the bugs through an infrared laser beam and takes a photograph of the inside space, followed by a transmission through Wi-Fi to authorized personnel for necessary action. That monitoring is done in real time and removes the need for regular human interference; hence it ensures uninterrupted and accurate detection of pest activity. [18].

The smart trap design involves many design structures that make it more appealing; these can be the use of multiple attractants, targeting several species and its laser beam entry. A 20-s delay is introduced so that the image can be taken after an insect comes to the full. Incase such takebacks happen, images captured are timestamped and posted to the predefined set of email IDs, both PCs and mobiles, with a backup being taken into the SD card within the equipment. The controlling element is an STM32F767 ARM microcontroller, which processes the laser beam's signal, captures the image, and manages the operations that provide storage and communication tasks of the available information.

Testing occurred across three applications—old food warehouse, livestock unit, and granary—where the traps were visually inspected daily by an entomologist, and manual and automated data were recorded and compared. The results not only point out that the device reliably registered and recorded the presence of insects but also supports its potential as a tool for IPM in urban environments.[18]

The smart trap also brings numerous advantages: it is cheap, small, and can work without much human intervention on its side, if there is Wi-Fi coverage. This makes it possible to deploy the traps in concealed places, such as under beds or in storage facilities. Quick installation of these traps into a networked system, under the concepts of smart cities, will therefore allow for monitoring from a centralized station and the development of interactive infestation maps. Future improvements could involve deep learning algorithms on activation and counting of insects, further enhancing the same device for urban pest management.[18]

2.4.9 Parturition detection in sows as test case for measuring activity behavior in farm animals.

It was also in the said paper where the "general activity" of the animals was deliberated since it is an important parameter in the behavior of farm animals, which has a relationship with different factors like stress, sickness, and reproductive activity. Radar sensors were utilized since they are technically advantageous compared to the other optical sensors, such as lesser sensitivity to environmental factors and interferences of any kind[19].

The research is made with the purpose to monitor the increase in parturition-related activity in sows and allows using radar sensors on the research concerning the further effectiveness of these sensors. The use of radar sensors in farm conditions and methods for monitoring and analyzing data are described. The article reports on a study that monitored the activity of sows housed in farrowing pens using radar sensors and compared the data with light barriers.[20]

The results indicate that radar-based sensors captured diurnal activity variations and revealed parturition-related activity increases concerning light barriers. The study showed that radar-based sensors hold potential in the accurate identification of the approaching parturition of sows, and the estimation of their sensitivity and specificity is promising[19].[20]

In general, it might be concluded from the results that radar sensors, under certain conditions, can represent a valid alternative to the monitoring of animal behavior at a farm, showing, except for robustness, some advantages as regards to the susceptibility to maintenance effort and assuring a degree of interference resilience. Further validation studies in view of exploring the suitability of radar sensors towards other scenarios and animal species must be conducted to refine the general activity measurement as basic parameter in monitoring systems in husbandry[20].

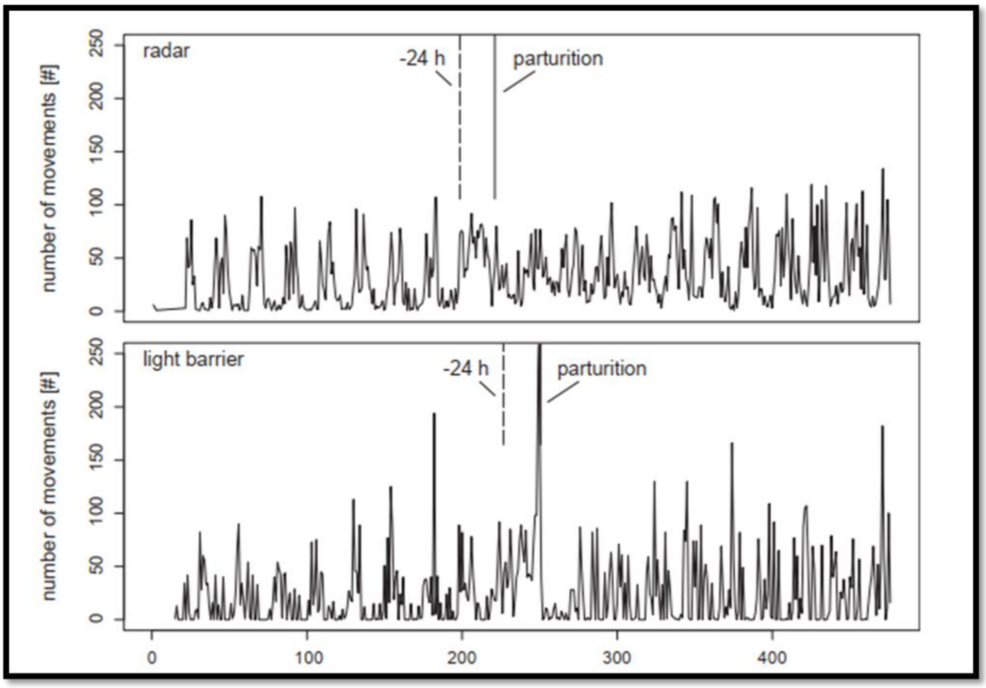


Figure 2.2: Summary of Detection Comparison[20]

2.4.10 The use of electricity against rodents.

The literature highlights the need for humane and eco-friendly rodent control to prevent property damage, food spoilage, and disease spread, noting that traditional traps and poisons can harm the environment and wildlife. The Tx Guardian system, an electric barrier designed to keep rodents out of buildings without killing or injuring them, is proposed as a solution. Laboratory tests involved a test house with electric barriers, showing that the shock effectively deterred both mice and rats with minimal injury. Rodents learned to avoid the barriers, demonstrating the system's effectiveness. However, full coverage of the barrier is crucial to prevent rodents from finding gaps. While lab-bred rodents were very exploratory, wild rodents might be more cautious at first but equally driven to find food and shelter.[21]

2.4.10.1 Impact on Non-Target Species

Rodenticides have been found in a significant percentage of various non-target animals. For example, Norwegian Eagle owls had rodenticides in 72% of 100 sampled dead owls, and rodenticides were detected in the faeces of 54% of 139 wild Norwegian red foxes. Exposure to these poisons can result in severe health issues, including reduced fertility, neonatal mortality, increased parasite load, and chronic weakening.[21]

2.4.10.2 Alternative Methods

To address these concerns, alternatives to rodenticides, such as lethal spring traps and non-lethal traps, are employed. However, these methods also present practical and ethical challenges, including potential suffering for the animals due to mishits or low impact power. Therefore, more humane methods are sought.[21]

2.4.10.3 Prevention Over Extermination

Given that many rodent species seek shelter indoors only seasonally, the goal should be to prevent entry rather than kill all invading rodents. Frightening methods, like ultra-sound, lose effectiveness over time due to habituation.[21]

2.4.10.4 Tx Guardian: Electric Barriers

Tx Guardian proposes using an electric barrier around buildings to deter rodents. This barrier delivers a non-lethal but painful electric shock when rodents attempt to cross. The goal is to teach rodents to avoid the area through aversive learning without causing lasting harm.[21]

2.4.10.5 Effects of Electric Current on Animals

Electricity is integral to normal animal physiology, such as heart and nervous system functions. The body's high water and electrolyte content facilitates the conduction of electric current, particularly through the nose and foot pads in rodents, which are not covered by fur.[21]

2.4.10.6 Safety and Pain Response

Electric fences, widely used in animal management, deliver high-voltage but low-current pulses, causing pain without significant harm. Animals quickly learn to avoid these fences, associating contact with pain. However, some individuals may still bypass the fence, driven by motivation or environmental factors.[21]

2.4.10.7 Laboratory Testing: Test Facilities and Protocols

The experiments were approved by the Norwegian Research Animal Authority and conducted at the Norwegian University of Life Sciences. Mice and rats were housed in a test room equipped with a test house and metal pipes that could be electrified. Enrichment items, food, and water were provided to ensure animal welfare.[21]

2.4.11 Design of Wild Animal Detection and Rescue System with Passive Infrared and Ultrasonic Sensor based Microcontroller

The current research study offers an insight into the requirement and significance of a need to produce and design a PIR sensor-controlled, ultrasonic signal-based wild animal pest repellent device. In other words, the very purpose is to detect the presence of a wild animal using PIR sensors interfaced with a microcontroller to transmit ultrasound that should create a disturbance in hearing capability. The researcher puts forward that in today's world plants are often damaged by various kinds of pests; as such, in this context, the modern-day requirement arises for some effective solution to protect plantations from animal pests since more conventional means failed to work.[22]

In terms of hardware, there are basically two major categories of parts in this system: the transmitter and the receiver. The transmitter concerns those PIR sensors that detect any animal's presence and then generate ultrasonic signals to disrupt any heard animals. The receiver, on the other hand, monitors animal movements and thereby activates indicators when these animals get into the detection zones. In terms of the software part, the algorithms are written in the C language. These manage sensor readings and emission or ultrasound signals.[22]

Testing demonstrated that the PIR sensor will activate for animals ranging from this sensor at up to 5 meters. This applied because the output voltage upon detection is the same for all animals detected. Animal disturbance experiments were conducted using the ultrasonic sensor and showed that the optimal frequency for maximum effect on the animal was 40 kHz. The effective range for this was established as being up to 20 meters because the animal disturbance capability dropped sharply beyond this.

Radio frequency communication at 433 MHz has also been built into this system so that the animals may be monitored remotely, and the monitored range can be increased up to 60 meters in this way.[22]

The researchers have included the fact that hearing frequencies in animal varieties are different, making it a strong point for them to check repellent at different ultrasonic frequencies to determine the best possible repellent system. Indeed, this calls on research to expand in carrying out subsequent studies to an improvement in the system to exact various species. In conclusion, the research suggests that animal repellent devices have the potential to grow by integrating sophisticated sensors and microcontroller-driven control systems with immense potential.[22]

This completes the design of the system; and this is a very good, up to date way to repel the wild beasts outside of the plantation areas. Putting together the PIR sensors, ultrasonic signals, and microcontrollers gives a reliable device that can help prevent wild animals' damage to agricultural produce. There is a point about the frequency of animal hearings in this research that will be useful as an information guide in the next study for related agricultural and wildlife protection and management.

Figure 2.3: PIR Sensor Sensitivity Measurement[22]

2.4.12 Animal monitoring based on IoT technologies

The use of grazing animals like sheep in vineyards requires automated support to control and condition their behavior to avoid damaging the vines. The current manuscript presents an animal behavior monitoring platform. The platform was developed based on the IoT technologies for data collection from animals, and a cloud platform for data processing and storage. ML has been applied to the developed platform for meaning extraction from the collected data. It involves monitoring sheep's posture to graze but not to hurt the vines in the process.[23]

Viticulture is generally a very labor-intensive activity, mainly in countries such as Portugal. Work in vineyards increases mainly in the spring when there is a need to control weeds. These weeds compete with vines for water and nutrients. The controlling of weeds has been done traditionally through manual removal or by allowing grazing sheep. Recently, mechanical and chemical control has also been used. These traditional methods of weed control are either labor-intensive or environmentally dirty and costly. The SheepIT project reinstates sheep grazing in an organized way using an IoT network that monitors and conditions the behavior of sheep for sustainable agriculture.[23]

The backend platform of SheepIT uses IoT collars that gather data related to posture and the location of sheep and forward it to a cloud platform for further processing. Sensors embedded in the IoT collars have local processing capabilities that deliver instant corrective stimuli, if required. This makes real-time monitoring and management of the animals possible due to the combination of data mining and machine learning techniques that are done with the cloud platform on the data. This way, the sheep graze without destroying the vines, which also fertilize the earth, thus becoming more sustainable.[23]

This paper talks about the development and testing of a set of machine learning methods that aim to undertake sheep posture infractions, where the test is done to find out if the sheep are eating the vines instead of the weeds. Essentially, several algorithms were tested for correct detection of such infractions, ranging from Random Forest and Decision Trees, to XGBoost, and so on. The results showed that all algorithms performed very similarly well, but Decision Trees were especially interesting because they are very easy to interpret-a characteristic that is much appreciated for the implementation of posture control mechanisms on the collars.

Finally, this paper concludes with some remarks on the great potential of the SheepIT platform to provide a sustainable solution for weed control in vineyards. The use case of the posture monitoring illustrated the effectiveness of the platform, and future work will Axel add to scalability, performance in large data sets and other use cases of ML, for instance, illness detection, panic attacks, and movement patterns. This paper also puts clear emphasis on integrating such advanced technologies as IoT and ML in agriculture to enhance productivity and sustainability.[23]

2.4.13 Implementation Of IoT Based Animal Detection System Illumination By Using Ultrasonic Sensor

A system has been developed in the research paper that is IoT-based and intended to reassure crop protection against wild animals. The proposed system detects an animal and diverts it without any harm. For this purpose, the mechanism of detection makes use of PIR, or Passive Infrared, and ultrasonic sensors which sense the movement of any animal, resending the signal to the controller. Upon detection, the system produces sound to deter the animals and sends an alert to farmers and forest authorities through a GSM module. The actual and direct objective is the safety of animals and crops, and this method is much more effective and humane compared to all the above previous methods.[24]

The paper starts with an explanation of the increasing incidences of human-animal conflict due to deforestation and increased animal attacks into human habitations. Crop damage and threats to human safety are the usual consequences of these conflicts. The paper has pointed out the disadvantages that crop protection and the advanced detection system their crops needed. Basically, image processing and sensor technology is incorporated into the proposed system to alleviate conflicts by way of a real-time alert issuance, and prevention.[24]

The methodology section details technical specifications and components' functionalities that are put to work in driving the system. The major components include the PIC16F877A microcontroller, PIR and ultrasonic sensors, LCD display, LDR, GSM SIM900A module, and APR audio board. Any component is chosen to fit the role it plays to dispense its services of detecting an animal, processing signals, and passing information across that expresses alerts. Power supply for energizing the system is through solar panels or a regulated source of power, allowing operations to go on even in areas where there is no supply of power.[24]

The working procedure of the proposed system is illustrated wherein the existence of animals is detected by use of sensors and appropriate actions are made to occur. Sense here says that PIR and ultrasonic sensors join in detecting the movement of animals BUT the APR board produces sound for repelling the animals and, in the night, an additional flash of light is also activated for enhanced deterring purpose from the animal. The GSM module generates message warnings to the farmers and forest officers so that immediate action will be taken to safeguard from the threat. The sensitivity measurement of ganthChapter-208and the frequency variation are the ways in which the system is tested for its effectiveness in the detection of animals also, working functionally at various distances.

It is a position put forward by this paper that the proposed system is a safe mode for crop protection from wild animals in a more humane way. It detects dispensable animals in a non-damaging manner due to its effective use of sensor technology. It is affordable and viable for farmers, yet it never lacks in sending warnings of real-time and prevention methods in time. The researchers suggested further improvements in the system by incorporation into a wireless network and several other additional sensors that would widen its functional area and enhance the scope of the system. The proposed IoT-based solution is a giant leap of protection in agriculture and can deal with the quite pervasive problem of animal intrusions in a scalable manner.[24]

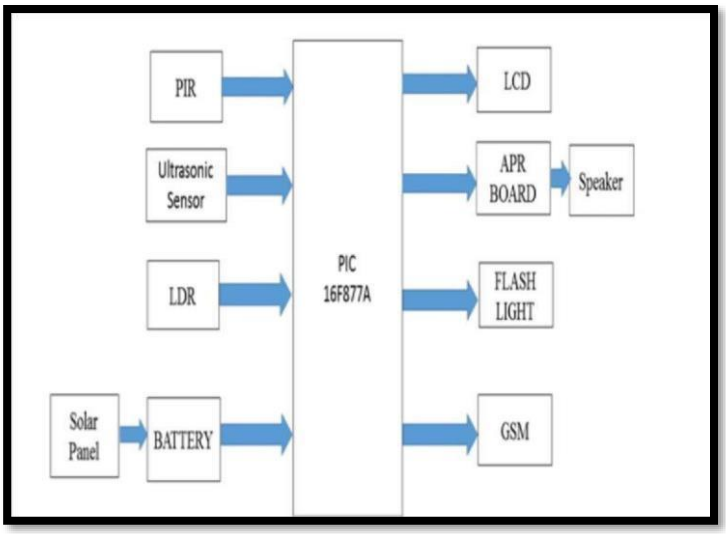


Figure 2.4: Block Diagram of the IoT Animal Detection System[24]

2.4.14 IoT-Based Transmission Line Fault Detector

The paper, "IoT-Based Transmission Line Fault Detector,"[25] equivalently goes deep into the system to detect faults in electricity transmission lines interstate and inform concerned authorities in real-time. In their research, Prof. Suraj Mahajan and his team have suggested a scheme through which faults in electricity transmission lines are detected automatically by using a set of sensors and IoT technology along with the transmission line to monitor integrity. It aims to find faults with accuracy and speed of the most essential requirement for a stable and performing power grid.[26]

This system architecture includes Node Microcontroller, GSM module, relays, batteries, and necessary electronics such as the IC7805 voltage regulator and transformers. Along the transmission lines, Voltage, current, temperature and vibration Measuring Sensors are used. The information of these sensors is processed by the microcontroller to understand abnormality for fault detection. This information is transmitted into a cloud platform through it followed by more analysis and storage.[26]

This system mainly helps in providing instant information to the maintenance team through the GSM communication and thus it reduces the time required for fault rectification. So, the power shortage can be prevented by this system which in turn increases the reliability of the power supply. IoT provides a platform not only for data collection and transmission but also to make condition for smart grid operations that real-time status is a must requirement".[26]

In its discussion, the paper also categorized the economic and safety aspects of the proposed system as follows: Due to the automated fault detection process, the need for manual inspections is reduced substantially, hence the reduction of operational costs and the risk to the maintenance staff. The action to rectify the problem starts immediately to prevent further damage and maintain stability in the power distribution network since it has a real-time alert mechanism for faults.

It is a cost-effective and reliable solution towards enhancing monitoring and maintenance of power transmission lines. The system's ability to detect faults in real-time and communicate the same on a real-time basis was an excellent tool for modernizing power grids and ensuring continuous electricity supply. This research has shown how the IoT can be used to transform traditional infrastructure or technology into smart systems with capacity to adequately meet contemporary demands.[26]

2.4.15 Digital Farming: IoT Enabled Smart Sensor Based Insect and Animal Detection System

In this journal article, Prof. Subhash Chandra Yadav et al.[25] proposed in an innovative way to enhance agricultural productivity by using IoT technologies: "Digital Farming: IoT Enabled Smart Sensor Based Insect and Animal Detection System". The authors further note that the crop growing cycle is influenced by an array of environmental factors, which include but are not limited to rain, temperature, soil moisture level, humidity, and solar radiation. Also, other factors like pests and crop diseases, mischievous use of fertilizers, affect the yields badly. The major contribution of the proposed system is to solve this problem by utilizing the IoT-based detection system to detect and report the conditions of insects and mammals in a crop field through smart sensors attached to Arduino based UNO Kit.[25]

The article begins with the importance of digital farming and the huge impact IoT technologies have left on agriculture. It deploys smart sensors to avail farmers to manage irrigation activities, crop monitoring, and other important farming activities. Soil monitoring, precision irrigation, and automated farming equipment are the most common applications in agriculture. Efficient and sustainable practices in agriculture are in a revolutionized state due to such digitalization.[25]

One of the super functions of power consumption is the very low consumption of this system because there is already a very small number of sensors installed within it, like the DHT11 sensor to measure Relative Humidity and Temperature, ultrasonic sensors to sense the presence of some small animals, IR sensors to detect large animals, and sound sensors in order to listen to the incoming signals for the arrival of pests. All these sensors are interfaced to the Arduino UNO microcontroller to collect data and send it to the ThingSpeak server with the help of the GPRS module. The ThingSpeak server processes the data and by use of an SMS, the farmers are made aware in case of any hurtful agent or environmental change that will see them take an early preventive measure.[25]

In the methodology area, the authors detail how the sensors have been set to detect various parameters and send data to the Arduino kit for real-time analysis. At set values of the threshold, the sensors activate alerts. The IR sensor detects big animals, the ultrasonic sensor measures distance to small animals, and the sound sensor detects pest sound. Data was visualized and stored in the server which in return showed the farmers some actionable insights into their crop conditions.[25]

Results from the study portray effectiveness of the IoT sensors enabled systems for monitoring crop fields. Data collected over several months indicates that the system can detect temperature and humidity variations, the presence of insects and animals. The system, in turn could successfully reveal the information to the farmers who were then to be able to take necessary steps in protecting the crops. The authors therefore assert that the technology would be a valuable tool for early warning and continuous monitoring, leading to various crop yields that ultimately lend themselves towards a sustainable farming practice. Future work will involve expanding the data collection to all seasons and all crop varieties, with an incorporation of machine learning solutions to improve predictive capabilities.[25]

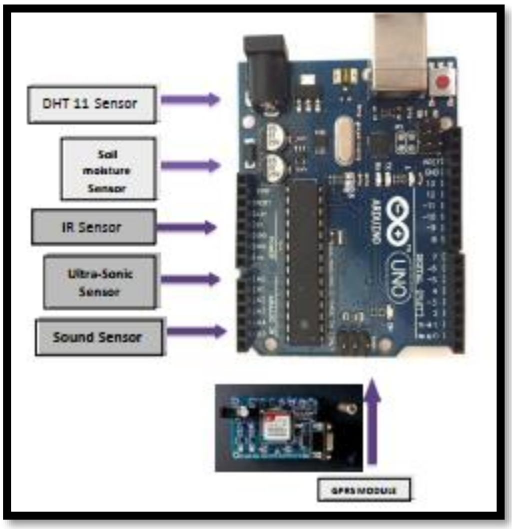


Figure 2.5: Proposed System Diagram with Arduino Kit[25]

2.5 Comparison of Literature Reviews

Table 2.2: Comparison of Literature Review

No.	Aspect	Author	Types of Methods/Devices	Type of Components Used	Features	Advantages	Disadvantages
1.	**Electronic Rat-Control Device**	Linda Madisen [10]	-Electronic repellent device	-Ultrasonic signals -Electromagnetic field changes -Light signals	-Prevents rodent adaptation to stimuli	-Initial repellent effect within 1-2 weeks - Effectiveness may vary	-Effectiveness may vary. -Potential interference from dirt and moisture
2.	**Rodent Control Strategies**	James P. Collins[17]	-Rodenticides -Mechanical Traps	-Rodenticides -Mechanical Traps -Biological Controls	-Second-generation rodenticides -Mechanical traps	-Diverse approaches with varying effectiveness -Non-toxic, humane, and environment-friendly	-Labor-intensive and limited effectiveness -Lack of understanding and clear responsibility
3.	**Forced Running vs. Electrical Shock**	Tahsin Khataei[12]	-Forced running. -Electrical shock	-Manual prodding -Electrical shock	-Stressful effects of forced exercise	-Both methods achieved the same exercise -Differential impact on locomotor activity	-Differential impact on locomotor activity -Potential negative effects on exercise performance
4.	**Urban Rodent Monitoring**	Michael H. Parsons[13]	-Trends in Urban -Rodent Monitoring	-Urban rodent monitoring initiatives	-Multidisciplinary urban rodent research approach	-Highlights urban rodent research challenges. -Lack of understanding and clear responsibility	-Lack of understanding and clear responsibility -Funding cuts and challenges in control

Table 2.2 continued

5.	**Electronic Rodent Repellent Devices**	Stephen A. Schumake [14]	-Sonic -Ultrasonic -Electromagnetic -Vibration	-Sonic -Ultrasonic -Electromagnetic -Vibration	-Real-time monitoring -Environment-friendly	-Non-toxic, humane, and environment-friendly -Adjustable parameters for efficacy	-Limited area coverage for shocking devices -Variation across species and environments
6.	**Parameters of Device Output**	David Simons[8]	-Frequency -Pulse Rate -Duty Cycle -Intensity	-Frequency generators -Transducers	-Adjustable frequency and intensity	-Adjustable frequency and intensity -Species-dependent trap efficacy	-Species-dependent trap efficacy -Limited effectiveness over short distances due to intensity drop-off
7.	**Trapping Efficacy of Rodent Traps**	Yoav Motro[15]	-Various live traps	-Mechanical components	-Species-dependent trap efficacy	-Trap efficacy is species dependent. -Implementation of Integrated Pest Management	-Trap efficacy is species-dependent. -Challenges in funding and resources
8.	**Rodent Control Programs**	Lisa M.Brown [17]	-Integrated Pest Management (IPM) -Traps	-Radar sensors -Light barriers	-Comprehensive vector control programs	-Comprehensive vector control programs -Real-time monitoring and Wi-Fi communication	-Controlling rodent populations was deemed challenging. -Lack of understanding among property/business owners

Table 2.2 continued

9.	**Smart Trap for Crawling Insects**	Erika M. Bueno[27]	-"Smart" trap with electronic components	-Microcontroller -Infrared laser -Camera	-Real-time monitoring and Wi-Fi communication for captured images	-Real-time monitoring and communication -Similar absolute numbers of movements	-Device size may limit use in certain areas. -Potential interference from dirt and moisture
10.	**Parturition Detection in Sows**	Md Whaiduzza man[20]	-Radar Sensors vs. Light Barriers	-Radar sensors -Light barriers	-Radar-based parturition detection performance comparable to other systems	-Similar absolute numbers of movements -Potential interference from dirt and moisture	-Potential interference from dirt and moisture -Results could benefit from verification using an independent group of sows
11.	**Design of Wild Animal Detection and Rescue System**	Yusman[22] Aidi Finawan [22] Rusli[22]	-PIR Sensors -Ultrasonic Sensors, -Microcontroller -RF Communication	Detects wild animals with PIR sensors -Generates ultrasonic signals to disrupt animals -Remote monitoring	-Effective in deterring animals -Long detection range (up to 20 meters), remote monitoring capability	-Limited by the range of ultrasonic signals -Effectiveness may vary by species	-May not work effectively in densely vegetated areas -Ultrasonic frequency might need adjustment for different animals

Table 2.2 continued

12.	**Animal Monitoring based on IoT Technologies**	Luís Nóbrega [23] André Tavares[23] António Cardoso[23]	-IoT Collars -Cloud Platform -Machine Learning Algorithms	-Monitors sheep posture to prevent vine damage -Uses ML for data processing and behavior correction	-Sustainable weed control -Real-time monitoring -Uses ML for accurate posture detection	-Dependent on IoT and cloud infrastructure -Initial setup cost may be high	-Requires continuous internet connectivity -Potential privacy issues with data collection
13.	**IoT-Based Animal Detection System**	Ayushi[24] Annu Mishra[24] Anuj Maurya[24]	PIR Sensors -Ultrasonic Sensors -PIC16F877A Microcontroller -GSM Module -APR Audio Board -Solar Panels	-Detects animal movement -Sends alerts via GSM -Produces sound and light to deter animals	-Humane method -Real-time alerts -Solar-powered	Effectiveness may vary at night or in different weather conditions	-GSM module coverage issues in remote areas -Potential false alarms from non-target movements

Table 2.2 continued

14.	**IoT-Based Transmission Line Fault Detector**	Prof. Suraj Mahajan [26] Ankit Rajendra Bhagat[26] Disha Nandulal Moon[26]	-Sensors (Voltage, Current, Temperature, Vibration) -Node Microcontroller -GSM Module -IC7805 -Transformers	-Detects faults in transmission lines -Sends real-time alerts, processes data on cloud	-Reduces manual inspection -Real-time fault detection -Enhances power grid reliability	-May require frequent maintenance of sensors -Dependent on GSM and cloud infrastructure	-High initial installation cost -Potential issues with sensor accuracy over time
15.	**Digital Farming: IoT Enabled Smart Sensor Based Insect and Animal Detection System**	Prof. Subhash Chandra Yadav[25] Prashant Kumar[25]	-DHT11 Sensor -Ultrasonic Sensor -IR Sensor -Sound Sensor -Arduino Uno -GPRS Module -ThingSpeak Server	-Detects insects and animals -Measures environmental parameters -Sends alerts to farmers	Low power consumption -Real-time monitoring -Early warning for pest and animal threats	Sensor accuracy may vary -Dependent on network connectivity and server reliability	-Potential data overload for farmers -System may require regular calibration and updates

2.6 Summary

The comparison table outlines various rodent control and monitoring methods, each with unique methodologies, components, features, advantages, and disadvantages. Linda Madisen's approach with electronic rat-control devices employs ultrasonic signals, electromagnetic field changes, and light signals to prevent rodent adaptation, offering an initial repellent effect within one to two weeks. However, its effectiveness may vary and is susceptible to interference from dirt and moisture. Similarly, Stephen A. Schumake's electronic rodent repellent devices use sonic, ultrasonic, electromagnetic, and vibration methods, emphasizing real-time monitoring and adjustable parameters for efficacy. Although these devices are environment-friendly and humane, they face limitations in area coverage and effectiveness across different species and environments.

James P. Collins presents diverse rodent control strategies, including rodenticides, mechanical traps, and biological controls. These methods offer non-toxic, humane, and environmentally friendly options but are labor-intensive and show limited effectiveness due to a lack of understanding and clear responsibility. Similarly, in a study of trapping efficacy by Yoav Motro, it was demonstrated that the efficacy of live traps is highly species-specific and that IPM is the focus, funding and resource difficulties are still encountered.

Tahsin Khataei said that while both resulted in the same exercise effects, such as weight loss/gain and changes in body composition, he also noted a differential effect on locomotor activity, which will adversely impact exercise performance. Michael H. Parsons writes of urban rodent monitoring efforts, calling for multidisciplinary research to aid in dealing with urban rodent issues—not to worsen it. Anyway, the lack of understanding and definite responsibility, plus funding cuts, enhances effective control measures.

Analysis of the output parameters of devices-these would encompass frequency, the rate of pulses, and duration of the duty cycle and intensity- is also available from the work of David Simons. This author suggests that such adjustment of intensity and frequency can make traps more effective, although for the species targeted, the generalizations do not necessarily apply, and effectiveness is also generally limited over shorter ranges due to drop-offs in intensity. Integrated pest management and concentration on radar sensor and light barrier traps within vector surveillance and control programs is described by Lisa M. Brown. Despite real-time monitoring and Wi-Fi communication advancements, challenges persist in controlling rodent populations and ensuring understanding among property and business owners.

Erika M. Bueno's development of a "smart" trap for crawling insects incorporates microcontrollers, infrared lasers, and cameras for real-time monitoring and communication. This innovation facilitates real-time monitoring but may face limitations in certain areas due to device size and potential interference from dirt and moisture. Lastly, Md Whaiduzzaman's research on parturition detection in sows using radar sensors and light barriers shows that radar-based detection is comparable to other systems, though the results would benefit from independent verification and face potential interference issues.

CHAPTER 3:

METHODOLOGY

3.1 Introduction

This chapter serves as the flow of the project making, outlining the systematic approach used to address the research questions or objectives. It provides a detailed account of the techniques, procedures, and tools employed in the study, ensuring transparency and reproducibility of the findings. Methodology is the systematic, theoretical analysis of the methods applied to a case of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge[28]. To realize this project as a product that is ready to use with safety characteristics, a very comprehensive plan is undertaking. A step-by-step procedure is done so that the project can be completed in time[29].

3.2 Project Design and Overview

3.2.1 Flow Chart

As in the Figure 3.1, the automated rodent trap system begins its process when it is powered on or reset, greeting the user with a welcome message displayed on an LCD screen. Once initialized, the trap door opens, ready to catch any rodent that pass through the trap inside. At this point, the system sends a notification to the user's mobile device by the help of Blynk App setup in the ARDUINO coding, letting them know that the trap has been reset and is prepared for action. The LCD screen then updates to indicate that it is in a standby mode, displaying a message that reads "Pest Awaiting," as it vigilantly monitors for any rodent activity.

The main component of the detection process is an infrared (IR) sensor that constantly checks for the presence of a rodent inside the trap. When no rodent is detected, the system remains in this standby mode, continuing to monitor. However, once a rodent is detected, the IR sensor promptly sends a signal to the Arduino microcontroller, which serves as the system's brain. The Arduino then activates a servo motor to close the trap door, effectively capturing the rodent inside.

Immediately after capturing the rodent, the LCD screen updates with a new message: "Rodent Caught." To provide an audible alert of this event, a buzzer sounds for 20 seconds, ensuring that anyone nearby is made aware of the capture. The BLYNK app shows pop-up messages to the owner’s cell phone so that the owner of the trap never forgets to check the trap. Moreover, the system activates an electric current from the electric shock circuit with the help of 5v Single relay module, flows the high voltage current through the aluminium panel within the trap for 20 seconds, likely to humanely euthanize the rodent. As all these events unfold, the system sends another notification to the user's mobile device, informing them of the successful capture.

The system then alerts the user, prompting them with the option to reset the trap. If the user chooses to reset, the process loops back to reopen the trap door and send another readiness notification through Blynk App to their mobile device. However, if the user decides not to reset the trap, the process comes to an end. This sophisticated sequence ensures a seamless and efficient operation, combining real-time monitoring, automated responses, and user notifications to manage rodent control effectively.

These states can be repeatedly restored to the structure via IoT. The Internet of objects (IoT) is the internetworking of basic machinery, transportation, architecture, and various objects integrated with equipment, programming, sensors, actuators, and framework organizations that enable these items to collect and exchange data. This stores crucial data using several current improvements and then streams the data unrestrictedly across various devices.

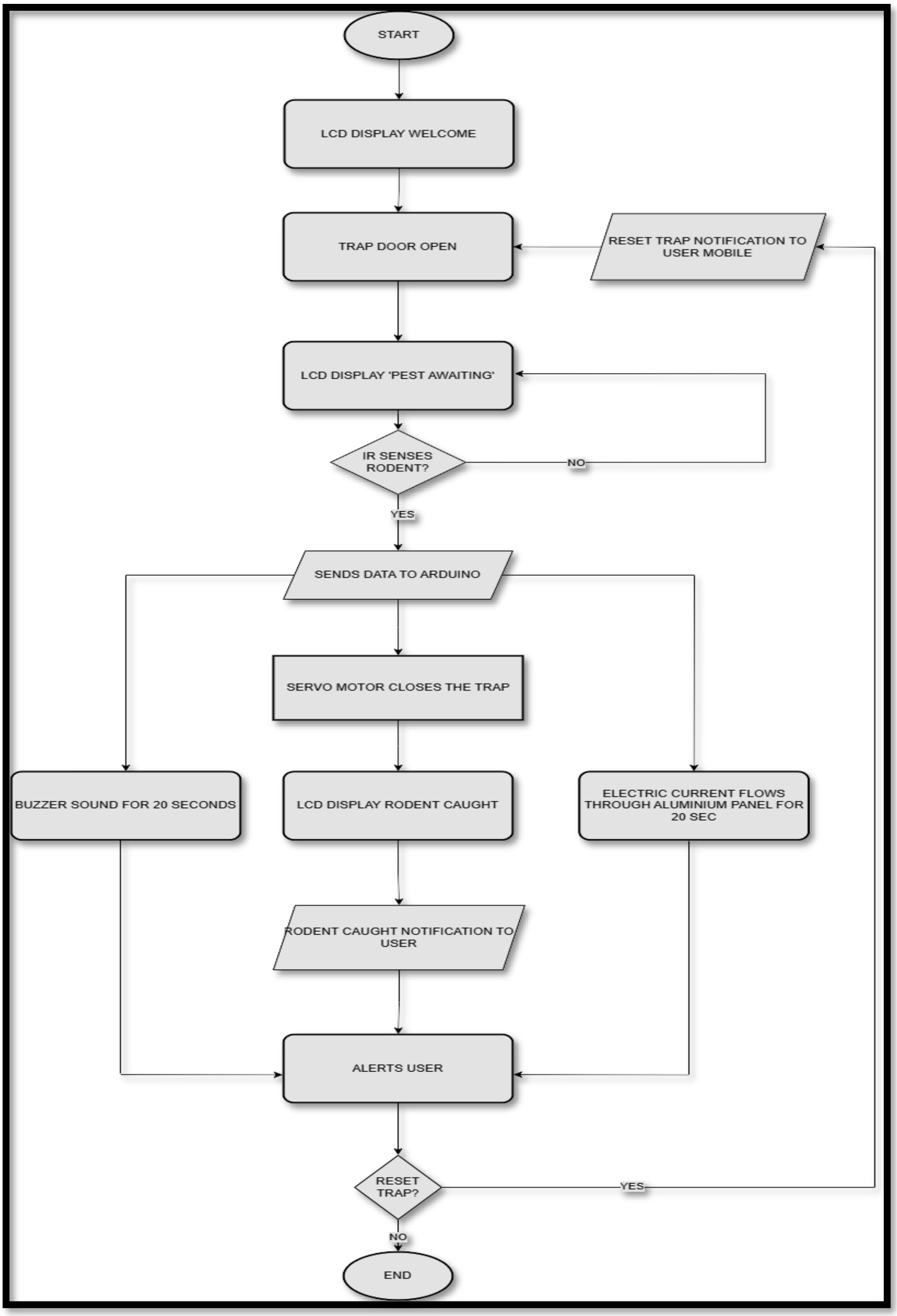


Figure 3.1: Flow Chart

3.2.2 Block Diagram of the Project

The Block diagram in Figure 3.2 IoT Rodent Guard has 2 portions. The first one is the hardware part and the second is the Software part. Which is the BLYNK software to send notification to the owner's cellphone via Wi-Fi Module

The automated rodent trap system presented in the schematic diagram centers around an Arduino Uno microcontroller, which orchestrates the operations of various components to ensure efficient and automated rodent trapping. The system begins with a DC power supply that provides the necessary electrical power to the Arduino and other connected devices, ensuring a stable operation throughout the process.

The core of the detection method is based on the IR sensor mounted to gather information on the presence of a rodent inside the trap. In the case that movement is detected by the IR sensor, a signal is sent to the Arduino to trap the rodent, as can be seen in the trapping sequence conducted afterwards. A button is also added within the system for manual control. It can be used to reset the trap and initialize the system at the beginning, and on that basis, it provides an option for user interaction when needed.

Whenever the IR sensor detects a rodent, Arduino will switch on a relay connected to high power components. The relay acts as a switch to the electric shock circuit. When the IR Sensor triggers, the Arduino instructs the Relay to deliver voltage from the Powerful Source to the Electric Shock Circuit. As a result, the rodent gets humane killing current for a predetermine time through an Aluminum Panel that suffices for a kill.

It also includes a buzzer that produces a sound for 20 seconds if any rodent is caught in it. This will alert any person in the surrounding region who may have heard. An

LCD display is also used to give some visuals to the user. Welcome, Pest Awaiting, and Rodent Caught are messages which help the user assess the real-time status of the system.

Its further links to a Wi-Fi module that can transmit information to the user's mobile device through the Blynk App. The module has an essential function to provide notification or messages to the user once an update is needed on the trap status, an alert regarding rodent caught, or a message to confirm the reset of the trap. This has been done through the development of software coding of Blynk Software to the Arduino Uno. The application enhances the awareness of users, and in this manner, suitable action can be taken on time.

In conclusion, the IoT Rodent Guard system is very advanced in integrating different components to provide very effective and user-friendly solutions for trapping rodents. The Arduino Uno microcontroller acts as the central controller, processing all inputs not only from the sensors but also from the user and therefore controlling outputs to ensure seamless trap functionality. The setup creates a new realm of automated rodent trapping that bridges the gap between real-time notifications, visual displays, and manual control options.

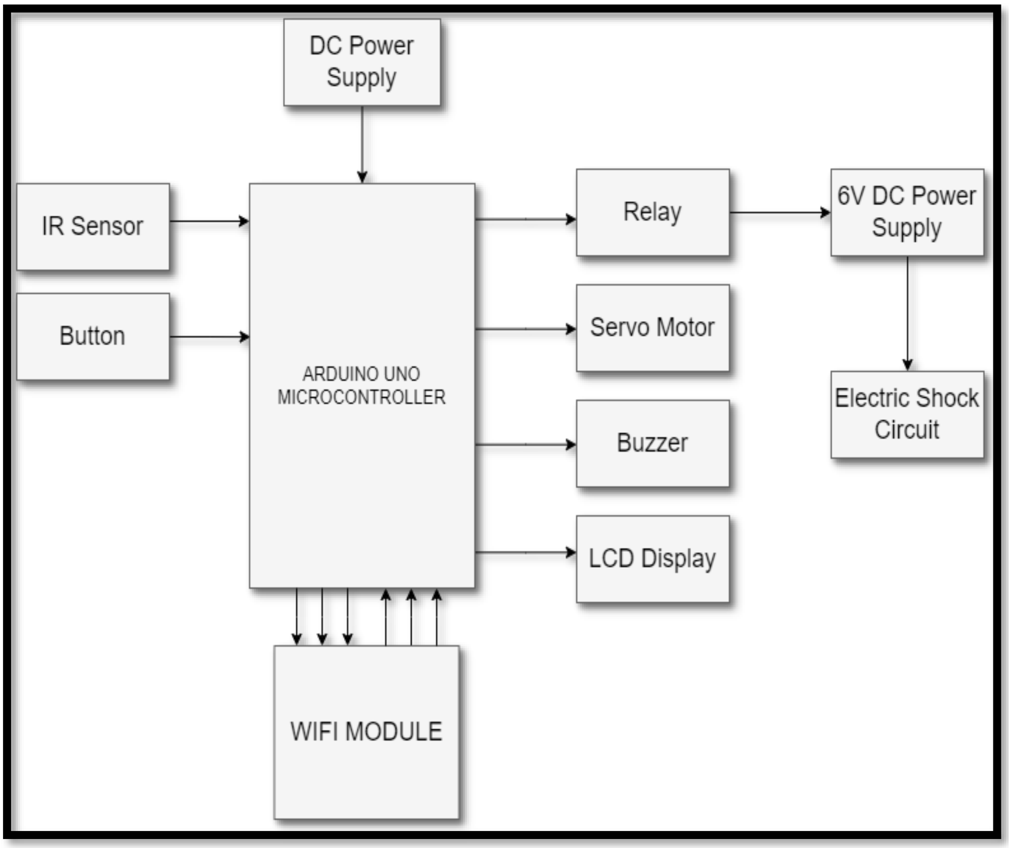


Figure 3.2: Block Diagram

3.3 ARDUINO Hardware Components

3.3.1 ARDUINO UNO

As shown in Figure 3.3, the Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). This board has 14 digital I/O pins in the input/output, with 6 of them as PWM, 6 analog inputs, a 16 MHz resonator, a USB connection, a power plug, an ICSP header, and a reset button[30]. The microcontroller needs to a USB cable not only connects to the computer but also an AC to DC source of a power supply.

The Uno allows for experimentation without excessive concern about potential errors; in the worst-case scenario, the microcontroller chip can be replaced inexpensively, enabling a fresh start. The name "Uno," meaning one in Italian, commemorates the release of Arduino Software (IDE) 1.0. Initially, the Uno board and Arduino Software (IDE) version 1.0 were the standard references for Arduino, subsequently advancing to newer releases. As the pioneering USB Arduino board, the Uno set the standard for the Arduino platform, serving as the benchmark model. For a comprehensive list of current, past, or obsolete boards, users can refer to the Arduino index of boards[31].

The Arduino Uno R3 is a microcontroller board based on the ATmega328P microcontroller. It is the brain of the project, responsible for controlling all the components and executing the code. It has digital and analog input/output pins that can be used to interface with various sensors, actuators, and other electronic components. In this project, it runs the code provided to control the trap mechanism, read sensor inputs, and communicate with external devices.

Figure 3.3: ARDUINO UNO

3.3.2 DC Servo Motor

Figure 3.4 is an application-specific motor that is used for precise positioning. In robotics, automation, and industrial machinery, a servo motor, unlike a DC motor, has built-in feedback mechanisms like encoders or sensors to constantly monitor the motor's position. A controller uses the feedback to control the rotation of the motor so that it can be precisely controlled to reach its desired position, velocity, or torque. DC Servo motors generally produce high torque at low speed, have very fast response times, and are highly accurate. Consequently, they form a very important part of systems requiring dynamic, reliable performance. The SG Micro Servo Motor is commonly applied to situations requiring precise angular control-the so-called trap doors for projects. The motor is thus able to set with accuracy the angle of rotation using the function servo.write(). The trap door will, therefore, be opened and closed with a lot of precision.

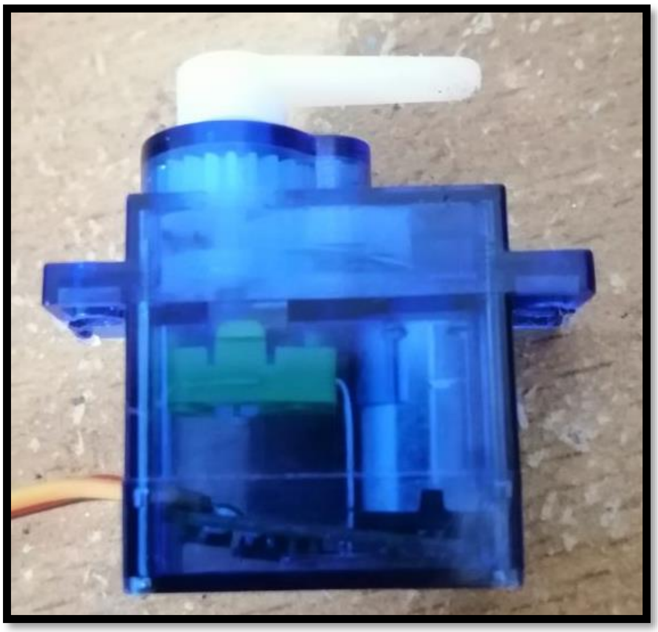


Figure 3.4: DC Servo Motor

3.3.3 ESP8266 Wi-Fi Module

The ESP8266 Wi-Fi Module is a general-purpose SOC solution. It features an integrated TCP/IP protocol stack. Allowing any microcontroller to access the Wi-Fi network can be done with this module. It either operates as an appliance during a stand-alone application or it is used to offload Wi-Fi networking functions from another application processor. Using pre-programmed AT command firmware, users can easily connect it to an Arduino device, which provides similar Wi-Fi capability as when attaching a Wi-Fi Shield. Famous and widely popular among users as a Wi-Fi and internet communication interface for Arduino projects. Throughout this project, it could be used to transmit data when a trap device is triggered or reset, resulting in remote monitoring and control. Due to its low price and active user community, ESP8266 remains one of the top choices for adding Wi-Fi to a wide range of Arduino-based projects.

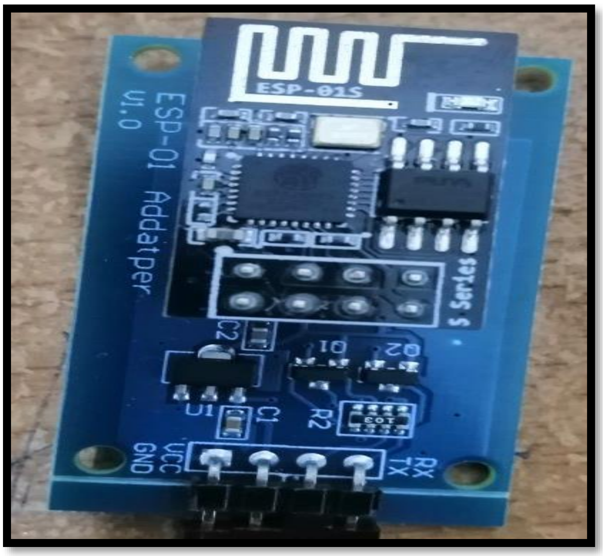


Figure 3.5: ESP8266 Wi-Fi Module

3.3.4 IR Sensor Module

3.3.4.1 IR LED Transmitter

IR LED emits light, in the range of Infrared frequency. IR light is invisible to us as its wavelength (700nm – 1mm) is much higher than the visible light range. IR LEDs have light emitting angles of approx. 20-60 degree and range of approx. few centimeters to several feet's, it depends upon the type of IR transmitter and the manufacturer. Some transmitters have a range of kilometers. IR LED white or transparent in color, so it can give out amount of maximum light.

3.3.4.2 Photodiode Receiver

Photodiode acts as the IR receiver as it conducts when light falls on it. Photodiode is a semiconductor which has a P-N junction, operated in Reverse Bias, means it starts conducting the current in reverse direction when Light falls on it, and the amount of current flow is proportional to the amount of Light. This property makes it useful for IR detection. Photodiode looks like a LED, with a black color coating on its outer side, Black color absorbs the highest amount of light.

The IR (Infrared) sensor detects changes in the amount of light absorption in its field of view caused by the disturbance of an object, such as a human or animal. It has two slots in it, and when an object passes in front of the sensor, it detects a change in the amount of light absorption reaching the Photodiode sensor. In the code provided, it is used to detect the presence of rodents by sensing their presence. When disturbance is detected, the activateTrap () function is called to trigger the trap mechanism.

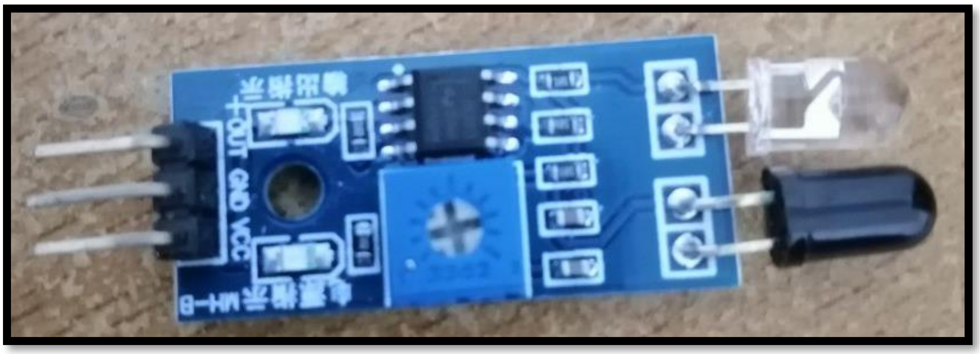


Figure 3.6: IR Sensor Module

3.3.5 Single Channel 5V Relay

It is a critical component in most electronics and automation projects. The single Channel 5V Relay is simply an electromagnetic controlled electric switch which can be used to give a higher voltage to the circuit by using a lower voltage signal. It incorporates coil, armature, contacts, and a spring in its electromechanical design. When one applies or energizes a 5-volt control signal, it shall function just like a switch. Thus, it works with microcontrollers as well as Arduino boards and several other devices. Since it is largely applied in home automation, robotics, and other electronic-based systems, the single-channel setup of the controls powers only one circuit, which makes it flexible for do-it-yourself and even for commercial purposes.The relays are said to isolate and switch higher power loads. For example, with respect to the electric shock panel for pest control, once activated, the relay closes the circuit of delivering the needed electric shock to the trapped rodent-quite a fascinating gadget in controlling potentially harmful rodents in homes. This is done using functions like digitalWrite() with proper setting of the output state of the relay.

Figure 3.7: Single Channel 5V Relay.

3.3.6 LCD Screen Display

The I2C LCD is a module for displaying messages and status information in this project like trap monitoring, communicating with Arduino via the I2C protocol, simplifying serial communication with just two wires. Initialized with the LiquidCrystal_I2C library, it's employed for showcasing welcome messages, status updates, and other pertinent data. Utilizing the Liquid Crystal Library, compatible with Hitachi HD44780 driver, this module, recognizable by its 16-pin interface, can be controlled. Methods like display() and noDisplay() facilitate turning the display on and off respectively, with the latter preserving text content while blanking the display, providing a swift method to maintain information without losing visibility

Figure 3.8: LCD Screen Display

3.3.7 Passive Buzzer

A passive buzzer, unlike an active one, needs an external electrical signal, typically from a microcontroller like Arduino, to produce sound. It operates through the piezoelectric effect, where an applied electrical signal causes a crystal inside it to vibrate, generating sound waves. This vibration frequency determines the pitch of the sound. In this project, like alarms, the buzzer is activated by applying a specific frequency tone using the tone() function and deactivated using noTone(). It produces the sound when there is a disturbance in the IR Sensor light ray. It alerts the nearby or owners when the rodent has been caught. It's essentially a straightforward sound-generating component reliant on external signals for operation.

Figure 3.9: Passive Buzzer

3.3.8 Push Button

A push button switch is a mechanical device designed to control an electrical circuit by the manual actuation of a button. These switches vary in shape, size, and configuration to suit different needs. The push button that used int this project is a simple 4x4 small button as referred to in the figure below. They operate on a simple in-out mechanism and can either break or initiate a circuit or serve as an input for user interface or function control. They are categorized as momentary, where the switch function lasts only while the button is pressed, or maintained, where the function remains latched after activation. The reset push-up button in this project, a momentary switch used to reset a trap mechanism. When pressed, it triggers resetting the trap to its initial state by opening the trap door again and initializing the display into awaiting mode to catch the rodent. Typically connected to an Arduino digital pin, it's configured with INPUT_PULLUP mode, reading the reset does not function if the trap is still under awaiting mode when not pressed and will function when been pressed after the rodent caught.

Figure 3.10: Passive Buzzer

3.4 Electric Shock Circuit Hardware Components

3.4.1 UF 4007 Diode

The UF 4007 diode is a type of fast recovery rectifier diode. The device is useful in electric shock circuits to keep the direction of the flowing current in check. This means they keep the current flowing in the right direction and prevents reverse or backward current from damaging the circuit[32]. Given this fast recovery time, they are highly suitable for high-frequency applications. It also protects the circuit from voltage spikes. It clamps the high voltage and thus saves the circuit from voltage spikes damages that help in improving the reliability and lifetime of the circuit.

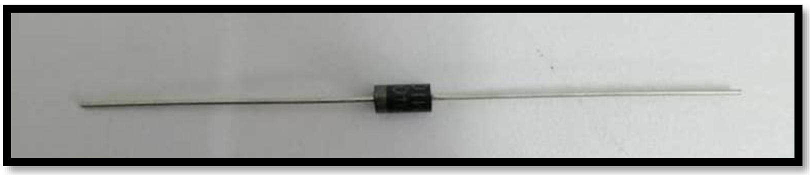


Figure 3.11: UF 4007 Diode

3.4.2 120 Ohm Resistor

This circuit also includes a 120-ohm resistor in the electric shock circuits to limit the current, due to the reason that a specific resistance provided will conduct a continuously particular current without passing excessive current which can damage other components in the circuit, much less threaten a human being. This resistor has a very vital role in maintaining circuit stability and efficiency due to ensuring the current flow at a rate that is under control and predictable.

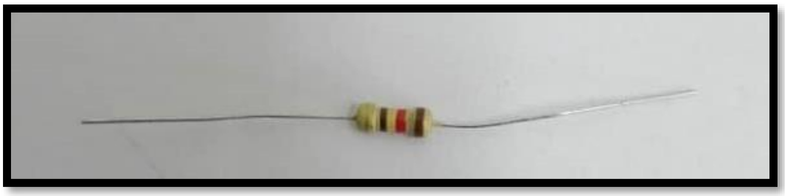


Figure 3.12: 120 Ohm Resistor

3.4.3 Switch

Figure below shows the switch in the electric shock circuit is one of the most important intensifying apparatuses that enable the user to control when the circuit will work and when not to. The reason for this is that the switch opens or closes the electrical path, so this allows the user to turn on or off the circuit at any time they want, which means, this feature provides a very important safety factor, which affords stopping the running of the circuit in times of emergency or when the instrument is not in use.

Figure 3.13: Switch

3.4.4 15KV Step-Up Transformer

This electric shock producing circuit requires a crucial element known as the 15KV step-up transformer that raises the voltage from a lowly level to a high voltage utilized for the purposes of the electric shock[33]. In step-up transformers, the voltage is stepped up through electromagnetic induction from the primary coil to the secondary coil with the achievable voltage boost. The voltage boost is essential because it is this high voltage that offers the circuit the property to generate the shock.

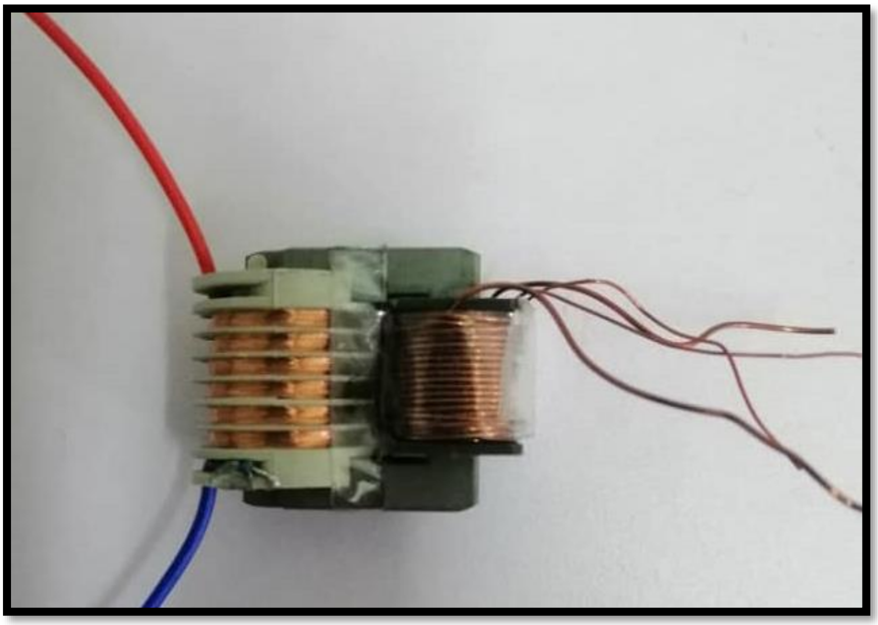


Figure 3.14: 15KV Step up Transformer

3.4.5 NPN Transistor

The NPN transistor of the electric shock circuit functions as switch or amplifier. It can be considered as one of the most vital components of the operational process of this circuit. When a small amount of current is provided in the base of the transistor, then it allows a much higher amount of current to flow from the collector to the emitter. In this capacity, the transformer is powered so that the circuit can produce the high voltage needed from it. The NPN transistor therefore makes it possible to work on greater current when there is a very small signal at the input, making the circuit more efficient and effective.

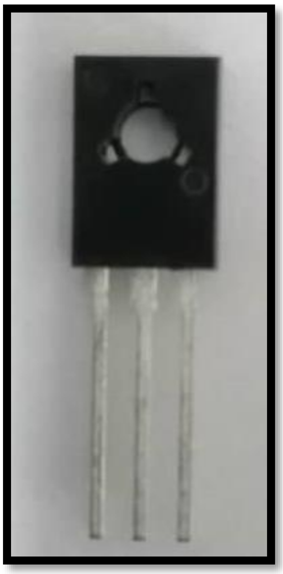


Figure 3.15: NPN Transistor

3.4.6 PCB Board

The PCB, or Printed Circuit Board, constitutes the support for mounting and interconnecting all the components together in a circuit for an electric shock. It is a flat insulating board with conductive pathways etched on it, which provides electrical connections to mount several components[34]. It holds all the components in their correct place without leaving the space and ensures that it is properly connected. Thus, providing a compact and orderly platform for the circuit. A PCB board also makes the circuit much more reliable and performs good and helps in easy assembly and servicing.

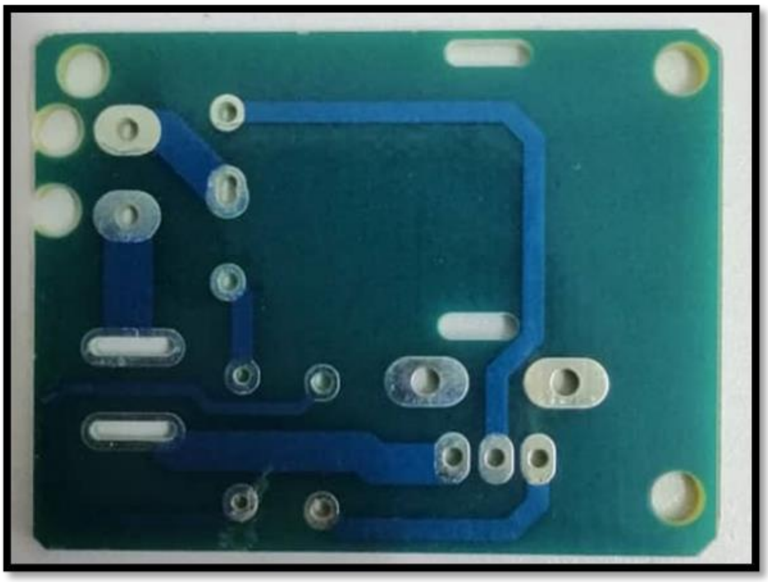


Figure 3.16: PCB Board

3.5 Software Description

3.5.1 Arduino IDE

The other main aspect of this project is the Arduino IDE. It forms the main software environment for the creation, testing, and deployment of programs written in other programming languages. In other words, the Arduino IDE is an integrated development environment employed in programming an Arduino Uno microcontroller board[31]. In this, the code is written using the Arduino Integrated Development Environment, and it primarily gives firmware controlling the functionality of the IoT rodent trap, such as reading the input from sensors, implementing the trap mechanism, and communication with some added devices such as the Wi - Fi module and the liquid crystal display. In essence, by writing code in the Arduino integrated development environment in the C/C++ programming language, the prototype can define the behavior of the trap in response to sensor inputs and trigger events accordingly. Also, due to the extensive library support of Arduino IDE different kinds of components and functionalities could be easily put into the project without any hassle, which itself promises compatibility and easy development.

Figure 3.17: Arduino IDE[31]

3.5.2 Blynk

Blynk is an IoT platform to develop applications where users can control and monitor connected devices through a mobile application remotely. It also allows the customization in drag and drop of user interfaces and dashboards, hence helping users to design intuitive interfaces that can be used to interact between the IoT project and by themselves in a very easy manner. Blynk due to being compatible with a wide range of hardware platforms like Arduino, Raspberry Pi, ESP8266, etc. is used for a wide variety of IoT devices and sensors[35]. Some such features include remote control and push notification along with data logging. Blynk provides cloud connectivity with secure communication protocols to transfer data to and from the devices and Blynk cloud server reliably and securely.

Here, Blynk is a software platform used in this project, by which IoT Rodent Guard is remotely monitored and controlled through a mobile application. By having the Blynk library in the Arduino firmware, the trap is now available in the Blynk app. Real-time notification of "Pest Awaiting" in case will be received by the user and once the pest gets caught by the trap, it will show the status of "Pest Caught." The user can remote control it anywhere with a network. With its drag-and-drop interface, Blynk allows users to customize designs of dashboards and control panels as per their specific needs, thus ensuring a better user experience and ease in management for IoT Rodent Guard. The cloud connectivity of this platform enables the trap and the mobile application to be connected seamlessly and securely, thus allowing reliable remote monitoring and control of the trap.

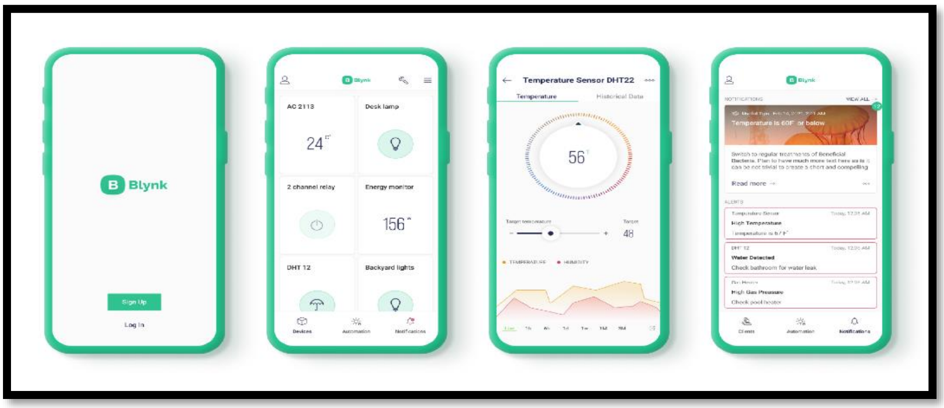


Figure 3.18: Blynk.[36]

3.6 Coding Implementation in the Arduino

The project wires up in the Arduino means writing and uploading the program to the Arduino board to run IoT Rodent Guard system. This program usually contains code (can be referred to in APPENDIX A) for reading sensor data, doing some processing e.g. achieving setpoints and controlling outputs (like controlling relay, servo, buzzer, push button and sensor). The Arduino in this project is probably programmed with the Arduino IDE, a C++ development environment that compiles to the native machine code of the ATmega328. The code interprets input from infrared sensor and push button, controlling output of the buzzer, relay, servo motor, LCD display, transmits signals to the electric shock board and interacts with ESP8266 module. These functions are defined to begin this sensor, read their values, and execute specific tasks dependent on certain conditions. For instance, the Arduino has been programmed to use a relay to send high voltage through a wire to the aluminum panel for a moment when the sensor detects a rodent, essentially acting as an onboard pest deterrent.

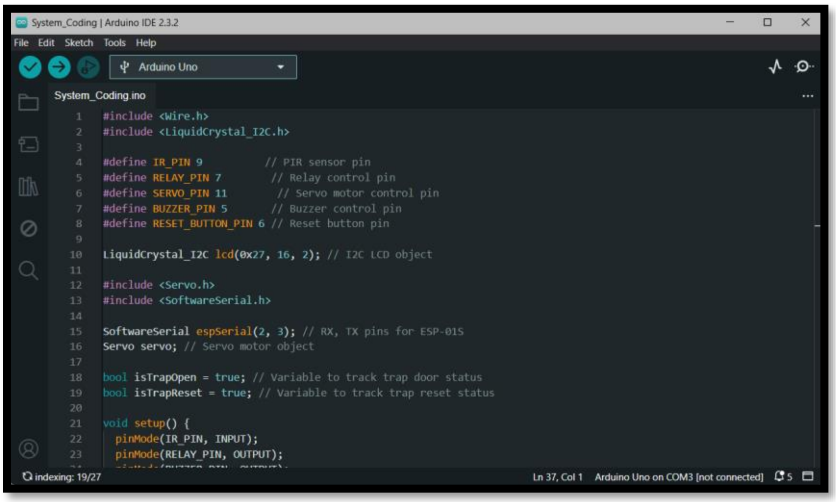


Figure 3.19: Coding Implementation in the Arduino

3.7 Coding Implementation in the ESP8266 Wi-Fi Module

The ESP8266 Wi-Fi module is coded to take care of all the communication related to the IoT Rodent Guard system. What could potentially be coding for the ESP8266 is establishing a Wi-Fi connection, communicating; the Arduino and with the Blynk cloud server to report the system status. The ESP8266 code (can be referred to in APPENDIX B) has been written in the Arduino IDE and uses libraries like ESP8266WiFi to handle connections to Wi-Fi and HTTP requests. Information shared by Arduino over serial communication which further sent as an alert on a remote server by ESP8266. In addition, it can provide a web interface for users to monitor and interact with the system for future work.

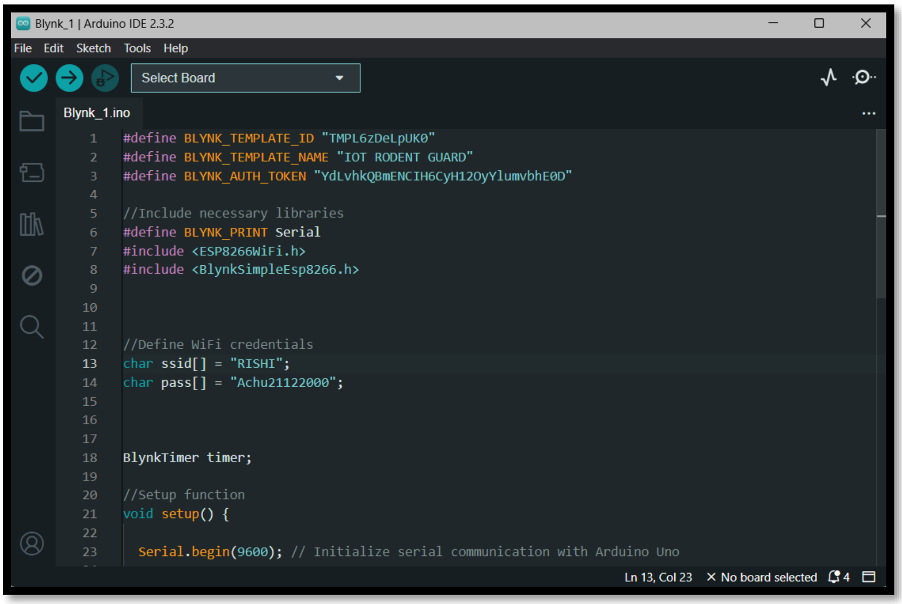


Figure 3.20: Coding Implementation in the ESP8266 Wi-Fi Module

3.8 Arduino Microcontroller and Components Setting up

Setting up the Arduino and its components involves assembling the hardware components and connecting them appropriately to ensure the system functions as intended. The Arduino board is connected to various inputs, relay, the ESP8266 Wi-Fi module and other components. Power is supplied to the Arduino and other components using a power source connector. The connections are typically made using jumper wires, ensuring that the pins on the Arduino correspond to the correct inputs and outputs. For example, digital pins on the Arduino are connected to infrared sensor, push button, relay module, passive buzzer, LCD, DC servo motor and communication pins for the ESP8266. Proper setup, the components were installed inside a plastic casing; securing components within an enclosure to protect the circuitry and organizing wiring to prevent shorts or disconnections.

3.9 Electric Shock Panel Soldering and Setting Setup

The electric shock panel is a critical component designed to deliver a high-voltage pulse to eliminate rodents. Setting up this panel involves careful soldering and assembly to ensure safety and functionality. The soldering process, as mentioned in Figure 3.17 below, involves attaching various electronic components to a PCB (Printed Circuit Board). This includes connecting resistors, capacitors, transistors, and the transformer that steps up the voltage. Proper soldering technique ensures strong electrical connections and prevents shorts. After soldering, the assembled PCB is mounted inside a protective enclosure. The aluminum panel is then connected to the Arduino through relays, allowing the Arduino to control the activation of the electric shock. The setup must ensure that the high-voltage components are insulated and that safety measures are in place to prevent accidental shocks.

Figure 3.21: Soldering Electric Shock Circuit

3.10 Arduino System Setup

So, among the components installed together, in the layout form with the IoT Rodent Guard System that is presented in Figure 3.15 among the design highlights inclusive a microcontroller Arduino Uno R3 version. This part of the hull is blue color and is the board that embodies the most main component of the system in that it receives data from various sensors and relays back control data to the various components. Starting from the right and moving to the left relative to the two-dimensional plane, it is this basic design with an LCD screen on white casing that shows the display and status of the system like an alert.

The rodent detection devices include the following key component is there for sensing the rodents.

These may include infrared sensors with the following very specific functions as far as sensing a possible presence of rodents in the model of the trap concerned. The remaining part of the setup is passive buzzer, and a relay module, which appears as the blue component in the setup, and it works as the switching of high voltage equipment by accepting low voltage signals from the microcontroller. This is very important particularly in the commissioning of electrical devices such as the electric shock panel without the microcontroller being in direct contact with actual voltage. The passive buzzer emits a certain frequency sound (500 Hz) as an additional alarm signal for the owner.

The system is also connected with a 5V DC servo motor that serves as a trap door actuator that closes or opens the door of the trap with an angle between 0° - 120° swinging angle. The small push button will reset the system as reusable and open the trap door.

Lastly, it also has installed with the ESP8266 Wi-Fi Module which is also an important innovation of this whole project by sending real-time monitoring and notification of the rodent status in the trap. This provides convenient to the owner for real-time status of the trap even though the owner is not available around the trap.

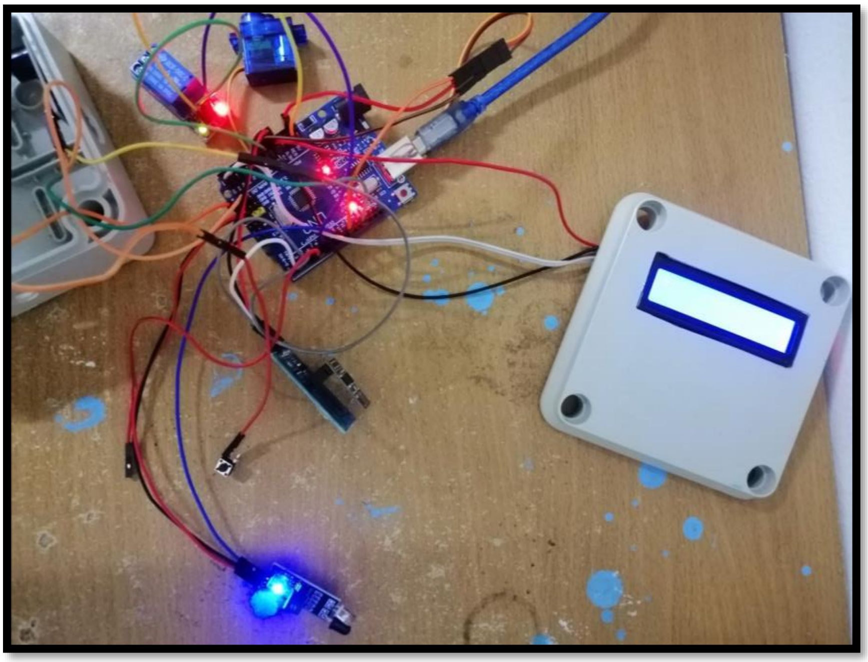


Figure 3.22: Arduino System Setup

3.11 IoT Rodent Guard Electric Shock Circuit Setup

Figure below shows the complexity of the working of the electric shock circuit, which in my opinion, is largely contributory in shaping deterrence in the IoT Rodent Guard System. The elements of this setup are as follows: As the specific goal of this work, it is supposed to describe the implementation of the fundamental principles by performing the setup to create, control and combine the mechanism of the electric shock with Arduino system. This can be seen with the 4 x 1.5V battery pack, which supplies power to each portion of the application; with this, the entire apparatus analyzes through its own bins of batteries and does not require an external power source. This system has a switch for controlling ON and OFF the circuit.

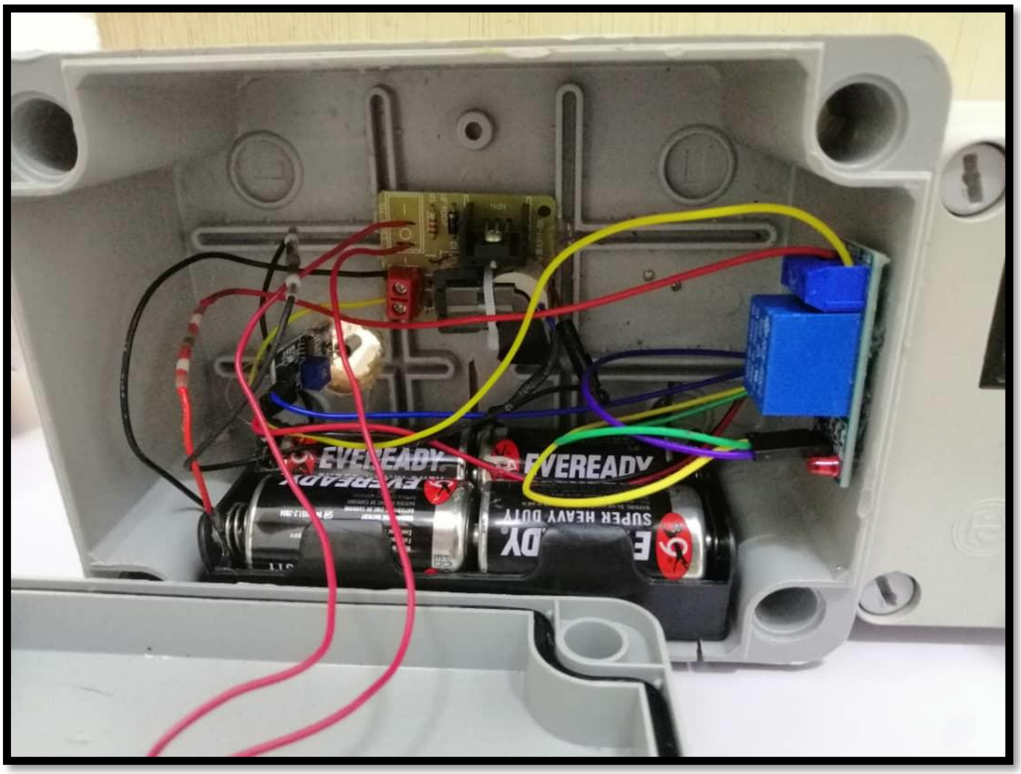


Figure 3.23: Electric Shock Circuit Combine with Project Setup

As shown above, inside the casing, there are various kinds of electronic components like diode and resistor and transistor used in handling power and to shield the circuit from different voltage. These components ensure that the energy which is supplied to the current of the electric shock panel is steady, sufficient, and harmless for which it is not capable to harm the human. This is connected to the relay module in the same way as it was connected to the circuit board at the very beginning of the setup, it just switches certain zones, including the high voltage loop. Consequently, it receives signals from the microcontroller to make or break the electrical impulses. This produces a balanced output depending on the sensors.

Firstly, as the large cylindrical section is a step-up transformer; the high voltage is required to produce the current that brought about the electric shock panel. Stepping the relay the circuit alters the current supply of the circuit which turns OPENS or CLOSES the current flow to the aluminum panel for a certain second (20 seconds) as were instructed by the coding in the microcontroller (Arduino Uno R3); which gives current mild shock to the rodents. This includes the networks of wires in the panel to ensure that required current is provided with the different sections of a panel and the microcontroller signals, which controls the shock mechanism.

This detailed arrangement helps emphasize the electric shock panels' safety with functionality feature. This preserves that the device does prevent rodents and works in the safe for humans and structured manner been used for years. The IoT Rodent Guard System is a smart and human approach to a common issue, protecting areas from rodent infestations automatically and efficiently using the following components.

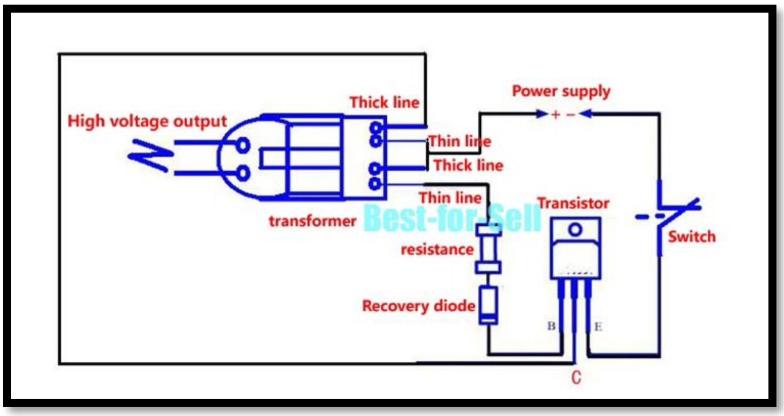


Figure 3.24: 15KV High Voltage and Frequency Schematic Diagram[37]

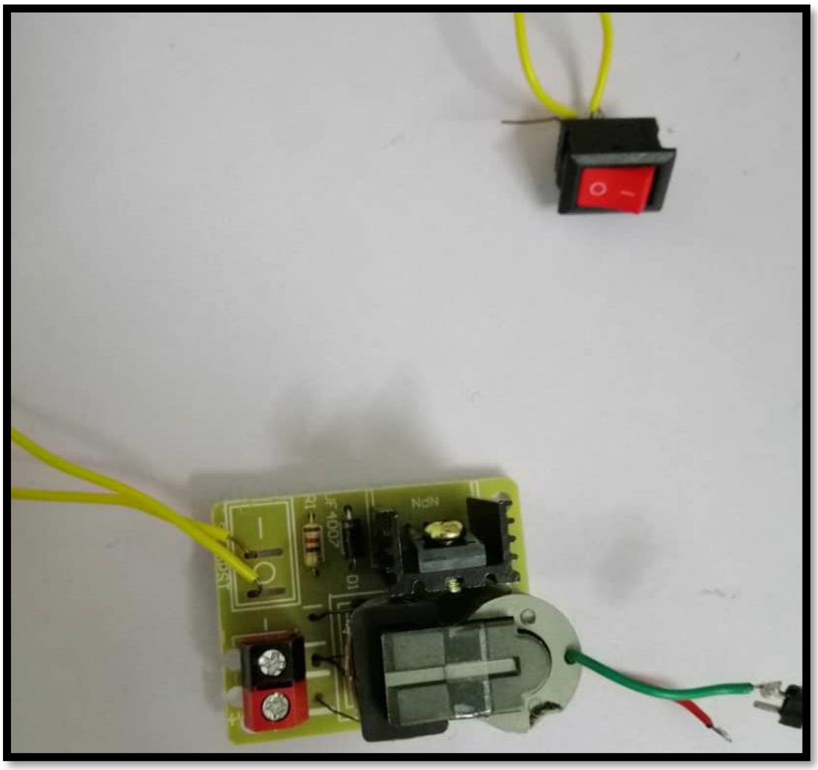


Figure 3.25: Electric Shock Circuit

3.12 Sustainable Development Goal (SDG)

The integration of Sustainable Development Goals in the design and implementation of the IoT Rodent Guard with an electric shock circuit is very significant for ensuring that the project contributes towards a broader social as well as environmental agenda in a positive light[38]. The SDGs give indicators for projects which are sustainable and ethical. The IoT Rodent Guard project, by being in alignment with these goals, is directly involved in not only important pest issues but also health and well-being, innovation, sustainable cities, responsible consumption, and life on land. Due to its focus on global goals, it provides long-term benefits and reduces negative environmental and social impact[38]. The IoT Rodent Guard with the implementation of the electric shock circuit has various strains incongruent with most of the Sustainable Development Goals.

3.12.1 SDG 3: Good Health and Wellbeing

The IoT Rodent Guard with the implementation of the electric shock circuit will enhance good public health, as it will curtail rodents in large numbers and very fast. Rodents are known to spread diseases such as leptospirosis, salmonella, and hantavirus. The disease spread is prevented by the IoT Rodent Guard, as through more effective and humane control of the rodents, improvement in community health and quality of life also results. Also, accidental exposure to health by humans and pets due to chemical poisons is reduced because the necessity of that gets reduced.

3.12.2 SDG 9: Industry, Innovation, and Infrastructure

The IoT Rodent Guard is itself an invention and implementation of innovation and technical improvement in pest management. This touches on SDG 9 to build resilient infrastructures, promote inclusive and sustainable industries, and innovate. IoT Rodent Guard applies the latest technology of sensors and IoT capability to allow monitoring and management in real-time. This invention not only enhances efficacy against the Base of the Pyramid rodent management style but also introduces a data-driven method of pest management that can be integrated into the smart city infrastructure.

3.12.3 SDG 11: Sustainable Cities and Communities.

The IoT Rodent Guard documented below can assist in making cities and human settlements safe, fair, adaptable, and sustainable, as indicated in SDG 11. Infestation by rodents is a common occurrence in urban areas, and this creates a big challenge to hygiene and public safety. When IoT Rodent Guard is installed in urban areas, it can assist in keeping the communities clean and safe by reducing the rodent population without using chemicals that are dangerous to humans. This green method of managing pests allows for improved quality of urban living and the building of more sustainable and resilient communities.

3.12.4 SDS 12: Responsible Consumption & Production

IoT Rodent Guard is part of the successes emerging from SDG 12, as the goal focuses on the need for responsible consumption and production patterns. Traditional methods of managing pests usually depend on chemical poisonous substances that affect not just the environment but also non-target species. An example on IoT Rodent Guard with electric shock circuits, bring out clearly the humane aspect besides being significantly from an environmental viewpoint as they try to eliminate applications of poisonous substances as much as possible. More so, this type of trap can be constructed for re-use, thus limiting dumping and enabling ethical production processes.

Figure 3.26: Sustainable Development Goals[38]

3.13 Summary

The design and development of the IoT Rodent Guard are proposed by the following suggested approach that shall use the Arduino-based microcontroller technology and IoT connectivity to develop a device with automatic detection and trapping features of rodents with real-time status updates sent to the user through a mobile application. This trap mechanism involves an IR sensor, to measure the movement of rodents, a servo motor, to shut the trap door, and an electric shock panel for human pest control. And with the addition of a Wi-Fi module in it, the system becomes remote, monitored and notified for the purpose of user convenience and efficiency. But at the same time, the limitations due to the reliability of the sensors, concerns regarding safety, need for maintenance, and feasibility in terms of expense must be strictly held in focus while delivering and implementing methodology.

CHAPTER 4:

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, the developed findings for the IoT Rodent Guard based system are presented and analysed. It involves the review and rating of the system in relation to its effectiveness and performance in operational functionality, effectiveness in capturing the rats, and an economic evaluation of the system within the prevailing real-life situations. The results from tests and measurements are based on the comprehensiveness of the test for understanding the capabilities of the system.

4.2 Hardware Integration

As discuss in Section 3.3 following Arduino UNO hardware, IR Sensor, ESP8266 Wi-Fi module, 5V Servo motor, LCD, 5V Relay Module, Passive Buzzer, Push button and many more are used to develop an efficient rodent trap system.

Table 4.1: Pins Configuration

Hardware Component	Hardware Pins	Arduino Pins
IR Sensor	-	D9
		GND
		VIN
5V Relay Module	-	D7
		GND
		VIN
DC Servo motor	-	D11
		GND
		VIN
Passive Buzzer	-	D5
		GND
		VIN
Push Button	-	D6
		GND
		VIN
LCD	-	A5
		A4
		GND
		VIN
ESP8266 WIFI Module	-	D2(RX)
		D3(TX)
		GND
		VIN
ARDUINO UNO	Power Supply Cable	-
Electric Shock Circuit	NO (5V Relay Module)	-
	C (5V Relay Module)	
	6V Power Supply	

The project system is, therefore, connecting very many hardware components to the Arduino Uno using pin connection in the realization of a single automated rodent trap. The wiring of the IR sensor to the Arduino uses pin D9 as an input for the signal, and it is connected such that the ground and power pins (GND and VIN) are connected to the corresponding GND and 5V power supply. The 5V relay module connects to the Arduino on pin D7, with additional connections on GND and VIN provided for power and grounding.

The input DC servo is pin D11 controlled, with GND and VIN powering it. The passive buzzer is connected to pin D5 and, like the others, gets its grounds and VINs for the power supply. The push button, for manual reset or startup, is inserted into pin D6, grounding and power supplied through GND and VIN.

For display purposes, an LCD is attached to the Arduino's analogue pins A5 and A4, as well as GND and VIN for power. The ESP8266 Wi-Fi module is connected to the system via digital pins D2 (RX) and D3 (TX) for serial communication, with the GND and VIN pins providing correct power supply.

The Arduino Uno is supplied by a power supply cable, which ensures that all connected components receive the appropriate power via the board’s-controlled outputs. The relay module's Normally Open (NO) and Common (C) terminals control the electric shock circuit, which is meant for compassionate euthanasia. The circuit is powered by a separate 6V power source.

4.3 Result and Discussion

4.3.1 Schematic Diagram of Project

The utility model discloses a touch control type multifunctional electric trap which can take alternating current-direct current as a power supply, comprising a high voltage generating circuit which is 15kV, a trigger controlling circuit and a delay circuit. The trigger controlling circuit is connected in series in the multifunctional Arduino circuit, the trigger controlling circuit can detect the fluctuation of direct current voltage on an external rodent shocking wire, the trigger controlling circuit magnifies the fluctuation and outputs trigger signal backward, the delay circuit can output the trigger signal when receives the trigger signal to the high voltage generating circuit immediately to make the high voltage generating circuit generate high voltage electricity and delivers to the aluminium panel, and the high voltage electricity stays on the panel for a period of time which is only about for 20 seconds as instructed in the ARDUINO Coding and disappears automatically. The utility model is safe and electricity saving, the utility model which needs no special person to look after the circuit for shut down the power supply.

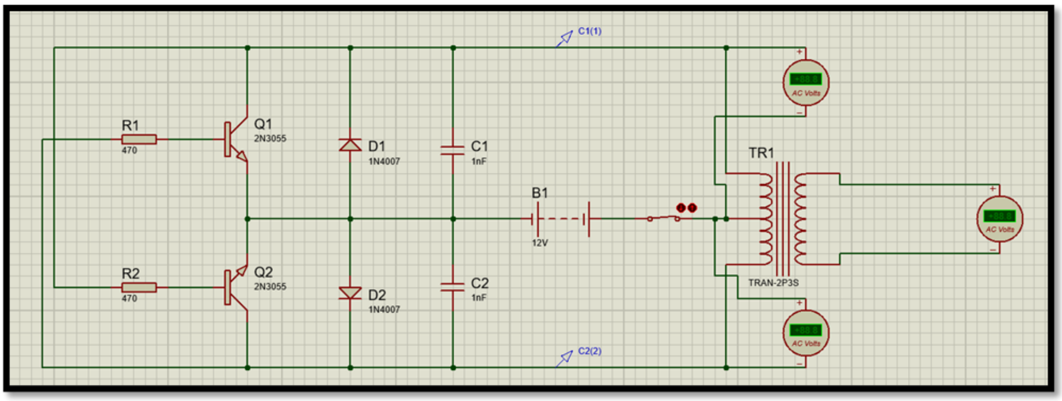


Figure 4.1: Schematic Diagram of Electric Shock Circuit

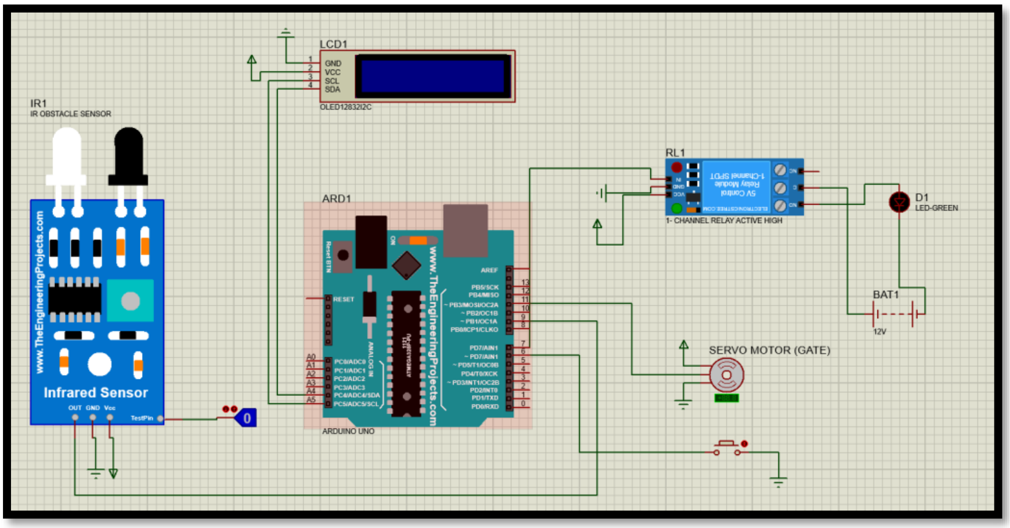


Figure 4.2: Schematic Diagram of ARDUINO Project

4.3.2 Schematic Diagram of Project

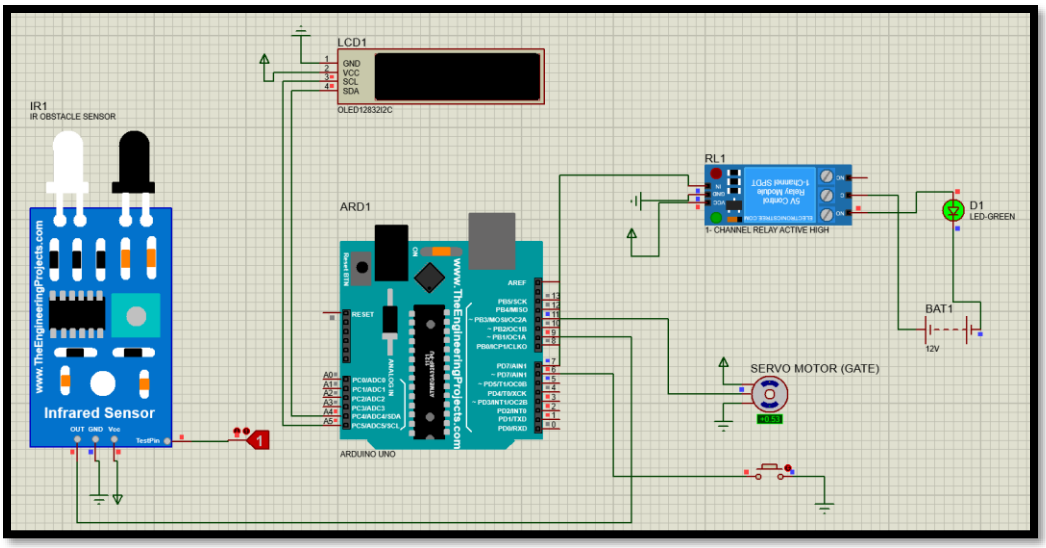


Figure 4.3: Schematic Diagram of ARDUINO Project

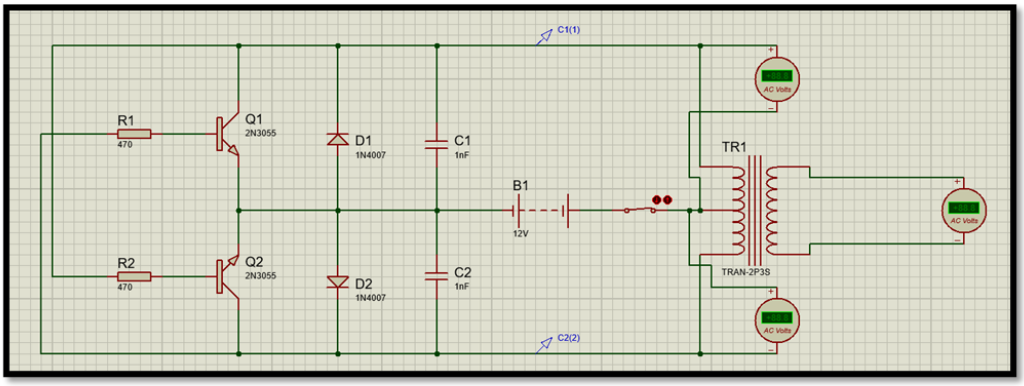


Figure 4.4: Schematic Diagram of Electric Shock Circuit

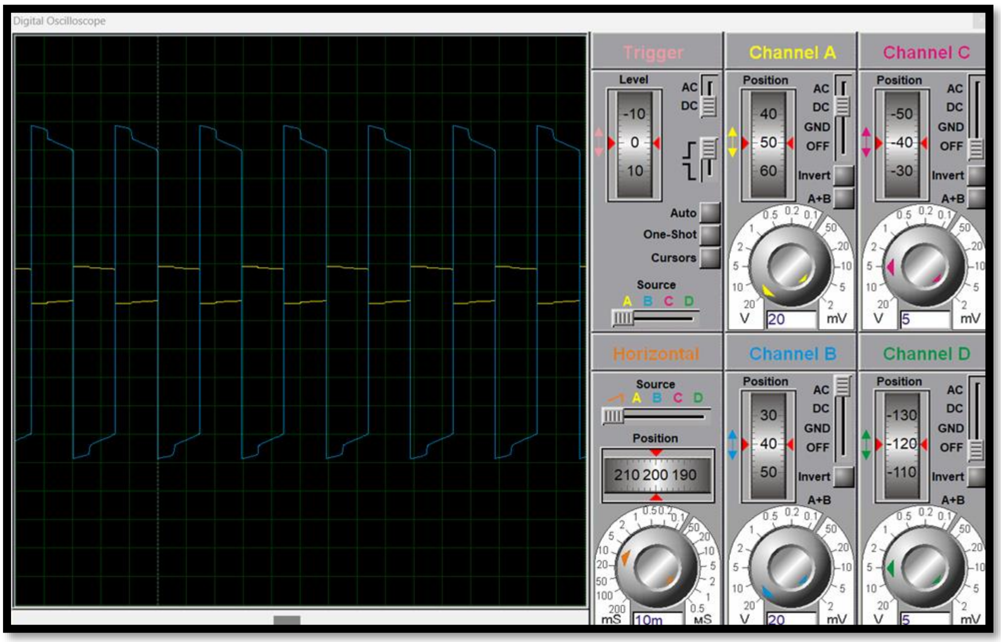


Figure 4.5: Output from the Oscilloscope of Electric Shock Circuit

4.3.3 Project System Result

This section details the overall performance and functionality of the IoT-Rodent Guard system. We will discuss the operational status of the electric shock circuit and various components, including the sensors, microcontroller, motor, and Wi-Fi module. The reliability and accuracy of the system in detecting and capturing rodents will be evaluated.

4.3.3.1 Scenario 1: Rodent Not Caught

This section describes the overall performance and working methodology of the IoT-Rodent Guard system. First, we will discuss if such an electric shock circuit will become operational active or not, along with the other constituents such as sensors, microcontroller, motor, and Wi-Fi module. Finally, we will evaluate this system to determine whether it is reliable and accurate for detecting rodents and then catching them.

4.3.3.2 Scenario 1: Rodent Not Captured

In the initial status at start-up, with no rodents caught, the trap door is open with "Pest Awaiting" on the LCD screen, and the electric shock component and the buzzer are both turned off by default in order not to waste energy by discharging an unnecessary noise. However, the Wi-Fi module is still connected and waiting to be used so that it may send a message when required. In this status, no notification is sent via the Blynk app, indicating that the entire system is on standby mode, waiting for rodent detection.

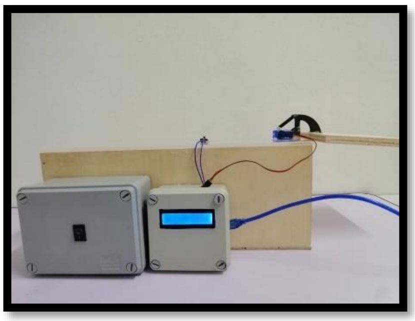
4.3.3.3 Scenario 2: Rodent Caught

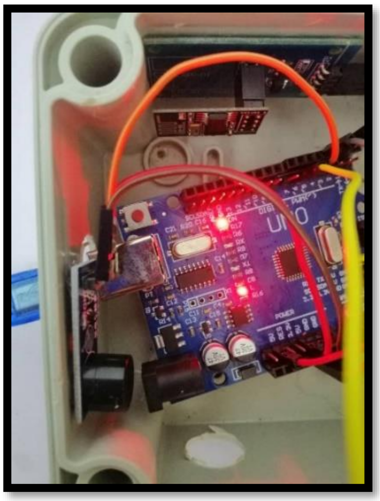
When a rodent is detected and caught, the door trap is automatically closed. The LCD changes to "Pest Caught" such that any observer around the area will know that the pest has been caught. At the same time, the electric shock system turns on for 20 seconds to quickly and humanely kill the rodent. The buzzer beeps for the same period to give a much more extensive warning. The Wi-Fi also works to send a mobile device a "Pest Caught" notification immediately through the Blynk application. This in turn notifies the owner for a corresponding action if needed.

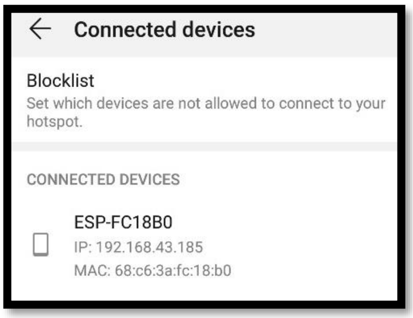
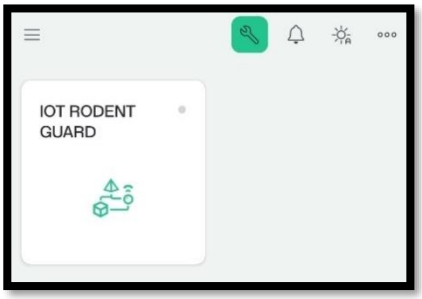
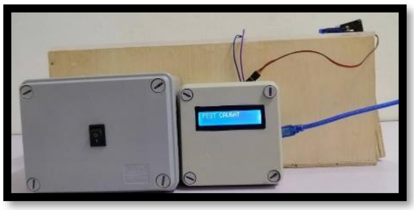
4.3.3.4 Scenario 3: Trap Reset

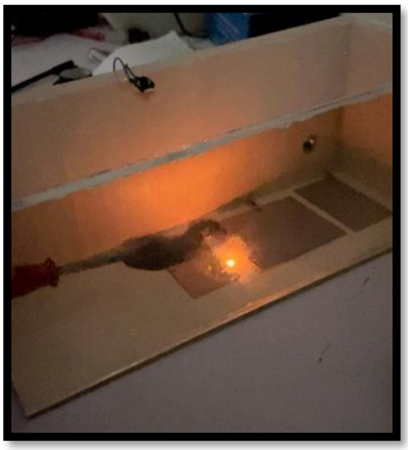
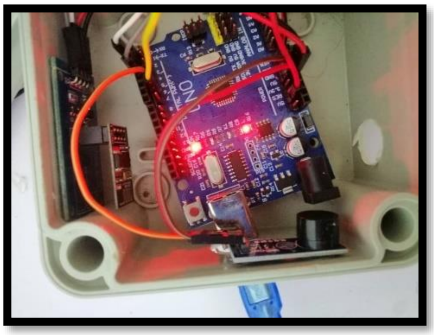
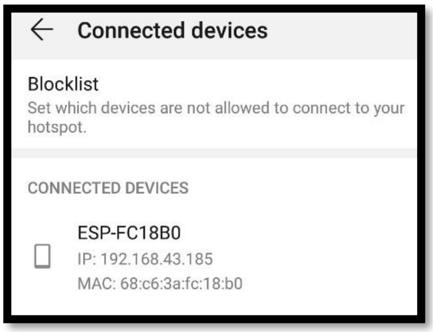
The trap resets back to its normal position once a rodent has been treated. The trap door again opens and on the LCD is again "Pest Awaiting", indicating that the system is again ready for any rodents. The electric shock system and buzzer are powered off in time for the next cycle of activation. The Wi-Fi stays on, so it would be fully operational. It sends a "Pest Awaiting Notification" to the Blynk app so that the owner would know that the trap is now in a reset state and ready to catch.

Table 4.2: Performance and Functionality of the IoT-Rodent Guard system

No.	Scenario	STATUS	FIGURES
1.	Rodent Not Caught	Trap Door: Open	 **Figure 4.6: Trap Door Open**

		LCD Display: Pest Awaiting	 **Figure 4.7: Pest Awaiting Display**
		Electric Shock: Off	 **Figure 4.8: Electric Current Off**
		Buzzer: Sound Off	 **Figure 4.9: No Sound**

		Wi-Fi Connection: Connected	 **Figure 4.10: Wi-Fi Connected**
		Blynk Notification: No Notification	 **Figure 4.11: No Notification**
2.	Rodent Caught	Trap Door: Closed	 **Figure 4.12: Trap Door Closed**
		LCD Display: Pest Caught	 **Figure 4.13: Pest Caught Display**

		Electric Shock: On (20 seconds)	 **Figure 4.14: Electric Current On**
		Buzzer: Sound on (20 seconds)	 **Figure 4.15: Sound On**
		Wi-Fi Connection: Connected	 **Figure 4.16: Wi-Fi Connected**

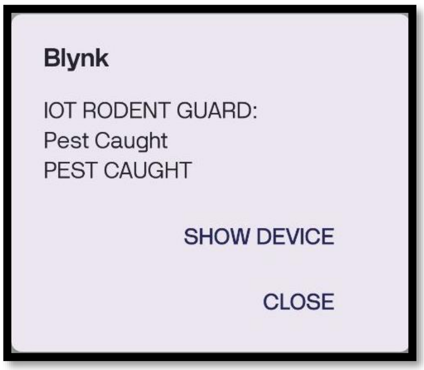
<table>
<tr>
<td></td>
<td></td>
<td>Blynk Connection: ‘Pest Caught’ Notification</td>
<td>

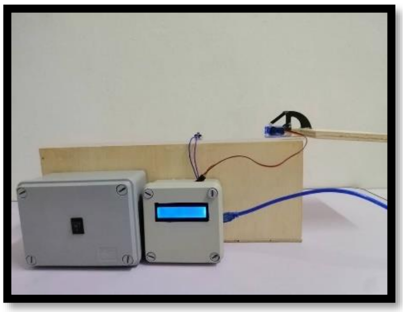
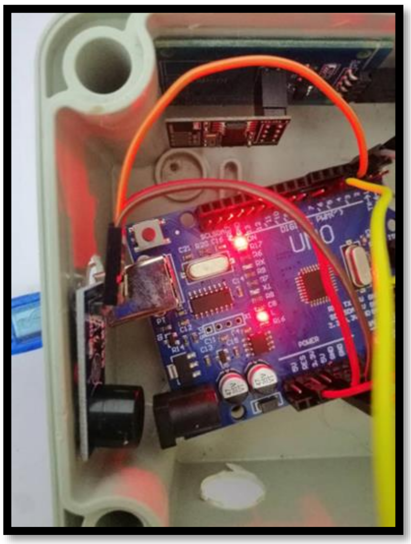
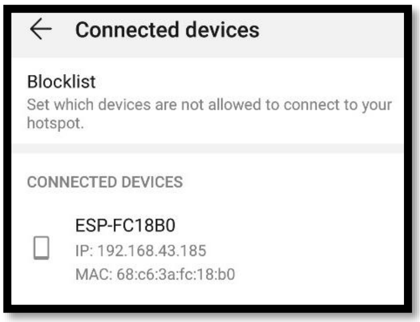
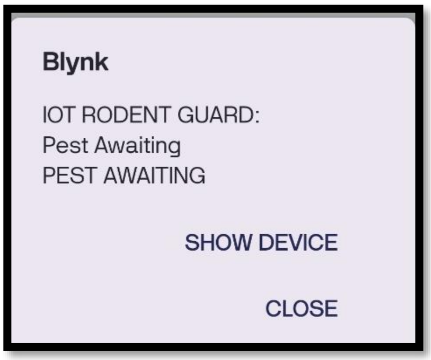
Figure 4.17: Pest Caught Notification</td>
</tr>
<tr>
<td rowspan="3">3.</td>
<td rowspan="3">Trap Reset</td>
<td>Trap Door: Open</td>
<td>
Figure 4.18: Trap Door Open</td>
</tr>
<tr>
<td>LCD Display: Pest Awaiting</td>
<td>

Figure 4.19: Pest Awaiting Display</td>
</tr>
<tr>
<td>Electric Shock: Off</td>
<td>
Figure 4.20: Electric Current Off</td>
</tr>
</table>

		Buzzer: Sound Off	 **Figure 4.21: Sound Off**
		Wi-Fi Connection: Connected	 **Figure 4.22: Wi-Fi Connected**
		Blynk Notification: ‘Pest Awaiting’ Notification	 **Figure 4.23: Pest Awaiting Notification**

4.3.3.5 Discussion

The IoT Rodent Guard system has demonstrated its performance under various scenarios. The state-transition, which is smooth and reliable among states, has every unit working as expected. Notification through Wi-Fi using the Blynk App makes the system real-time for sending notifications for up-to-date status on the situation. The electric shock and buzzer are thereby effective at the same time, in concise and humane dispatch of rodents. An LCD for clear status information.

4.3.4 Voltage and Current Measurement for Electric Shock Trap

This section will concern the technical performance of the Electric Shock mechanism. The experiment measured the actual voltages and currents supplied into the load during the ES to assure it is within the designed parameters. Discussion of the results will be held and confirmed safe and effective in a bid to reaffirm the electrical components.

Table 4.3: Voltage and Current Measurement for Electric Shock Circuit

Status	Input Voltage	Input Current	Output Voltage
No Rodent	6.0 V	68.0 mA	15kV
	6.0 V	68.2 mA	15kV
	5.8 V	67.9 mA	15kV
	5.9 V	67.8 mA	15kV
	5.9 V	68.1 mA	15kV
Rodent Caught	5.7 V	68.2 mA	15kV
	5.8 V	67.9 mA	15kV
	5.8 V	67.8 mA	15kV
	5.7 V	68.0 mA	15kV
	5.7 V	68.1 mA	15kV

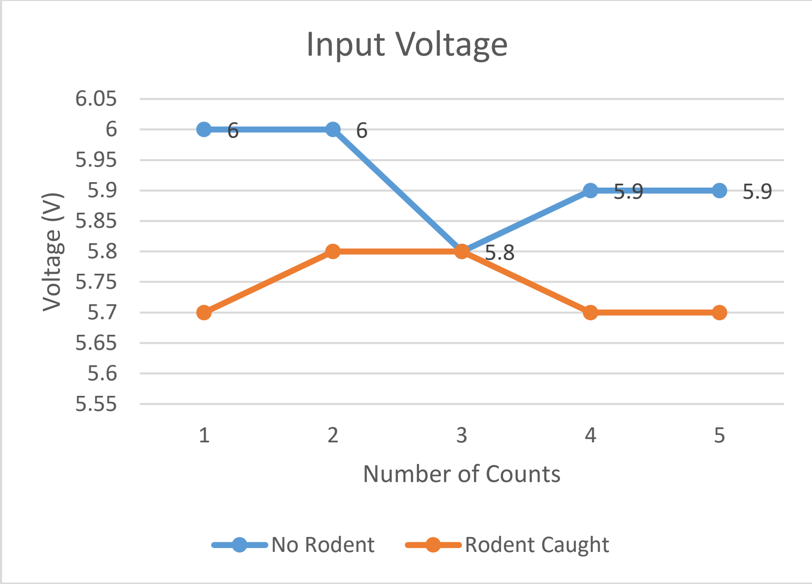


Figure 4.24: Input Voltage Over Rodent Status Graph

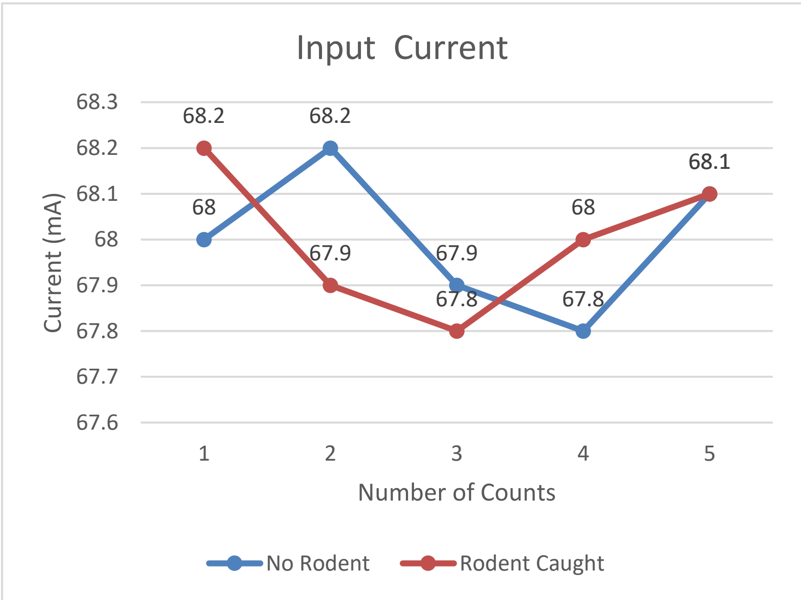


Figure 4.25: Input Current Over Rodent Status Graph

Figure 4.26: Input current measurement of the Electric Shock Circuit by Multimeter.

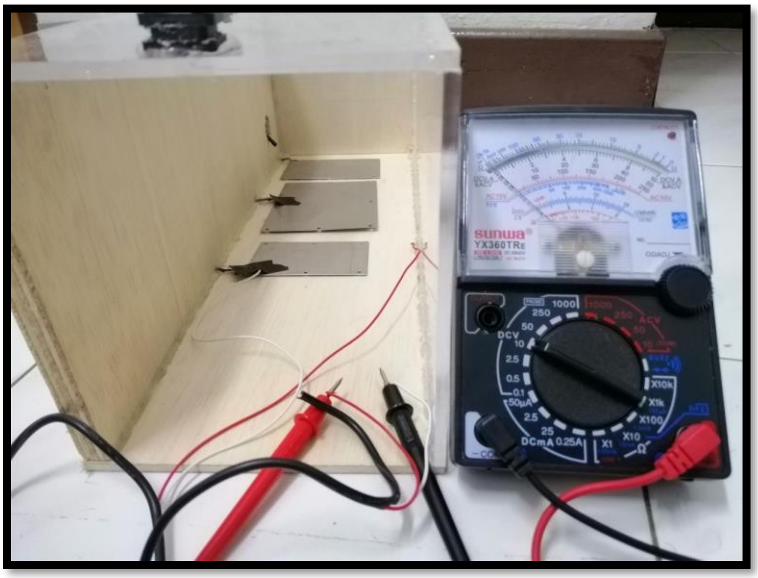


Figure 4.27: Output current measurement of the Electric Shock Circuit by Multimeter.

4.3.5 Notification System Performance

One of the most vital characteristics of the IoT Rodent Guard system is informing the owner about the occurrence of catching a rodent. Therefore, a time measurement for sending notifications through the application of Blynk has been carried out. Below table is the performance and success of this process of notification to ensure the owner had been notified immediately about the status of the trap.

Table 4.4: Time taken of the notification by Blynk App

Notification	Aspect Time Delay	Time Taken
Pest Caught	20.00 s	20.15 s
		20.45 s
		21.20 s
Pest Awaiting	5.00 s	1.00 s
		1.36 s
		1.21 s

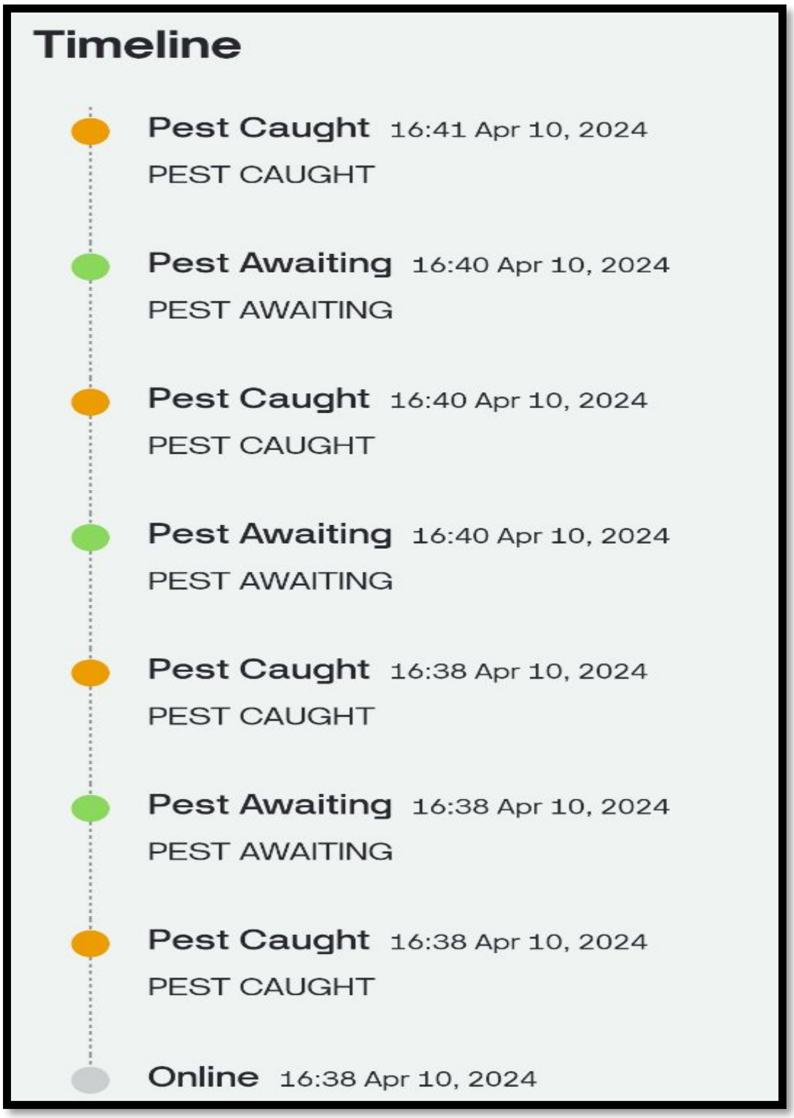


Figure 4.28: Timeline summary of Rodent Trap notification.

The performance of the IoT rodent trap on different metrics was evaluated, demonstrating its viability and effectiveness as a modern solution for rodent control. The results and discussions of strengths and weaknesses are also included to evidently reflect on the future improvements and applications of the system.

4.4 Summary

The current chapter thus subjects the IoT Rodent Guard system to a detailed study and finds it to be a performing success under a wide array of parameters. Advantages such as seamless transitions across modes of operation, real-time warnings, and compassionate dispatch form the crux of the benefits of such systems as revealed through the study. A sequence of findings and discussions, therefore, leads to significant insights into the abilities and possible areas of future enhancements that make the system a feasible answer to modern rodent control.

CHAPTER 5:

CONCLUSION AND FUTURE WORKS

5.1 Conclusion

In conclusion, this product can give many advantages to other people. From the operation of IoT Rodent Guard, we can conclude that our project uses many electronic devices such as IR sensor, Arduino, servo motor and other components. There are various new things that have been discovered on completing this project. Thus, there is lots of valuable knowledge that we can gain from the components used in this project. The experience of revealing new things is very useful, especially on making new things to make it useful for people's future prospect. Lastly, we are convinced that our product is one of the new ventures and very useful for all people, especially for industrial industries[39].

This IoT Rodent Guard is a tremendous home device that enables to catch mice alive or dead. It works well while activated and, in our tests, no issue has been noticed. It uses less energy while waiting for the rodent. In fact, only the IR Emitter and receiver are activated at this point and the LCD also displays a message, but the backlight is turned off. When a rodent is detected, the LCD remains lit after the door closes, until it is reopened again. Moreover, the controlling system that performs also sends notification to the owner to alert that a pest has been caught. The voltage consumption increases a little bit more after the rodent has been captured to give the electric shock to the rodent.

The device is made of electronic components and must be protected from humidity. There is no safety issue since the device uses a 6V battery to operate and has a backup emergency on/off switch for electric shock system. The device, as it is conceived, can also be used to capture other pests.

In the end, the Development of IoT – Based Rodent Guard Using Electric Shock Trap System successfully achieves its primary objectives of developing an integrated automated smart rodent trap using an Arduino board, IR sensors, a servo motor, a relay, and a Wi-Fi module. The system has been built precisely and implemented to detect the presence of rodents accurately and to trigger precise commands from the Arduino to activate the servo motor, ensuring effective trapping. The relay system efficiently delivers a timed electric shock, providing a humane solution to rodent control.

Moreover, the system also achieved in offering users the ability to customize various settings such as alerting, notification preferences, and operating hours through the Blynk app, enhancing user control and convenience. These features not only increase the system's specialty but also ensure it can be adjusted to meet specific needs and preferences in different environments.

Overall, the project successfully meets all outlined objectives, demonstrating a strong and innovative approach to rodent management. The integration of IoT technology with traditional pest control methods showcases significant potential for improving efficiency, safety, and effectiveness in rodent control practices across various sectors.

5.2 Limitations

Although the IoT Rodent Guard system performs satisfactorily in its functional aspects, there are some implementation issues associated with this system such as:

i. Sensor Reliability: IR sensors used could be subject to false triggering or missing their detection target due to various environmental factors bordering on dust, humidity, and temperature.

ii. Dependence on Power: The system requires a permanent power supply for proper operation. Thus, in cases where there is a power shortage or power depletion of the battery, there is perpetual disruption experienced in functionality.

iii. Wi-Fi Connectivity: How it relies on Wi-Fi is one of the major issues related to remote monitoring and control.

iv. Scale: The design proposal is suitable for small-scale purposes. Expanding it to more prominent sites or multi-site situations may be substantial tasks.

v. Safety Considerations: The electric shock circuit to be inhumane by purpose, can be otherwise dangerous if not handled properly or covered appropriately.

5.3 Project Potential

The IoT Rodent Guard system is deemed very promising in terms of development and application in the following vast array of scenarios:

i. Commercial Pest Control: The technique is appropriate for commercial pest control firms, providing a much more efficient and humane alternative to existing methodologies.
ii. Agricultural Use: The equipment can be utilized by farmers to get rid of rodents from laying ruin to crops, thereby cutting down loss, hence improving yield.
iii. Urban Setting: The equipment can be utilized in an urban setting where rat infestation exists, such as at agriculture sites, restaurants, and warehouses.
iv. Research Applications: The technology enables researchers to humanely collect and study rats outside the labs and artificial environments.
v. Smart Home Integration: It can be integrated into the smart home system, to give a wholesome pest control solution along with other smart devices at home.

5.4 Future works and Recommendations

Future Work for this rodent trap project can be done in the improvement of the efficiency of IoT Rodent Guard system and its short comings. These are attained by the following: through the selection of low-power components and optimizing its power consumption for the different operational states. As an additional feature, connectivity can be added like IoT to make remote monitoring and sending notifications to give users real-time updates of the trap status, capture. Improving the design on weather resistance to withstand outdoor conditions and expanding the device's flexibility in trapping all kinds of pests would provide versatility in its application on various environments.

vi. Improved Sensor Technology: optional for a more powerful IR sensor or the addition of others - e.g., ultrasonic/microwave sensors to enhance precision in the detection process within adverse weather conditions.

vii. Power Back-up Feature: In general, there must be a power back-up feature whereby the device will have the ability to operate even during power failures once some alternative powers are availed here, such as rechargeable batteries or solar power.

viii. Greater Wi-Fi Stability: Seek other communication means like LoRa or GSM, which can establish connectivity much more stable compared to Wi-Fi and especially where places with poor Wi-Fi signals must be researched.

ix. Security Upgrades: Make it safer by providing vandal-proof cabinets for the electric shock circuit, and safety features to prevent unintended trigger fire.

x. Scalability: Custom designed components with scalable solutions capable of being deployed over large areas and multiple traps. Improvements to the User Interface: Further develop the Blynk app interface for in-depth analytics, historical data, and customizable warnings for a seamless user experience.

xi. Cost Reduction: Find cheaper hardware components that make the kit affordable and not costly for a larger population of users.

xii. Community Feedback: Seek feedback from the end-users and redesign the form-factor as well as functionality to provide the users with an improved version for their usage.

xiii. Humidity-Proofing: Develop devices to be resistant to humidity to improve their lifespan in varied environmental conditions.

xiv. Compatibility to wildlife provisions: Make sure this gadget complies with the wildlife provisions and ethical values set, especially when other creatures are caught apart from mice.

xv. Collaboration with Pest Control Professionals: Adapt the latest scientific findings and good practices to develop device design and operations

xvi. Educational purpose: Produce teaching tools and programmers to diffuse Humane pest control practices proper utilization of devices.

Implementing these will make the 'IoT Rodent Guard' system rugged, enhance efficiency and be user-friendly and widen the application area to cover all types of users and applications.

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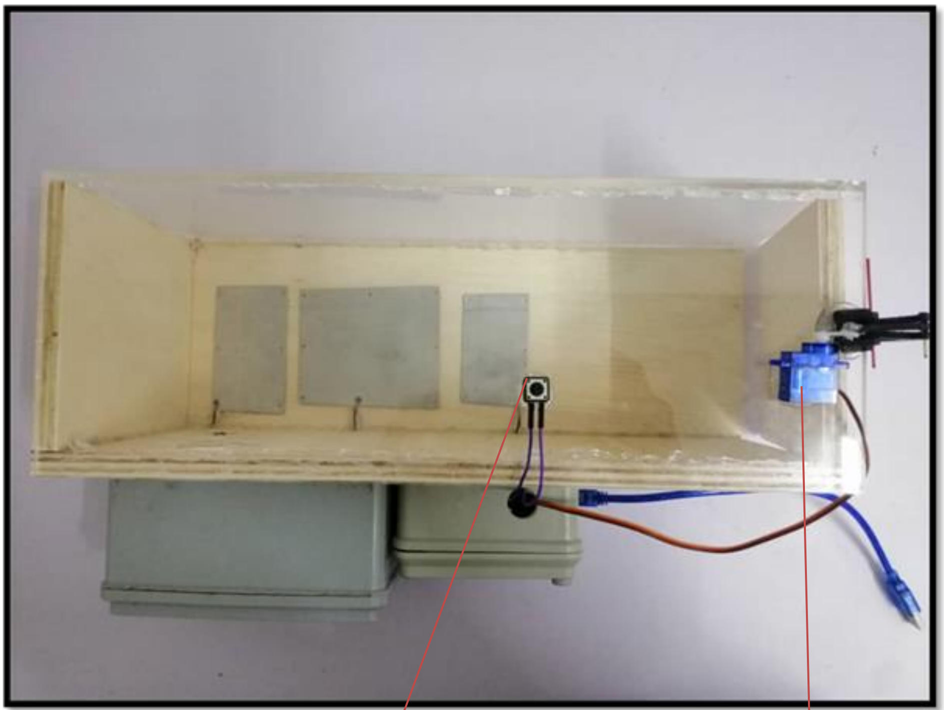
APPENDICES

Appendix A – Prototype Model

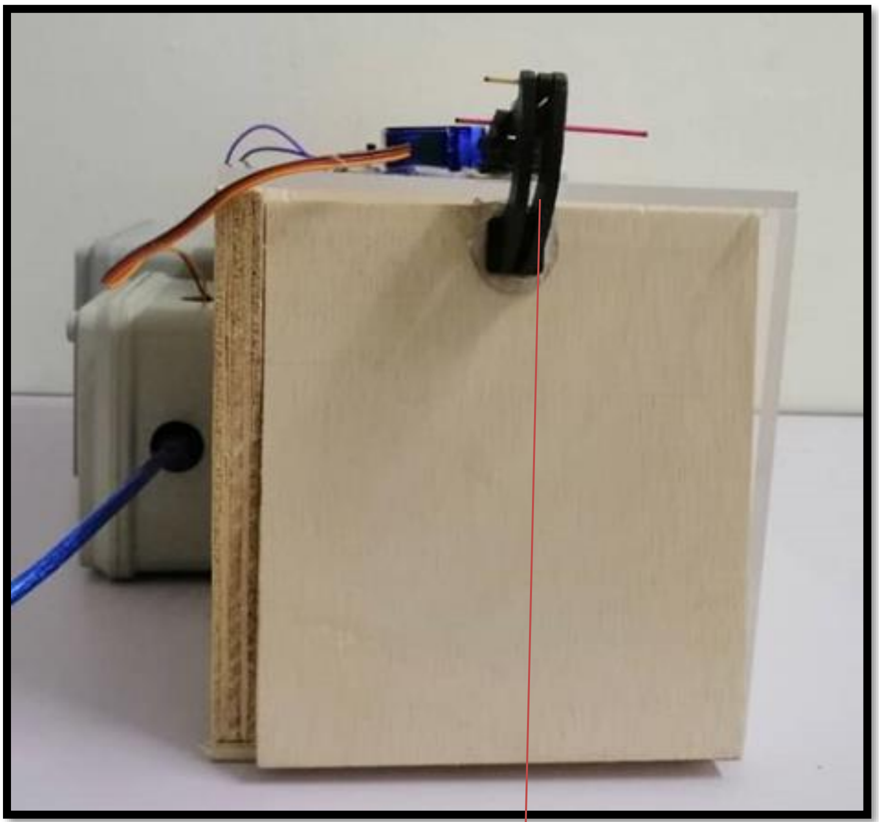
Left View:



Push Button

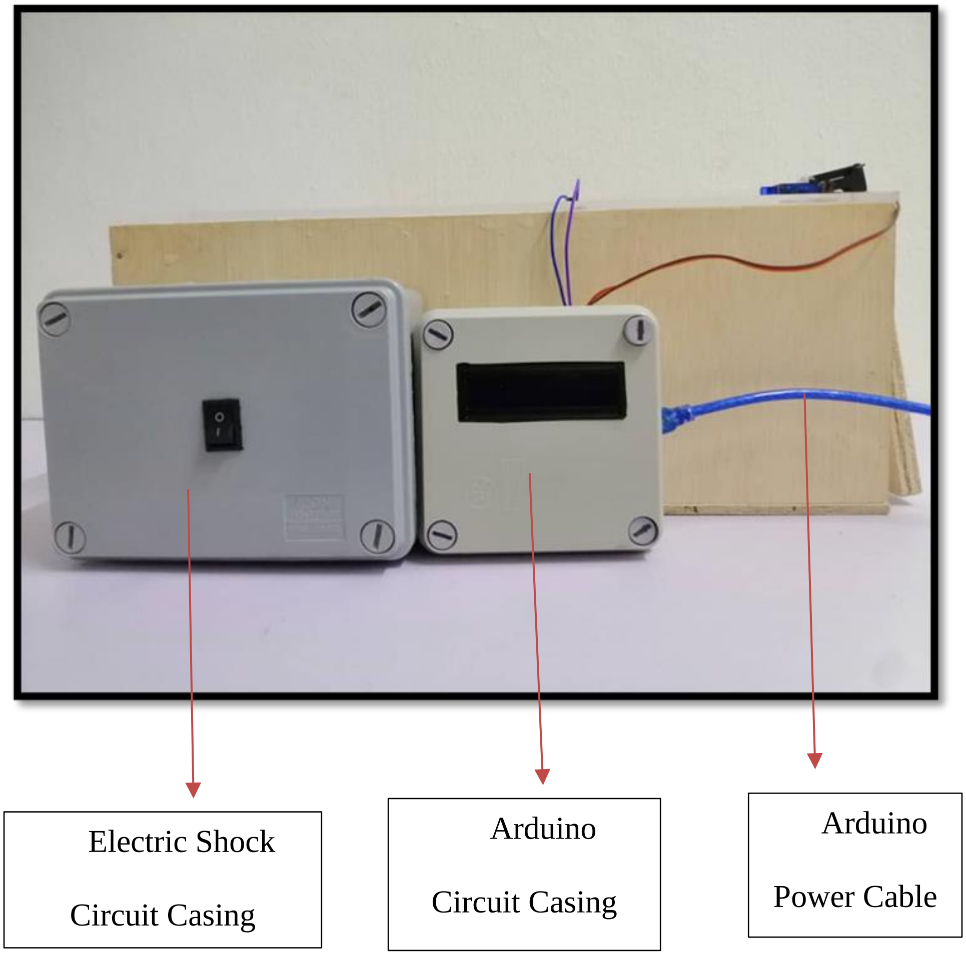
Servo Motor

Front View:

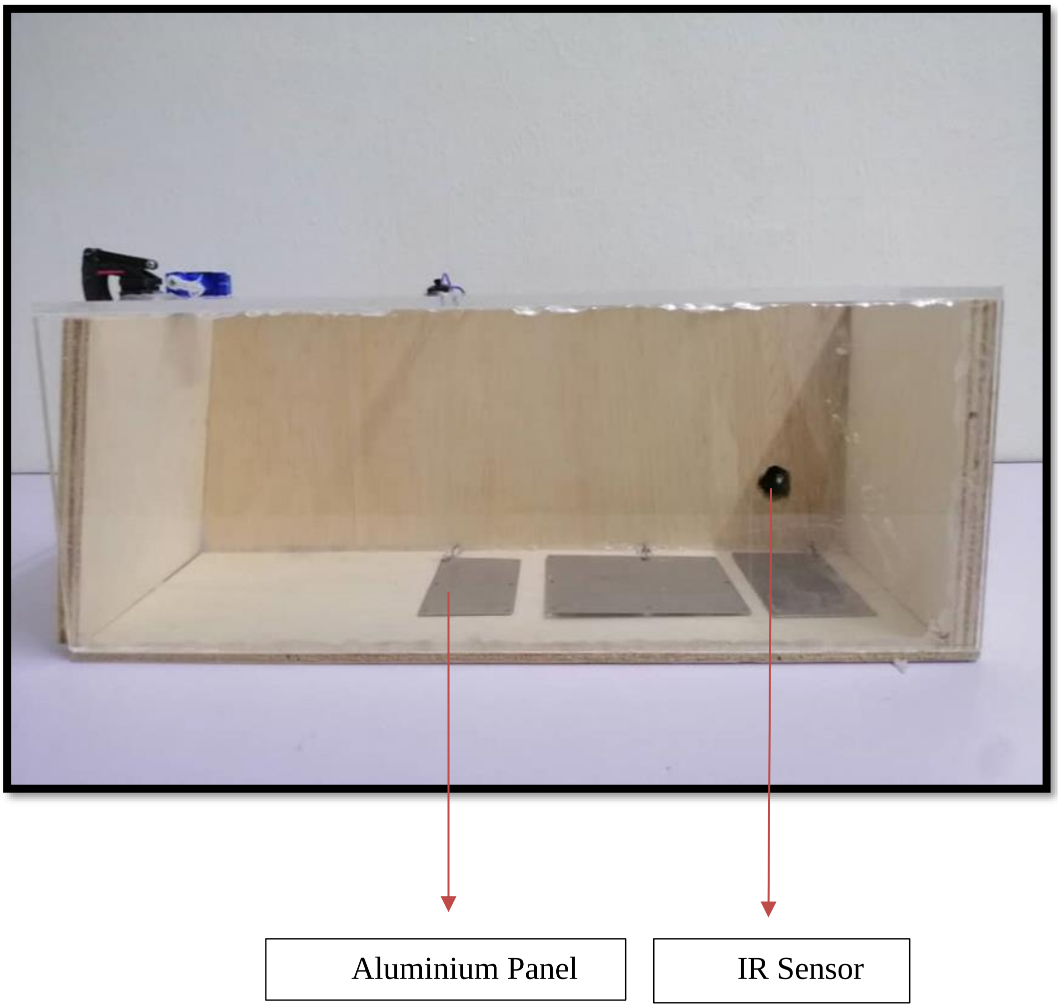


Servo Hinge

Plan:


Electric Shock
Circuit Casing
Arduino
Circuit Casing
Arduino
Power Cable

Right View:



Appendix B – Arduino Uno Programming Code

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

#define IR_PIN 9           // PIR sensor pin
#define RELAY_PIN 7         // Relay control pin
#define SERVO_PIN 11         // Servo motor control pin
#define BUZZER_PIN 5        // Buzzer control pin
#define RESET_BUTTON_PIN 6 // Reset button pin

LiquidCrystal_I2C lcd(0x27, 16, 2); // I2C LCD object

#include <Servo.h>
#include <SoftwareSerial.h>

SoftwareSerial espSerial(2, 3); // RX, TX pins for ESP-01S
Servo servo; // Servo motor object

bool isTrapOpen = true; // Variable to track trap door status
bool isTrapReset = true; // Variable to track trap reset status

void setup() {
  pinMode(IR_PIN, INPUT);
  pinMode(RELAY_PIN, OUTPUT);
  pinMode(BUZZER_PIN, OUTPUT);
  pinMode(RESET_BUTTON_PIN, INPUT_PULLUP);

  lcd.init();
  lcd.backlight();

  servo.attach(SERVO_PIN);

  Serial.begin(9600); // Initialize serial communication
  espSerial.begin(9600);

  displayWelcomeMessage(); // Display welcome messages
}

void loop() {
  if (isTrapReset) {
    displayAwaitingMessage(); // Display awaiting message if trap is
reset
    if (digitalRead(IR_PIN) == LOW) {
      activateTrap(); // Activate trap if PIR sensor detects motion
      pestCaught(); // Send PIR sensor data to ESP-01S
    }
  }
```

```
  if (digitalRead(RESET_BUTTON_PIN) == LOW) {
    resetTrap(); // Reset trap if reset button is pressed
    pestAwaiting(); // Send Button data to ESP-01S
  }
}

void displayWelcomeMessage() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Welcome");
  delay(3000);

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("IoT RODENT GUARD");
  Serial.println("System Start");
  Serial.println("Pest Awaiting");
  delay(5000);
}

void displayAwaitingMessage() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("PEST AWAITING");
}

void activateTrap() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("PEST CAUGHT");

  isTrapReset = false; // Trap is now activated, reset button disabled

  servo.write(120); // Close the trap door
  delay(2000); // Allow some time for the door to close

  digitalWrite(RELAY_PIN, HIGH); // Turn on electric shock panel
  tone(BUZZER_PIN, 500); // Activate buzzer
  delay(20000); // Buzzer will sound for 20 seconds or until reset

  digitalWrite(RELAY_PIN, LOW); // Turn off electric shock panel
  noTone(BUZZER_PIN); // Turn off buzzer
}

void resetTrap() {
  servo.write(0); // Open the trap door
  delay(2000); // Allow some time for the door to open
```

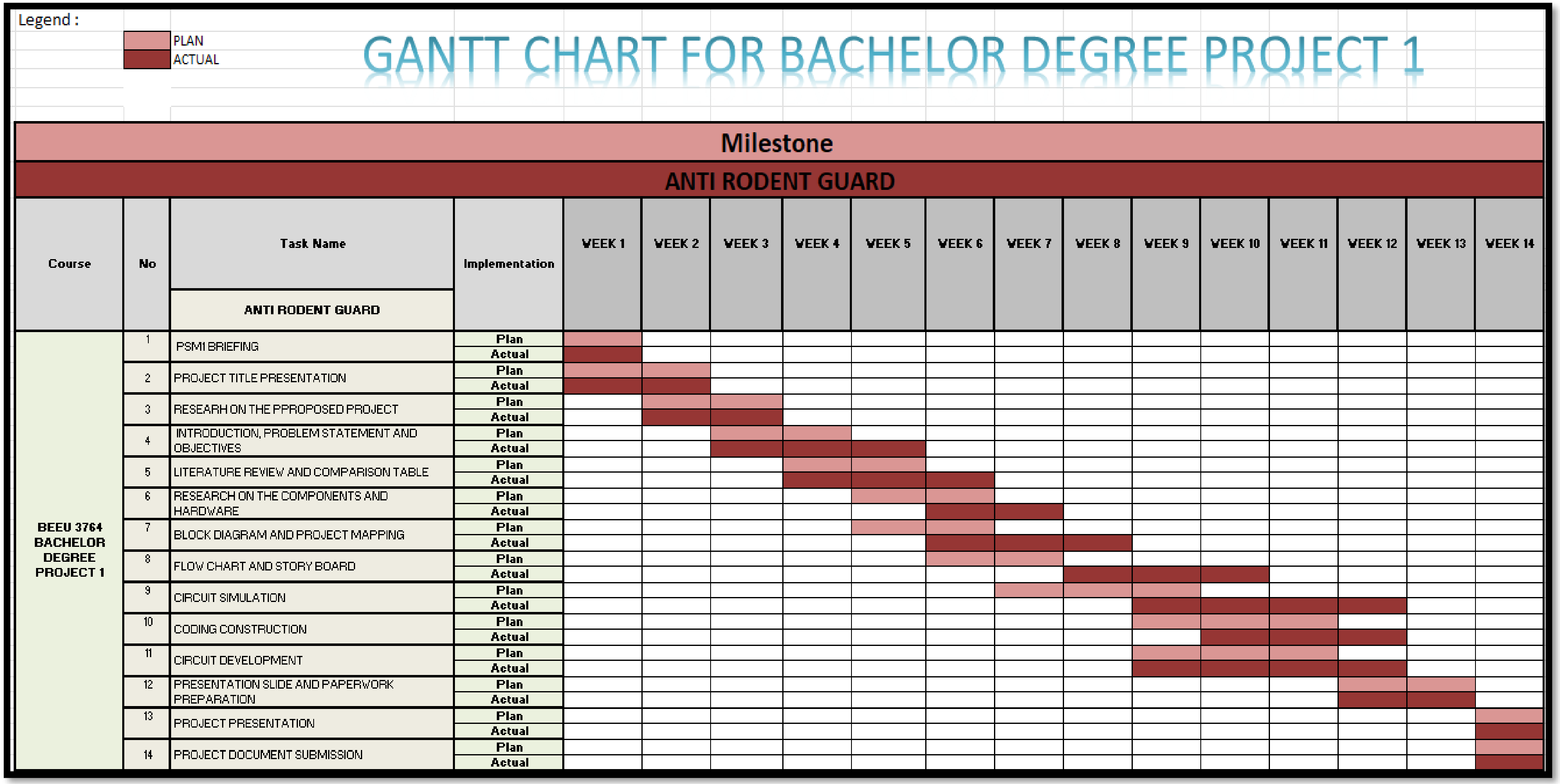
```
  isTrapOpen = true;
  isTrapReset = true;

  displayAwaitingMessage(); // Display awaiting message
}

void pestCaught() {
  espSerial.println("#"); // Send PIR sensor data to ESP-01S
  Serial.println("Pest Caught");
}

void pestAwaiting() {
  espSerial.println("*"); // Send PIR sensor data to ESP-01S
  Serial.println("Pest Awaiting");
}
```

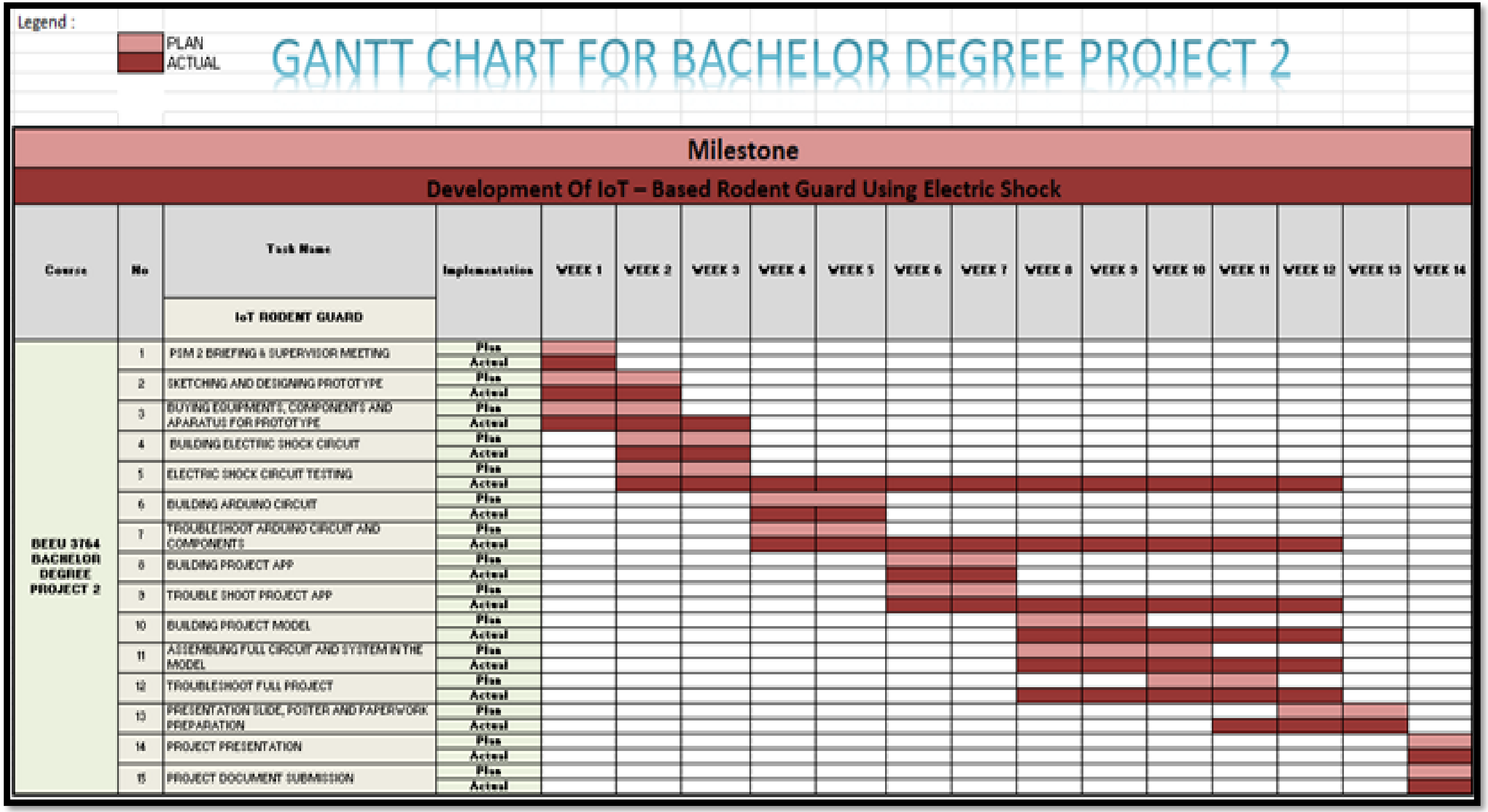
APPENDIX C – Esp8266 Wi-Fi Module Programming Code

```
#define BLYNK_TEMPLATE_ID "TMPL6zDeLpUK0"
#define BLYNK_TEMPLATE_NAME "IOT RODENT GUARD"
#define BLYNK_AUTH_TOKEN "YdLvhkQBmENCIH6CyH12OyYlumvbhE0D"

//Include necessary libraries
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

//Define WiFi credentials
char ssid[] = "RISHI";
char pass[] = "Achu21122000";

//Define PIR sensor and reset button pin
#define PIR_PIN 2           // PIR sensor pin
#define RESET_BUTTON_PIN 5  // Reset button pin


BlynkTimer timer;

int flag = 0;
//Loop function
void SensorTriggered() {


  if (digitalRead(PIR_PIN) == HIGH) {
    if (flag == 0) {
      Blynk.logEvent("pest_caught", "PEST CAUGHT");

      //Print notification sent
      Serial.println("Notification sent to Blynk app");

      flag = 1;
    }
  }
  if (digitalRead(RESET_BUTTON_PIN) == LOW) {
    flag = 0;
    Blynk.logEvent("pest_awaiting", "PEST AWAITING");

    //   //Print notification sent
    Serial.println("Notification sent to Blynk app");
  }
  // Check reset button status
  // else if (digitalRead(RESET_BUTTON_PIN) == LOW && flag==1) {

  //   Blynk.logEvent("pest_awaiting", "PEST AWAITING");
```

```
  //   //Print notification sent
  //   Serial.println("Notification sent to Blynk app");

  //   flag=0;
  // }
}


//Setup function
void setup() {
  //Initialize serial communication
  Serial.begin(115200);

  WiFi.begin(ssid, pass);

  // Wait for connection
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }

  //Initialize PIR sensor and RESET pins
  pinMode(PIR_PIN, INPUT);
  pinMode(RESET_BUTTON_PIN, INPUT_PULLUP);

  //Initialize Blynk
  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);

  //Print connection status
  Serial.println("Connected to WiFi");

  timer.setInterval(5000L, SensorTriggered);
}


void loop() {

  Blynk.run();
  timer.run();
}
```

Appendix D – Gantt Chart




Legend :
PLAN
ACTUAL
GANTT CHART FOR BACHELOR DEGREE PROJECT 2
Milestone
Development Of IoT – Based Rodent Guard Using Electric Shock
Course
No
Task Name
IoT RODENT GUARD
Implementation
WEEK 1
WEEK 2
WEEK 3
WEEK 4
WEEK 5
WEEK 6
WEEK 7
WEEK 8
WEEK 9
WEEK 10
WEEK 11
WEEK 12
WEEK 13
WEEK 14
BEEU 3764 BACHELOR DEGREE PROJECT 2
1 PSM 2 BRIEFING & SUPERVISOR MEETING
2 SKETCHING AND DESIGNING PROTOTYPE
3 BUYING EQUIPMENTS, COMPONENTS AND APARATUS FOR PROTOTYPE
4 BUILDING ELECTRIC SHOCK CIRCUIT
5 ELECTRIC SHOCK CIRCUIT TESTING
6 BUILDING ARDUINO CIRCUIT
7 TROUBLESHOOT ARDUINO CIRCUIT AND COMPONENTS
8 BUILDING PROJECT APP
9 TROUBLE SHOOT PROJECT APP
10 BUILDING PROJECT MODEL
11 ASSEMBLING FULL CIRCUIT AND SYSTEM IN THE MODEL
12 TROUBLESHOOT FULL PROJECT
13 PRESENTATION SLIDE, POSTER AND PAPERWORK PREPARATION
14 PROJECT PRESENTATION
15 PROJECT DOCUMENT SUBMISSION
Plan
Actual