IT4010 – Research Project - 2023

Enhancing Sustainable Crop Protection through Machine Learning-Driven Integrated Strategies

TMP-2023-24-074

Project Proposal Report

B.Sc. (Hons) Degree in Information Technology Specialized in

Software Engineering

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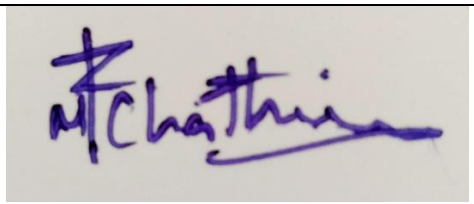
DECLARATION

I declare that this is my own work, and this proposal does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any other university or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

Name	Student ID	Signature
Anuththara R.M.C	IT20637064	

The above candidate has carried out research for the B.Sc. Dissertation under my supervision.

Signature of the Supervisor: _____ Date: _____

ABSTRACT

Crop damage inflicted by macaque monkeys has emerged as a critical concern undermining agricultural productivity. This research component presents an innovative approach to mitigating the issue by integrating image classification and effective deterrent mechanisms. The primary goal is to confirm macaque monkey intrusion during crop raiding incidents and subsequently repel them to curb yield losses. The methodology entails the deployment of camera systems strategically positioned across agricultural fields. Upon detecting the presence of macaque monkeys via image classification, triggered by their distinct characteristics, the cameras are activated to capture footage of the intrusion in real-time. The captured images provide visual confirmation of macaque involvement. Upon successful confirmation, an immediate response mechanism is triggered. A non-harmful high-frequency sound, proven to be effective in repelling macaque monkeys, is emitted through a designated output device. Simultaneously, an alert is dispatched to farmers, along with recorded video footage showcasing the situation within the crop field. This research component contributes to effective pest management and sustainable agriculture by offering a novel solution that combats human-wildlife conflict. By amalgamating image classification and timely deterrent measures, the approach furnishes an automated and efficient response to curtail crop damage. The provision of visual evidence to farmers enhances informed decision-making and targeted intervention. The effectiveness of this system is evaluated through field trials, gauging its ability to accurately confirm macaque monkey presence, activate responses, and repel the intruders.

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1. INTRODUCTION

Figure 1:Macaque Monkey crop raiding

In recent times, the escalating concern of agricultural productivity decline due to crop damage caused by macaque monkeys has reached a critical juncture. Addressing this issue calls for innovative approaches that not only identify the intrusion of these primates but also effectively deter them from ravaging valuable crops. This research component introduces a pioneering method that amalgamates image classification techniques with practical deterrent mechanisms, aiming to revolutionize the way we manage this agricultural challenge.

The core objective of this study is twofold: first, to establish concrete evidence of macaque monkey involvement during crop raiding incidents, and second, to implement an immediate and efficient strategy to repel them, thus curtailing the substantial losses incurred by farmers. The approach hinges on the strategic deployment of camera systems across agricultural fields, poised to act as vigilant sentinels. These cameras are equipped with sophisticated image classification capabilities, primed to detect the unique features of macaque monkeys that distinguish them from other potential intruders.

Once a macaque intrusion is confirmed via the image classification system, the cameras spring into action, capturing real-time footage of the ongoing raid. This visual documentation not only

corroborates the presence of the primates but also aids in identifying patterns and behaviors. The subsequent step involves a swift and humane response mechanism. A non-harmful high-frequency sound, scientifically proven to be effective in repelling macaque monkeys, is emitted through designated output devices strategically placed in the fields. Additionally, farmers are promptly alerted, receiving video recordings of the breach as it unfolds.

The significance of this research component extends beyond immediate agricultural concerns, contributing substantially to the broader sphere of pest management and sustainable farming practices. By merging cutting-edge image classification technology with timely intervention measures, this approach offers an automated and streamlined response to mitigate crop damage. Empowering farmers with visual evidence not only enhances their decision-making capabilities but also facilitates targeted and informed interventions.

To gauge the effectiveness of this innovative system, comprehensive field trials are conducted. These trials meticulously assess the system's accuracy in confirming macaque presence, its seamless activation of deterrent measures, and its success in repelling intruders. The outcomes of these trials promise to usher in a new era of effective human-wildlife conflict resolution, paving the way for a harmonious coexistence between agriculture and wildlife.

1.2. Literature Survey

Development of Animal-Detection System using Modified CNN Algorithm [1]

This research paper presents a solution to the problem of crop damage caused by animal intrusion in agricultural fields.

- The proposed system utilizes a modified Convolutional Neural Network (CNN) algorithm to detect intruding animals.
- Alert farmers while avoiding harm to both animals and crops.

The system incorporates components like PIR sensor, Thermal Imaging camera, GSM module, and hologram, connected to a Raspberry Pi module. It processes animal images through the modified CNN algorithm, ensuring effective crop protection and mitigating losses for farmers.

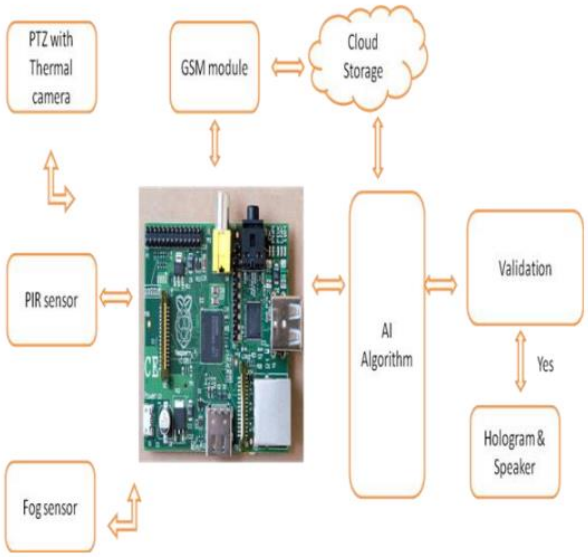

Figure 2:Overall Block Diagram of Animal Intrusion Detection

The paper highlights the escalating issue of animal intrusion due to deforestation and human-animal conflicts, particularly in densely populated countries like India. The proposed AI-based system can differentiate between different animal categories and minimize false alerts by distinguishing between owners, laborers, and intruding animals.

Operating in real-time, it is remotely manageable, eco-friendly, and operates on low voltage. The research has developed a prototype with sensors and PTZ cameras, achieving 94.63% accuracy in classifying images. The system offers an affordable solution to safeguard crops and livelihoods from animal-related damage, making it promising for farmers facing persistent challenges from animal intrusion.

Intelligent System for Detection of Wild Animals Using HOG and CNN in Automobile Applications [2]

The research paper tackles the issue of Animal Vehicle Collisions (AVCs) or roadkill, which endangers both humans and wildlife due to increasing fatalities.

The study has introduced a new method for detecting nocturnal wildlife, particularly deer, using thermal image processing integrated into vehicle cameras.

The system employs radiometric images for hotspot and moving object identification, utilizing Histogram of Oriented Gradient (HOG) transformation to extract features.

A one-dimensional Convolutional Neural Network (1D-CNN) then utilizes binary cross-entropy for object presence detection, achieving around 91% accuracy in identifying wildlife on roads during nighttime. The paper underscores the role of Artificial Intelligence (AI) and Computer Vision in enhancing human capabilities, especially in areas like autonomous vehicles and surveillance. It highlights preprocessing techniques for relevant data extraction from visual information. The paper's core contribution lies in the

combined use of CNN and HOG transformations for thermal image wildlife detection, effectively reducing animal vehicle collisions.

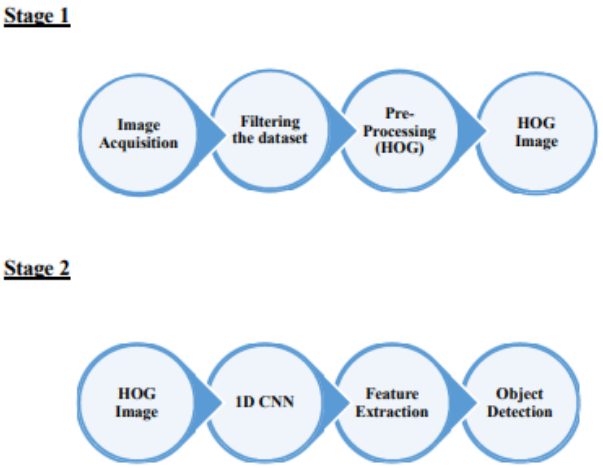

Figure 3:Overall Block Diagram of the Intelligent System

The proposed system has achieved notable accuracy through computer vision and machine learning, with testing times of 1 to 3 seconds. The study envisions real-world implementation by incorporating pre-trained network models into CNN for improved accuracy.

It suggests exploring different epochs, convolution layers, activation functions, and classifiers to enhance the model. The research aims to refine real-time implementation and improve image detection accuracy for road safety and wildlife preservation. In conclusion, the paper presents an innovative approach to mitigate animal vehicle collisions using thermal image processing and intelligent systems. It demonstrates the effectiveness of combining CNN and HOG transformations for accurate wildlife detection and emphasizes the potential for advanced neural networks and parameter tuning to further enhance the model.

Crops Protection System from Animals using Arduino [3]

The research paper addresses the issue of crop damage resulting from animal intrusions, which is challenging for farmers who cannot constantly monitor their fields.

The proposed solution involves an Arduino-based device equipped with a PIR motion sensor, LED lights, a buzzer, and a GSM module.

When animals like buffaloes or cows enter the field, the PIR sensor detects their presence, triggering the Arduino to activate the buzzer and flash LED lights while sending a message to the farmer within 10 seconds for prompt action.

The paper underscores the significance of agriculture as a crucial economic sector and highlights the substantial losses caused by animal intrusions, necessitating innovative protective measures. Unlike expensive and complex wireless sensor-based systems, the paper advocates for a cost-effective solution utilizing Passive Infrared (PIR) sensors for accurate detection.

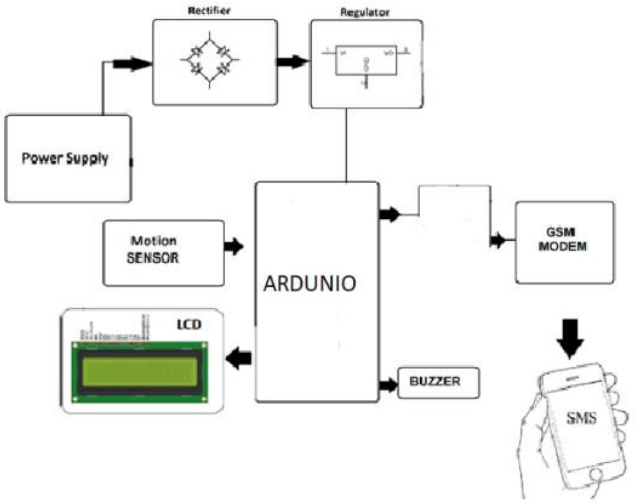

Figure 4:Overall Block Diagram of Crop Protection Arduino System

The proposed system aims to secure crops without harming animals or humans, utilizing a combination of components to deter animals effectively. By introducing this technology-driven approach, the paper emphasizes the practicality and affordability of the solution, highlighting its potential to safeguard crops, benefit farmers, and ensure the well-being of all stakeholders. In summary, the research introduces an Arduino-based system to mitigate crop damage caused by animal intrusions, offering real-time alerts and humane deterrents to protect both agricultural yield and the ecosystem.

Crop Field Protection From Animals Using Convolutional Neural Networks [4]

The research paper introduces an automated crop security system designed to combat agricultural damage caused by animals such as buffaloes, cows, goats, and birds.

Employing Convolutional Neural Networks (CNN), the system identifies animals through photo analysis and triggers an alarm to deter them from crops.

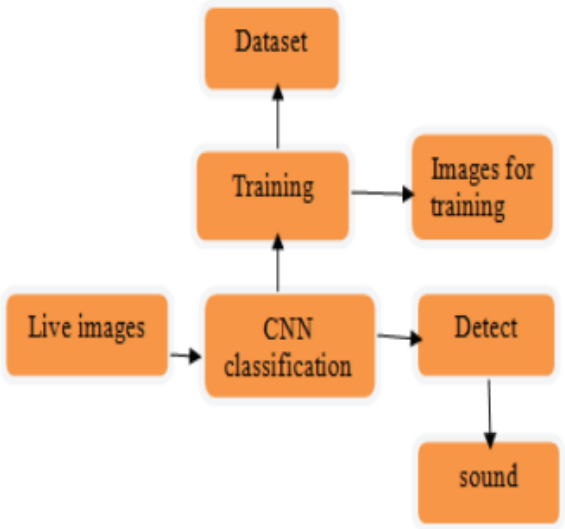

Figure 5:Architectural Diagram of Crop Field Protection System

This technology addresses challenges faced by farmers who incur losses due to animal attacks, offering a solution to constant vigilance limitations. The global impact of wild animals like monkeys, elephants, and birds on crops is substantial, necessitating protective measures. The system not only shields crops but also diverts animals away from harm, creating a secure agricultural environment and reducing costs and labor compared to IoT sensors or manual supervision. The system's core aim is to establish an alert mechanism that prevents crop damage by wildlife. While web-based cameras aid animal tracking, automated image analysis is crucial due to vast datasets. CNN and computer vision efficiently process wildlife images, reducing human involvement by 99% in animal identification tasks and 96% in volunteer efforts.

The escalating issue of crop damage by animals calls for immediate attention, prompting the research's introduction of a smart agricultural surveillance system. By incorporating deep neural networks, the system efficiently identifies and deters animals, benefiting farmers by safeguarding fields, cutting costs, and alleviating security efforts. In conclusion, the research presents an innovative automated solution for crop protection against animal damage. By harnessing CNN and computer vision, the proposed system not only identifies animals effectively but also mitigates losses, showing promise in enhancing agricultural yield and addressing the pressing challenge of animal-related agricultural damage.

Early Warning System from Threat of Wild Animals using Digital Image Processing [5]

The research paper addresses the pressing issue of wildlife intrusion in regions with high human mobility, emphasizing the risks posed to both humans and animals.

Instances of humans encountering wild animals without adequate recognition can lead to direct attacks. The difficulty in monitoring and surveilling animals due to their distinctive movement patterns and sizes is highlighted. Furthermore, identifying species from photographs is challenging.

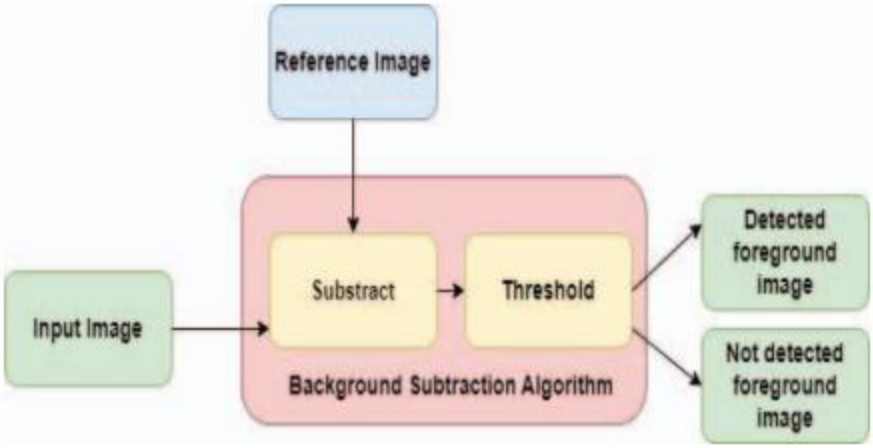

Figure 6:Background Subtraction method

Dangerous species such as elephants, tigers, and monkeys, which pose threats to both humans and their own population, necessitate prolonged recovery periods. The study proposes a solution rooted in digital image processing, convolutional neural networks, and background subtraction methods.

The paper focuses on the context of India's expanding industrial and agricultural sectors, which have encroached upon forested areas due to growing human populations. This habitat shift has led to human-animal conflicts as animals venture into villages for crops and water, resulting in harm or fatalities. The need for a monitoring system to safeguard human livelihood while preserving animal populations is underscored. The creation of an animal intrusion monitoring system is advocated to track and mitigate human-animal encounters in forested zones. The research outlines the successful design and development of an Early Warning System against the threat of wild animals. The system aims to minimize conflicts between humans and animals in natural settings by detecting moving objects through successive frame differencing in videos.

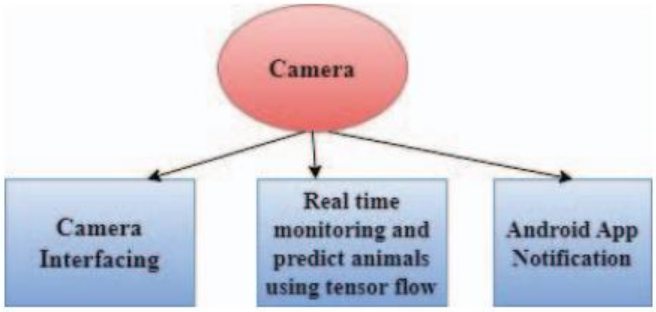

Figure 7:Camera Functions

The system employs an Android app to deliver timely alerts upon animal detection. The paper concludes on a positive note, expressing satisfaction with the timely completion of the project. The system is seen as a step toward reducing human-animal conflicts and ultimately saving lives. The proposed technology holds potential for implementation in various forest areas to enhance societal well-being.

IoT based Animal Trespass Identification and Prevention System for Smart Agriculture [6]

The research paper discusses the challenges faced by Indian farmers, notably the issue of animal trespass into agricultural fields, particularly near forested and hilly regions. This problem leads to significant crop damage and financial losses, disproportionately affecting low-income farmers heavily reliant on agriculture. Current solutions like traditional methods and government compensation are often inefficient and inadequate.

To address this issue, the paper proposes an innovative Internet of Things (IoT)-based solution. The system involves an Arduino-based IoT prototype that employs various sensors and hardware modules. It detects animal movement using a Passive Infrared (PIR) sensor and then uses parallel Ultrasonic sensors to determine animal presence in specific zones near the field border. Upon detection, a buzzer sounds to deter the animal, and a GSM module sends an alert to the farmer through Telegram. Additionally, an ESP32 Camera Module captures field images in real-time, allowing the farmer to assess the situation remotely and serving as evidence for compensation claims.

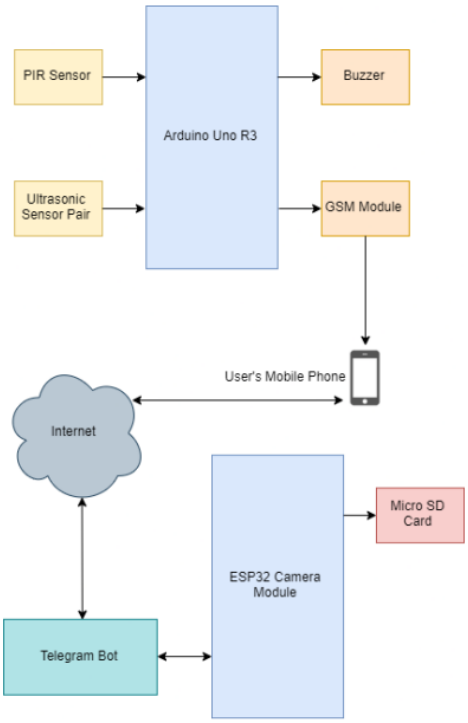

Figure 8:Architecture Diagram of the Animal Trespass Identification and Prevention System

This approach offers several advantages, including cost-effectiveness, harm-free animal deterrence, and improved evidence collection for insurance or government claims. The study highlights that the proposed IoT-based system offers a practical and efficient way to address the pressing issue of animal trespass in Indian farmlands. By leveraging technology, the system aims to reduce economic losses, enhance farmer control, and streamline the compensation process.

Real Time Recording and Monitoring of Wild Animal Movements [7]

The research paper addresses the growing issue of animal attacks caused by the encroachment of wildlife into human-populated areas due to habitat loss driven by globalization and industrialization.

The study aims to mitigate conflicts between humans and animals while ensuring the safety of both. To tackle this problem, the researchers employ deep learning techniques, particularly the YOLOv5 object detection model, to identify wild animals in images. Upon detection, species-specific sound frequencies are utilized to deter animals back to their habitats, while alerts are dispatched to local residents.

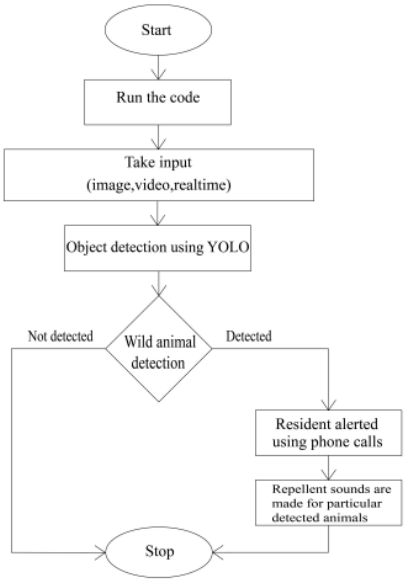

Figure 9:Architecture Diagram of the Real Time Recording and Monitoring Animals System

The paper emphasizes the escalating conflicts between humans and wildlife, including crop damage and threats to human and animal lives, especially in regions with a high rural population near wildlife habitats. Traditional methods of protection, like hiring guards, have proven inefficient. The study's focus lies in safeguarding crops and preventing harm to both humans and animals. It proposes a novel approach involving a camera-based monitoring system in forested areas adjacent to human settlements. This system detects animal movements through machine learning models and triggers appropriate sounds to repel them. Alerts are simultaneously sent to residents to maintain vigilance. The core objective is to protect agricultural lands without resorting to animal harm, offering an alternative to the persistent problem of animal attacks on crops and humans. The research introduces an effective solution by implementing continuous monitoring, animal detection, tracking, repelling sounds, and user notifications through computer vision. This multifaceted approach strives to reduce human-animal conflicts and secure both livelihoods and lives.

1.3. Research Gap

Research Name	Research [1]	Research [2]	Research [3]	Research [4]	Research [5]	Research [6]	Research [7]	System
More than 94% accuracy obtain	✗	✗	✗	✗	✗	✗	✗	✓
When the camera turns on only triggered, rather than being always active.	✗	✗	✗	✗	✗	✗	✗	✓
Ring the nearest buzzer when the attack	✗	N/A	✓	✗	✗	✗	✗	✓
Provide alert when the attack	✓	N/A	✓	✓	✓	✓	✓	✓
Provide alert including current situation of crop	✗	N/A	✗	✗	✗	✗	✗	✓

Table 1:Research Comparison

Introducing a comprehensive approach to mitigate macaque monkey-related crop raiding, this research encompasses innovative technologies for accurate detection, non-harmful deterrence methods, and a real-time alert system to notify farmers. Macaque presence is identified through camera traps and ML based image recognition. The proposed alert system ensures timely notifications to farmers, facilitating immediate responses to potential crop raiding incidents. By integrating these elements, this study aims to provide a comprehensive and ethical solution to the challenges posed by macaque monkeys in agricultural settings.

Referring to [1] research, there is also an animal detection system in place, which has managed to achieve an accuracy rate of 94%. However, it does not consider a specific animal. When the system detects an animal, it triggers a buzzer. The buzzer it activates is not consider the nearest one to the potential animal threat.

We are working on further enhancing this to not only identify macaque monkeys but also to determine their direction of movement. Once their presence and direction are detected, the system will trigger a sound from the nearest buzzer. This targeted alert will aid in alerting

individuals in the vicinity about the specific location and movement of the macaque monkeys, enabling them to take appropriate actions promptly.

In their current system, the camera always remains active, resulting in a significant waste of power. A more power-efficient approach would involve activating the camera only when it is triggered, thereby conserving energy and resources effectively.

Referring to [2] research related to the detection of wild animals using a combination of the Histogram of Oriented Gradients (HOG) feature descriptor and Convolutional Neural Networks (CNN). The research has achieved an accuracy of 91% by effectively utilizing computer vision and machine learning techniques.

As mentioned in [3] research alerts are sent to users using GSM technology. It will also emit a buzzer sound to alert individuals in the area to take appropriate measures to prevent crops from being harmed by smart farming. It will send the status of field to the particular farmer, then he can come to field and protect his field. We are planning to enhance this alerting system by incorporating the capability to send video clips of the current crop field conditions when there is an attack by macaque monkeys. This improvement will provide a visual representation of the situation, allowing farmers to directly observe the extent of the threat posed by the monkeys to their crops.

Subsequently, the farmer can access this information and decide whether a visit to the field is required for protection. This method ensures that the farmer remains informed about the field's situation without the need to physically be present until necessary.

Research mentioned earlier, where the accuracy of animal detection remained below 94%, we are embarking on an initiative to surpass this threshold by employing a larger and more comprehensive dataset. Through the utilization of this extensive dataset, we aim to enhance the accuracy of our Macaque Monkey detection system significantly.

1.4. Research Problem

The core focus of this research is to substantiate instances of macaque monkeys engaging in crop raiding activities, coupled with the design of a humane methodology to discourage such behaviors. This investigation hinges on the utilization of image classification techniques, which are initiated by specific visual cues associated with macaque monkey presence. These cues serve as triggers to activate strategically positioned cameras of the monkeys' actions. By employing this method of visual verification, the study endeavors to establish the undeniable connection between macaque monkeys and crop raiding incidents. After this confirmation, the research delves into the development of a non-harmful deterrent system, potentially incorporating elements such as unobtrusive buzzers. The ultimate objective is to encourage the macaque monkeys to disengage from agricultural areas without inflicting any harm. In tandem with this effort, the research also aims to implement an alert mechanism, promptly notifying farmers

about the emergence of monkey-related activities. In summation, the research pursues a comprehensive understanding of macaque monkeys' propensity for crop raiding while devising a compassionate and effective strategy for their repulsion, leveraging image classification techniques to facilitate the entire process.

1. OBJECTIVES

2.1. Main Objective

The main objective of this research is to confirm instances of macaque monkeys engaging in crop raiding and to develop a non-harmful method for repelling these macaque monkeys using image classification, automated response (buzzers), and farmer alerts.

2.2. Specific Objectives

Camera System Setup:

- Install and position cameras strategically across the farmland to capture comprehensive footage of the crop fields.
- Set up a reliable trigger mechanism for cameras, such aa time-lapse intervals, to capture instances of macaque monkey presence.

Image Classification:

- Develop an image classification model using machine learning techniques to accurately detect and classify macaque monkeys in the captured footage.
- Train the model on a diverse dataset of macaque monkey videos to ensure robust performance.

Confirmation of Crop Raiding:

- Analyze the footage and processed data to confirm instances of macaque monkeys engaging in crop raiding activities.
- Compare the model's classification results with manual validation to measure the accuracy of detection.

Non-Harmful Repelling Method:

- Research and develop a repelling mechanism that discourages macaque monkeys from entering the crop fields without causing any harm to them.
- Possible repelling methods include emitting non-harmful sounds, using visual deterrents, or releasing natural scents disliked by macaque monkeys.

Farmer Alert System:

- Implement a real-time alert system that notifies the farmer when the image classification model detects macaque monkeys in the crop fields.
- Alerts can be sent via SMS, mobile app notifications, or email to enable timely intervention.

Field Testing and Validation:

- Conduct controlled field tests to validate the effectiveness of the non-harmful repelling method.
- Measure the reduction in macaque monkey presence in the crop fields and the corresponding decrease in crop raiding incidents.

2. METHODOLOGY

The research methodology encompasses a series of interconnected steps designed to authenticate occurrences of macaque monkey crop raiding while devising a humane repelling system, bolstered by image classification, automated responses, farmer alerts, and the implementation of buzzers. Initially, an array of high-resolution cameras will be strategically situated across the farmland to meticulously capture potential macaque activities. A diverse compilation of macaque monkey images, alongside negative examples, will be amassed and enriched to train an image classification model. This model will undergo meticulous fine-tuning and validation using a distinct dataset. Once deployed, the model will meticulously scrutinize camera footage to discern the presence of macaques, with manual validation serving to affirm its precision. Simultaneously, an ethically sound repelling approach will be explored and selected, with options like sound emission, visual cues, or natural scents coming under careful consideration. An automated response system will be seamlessly incorporated to activate chosen deterrents upon macaque detection, including the measured emission of buzzers. Furthermore, a communication module will promptly alert farmers through SMS, app notifications, or email, ensuring real-time updates. Rigorous field tests will gauge the system's efficacy in deterring macaque activity and promptly notifying farmers, with subsequent data analysis quantifying the reduction in crop raiding incidents. The research will consistently adhere to ethical standards, prioritizing the well-being of both macaque monkeys and the ecosystem at large.

3.1. Overall System Diagram

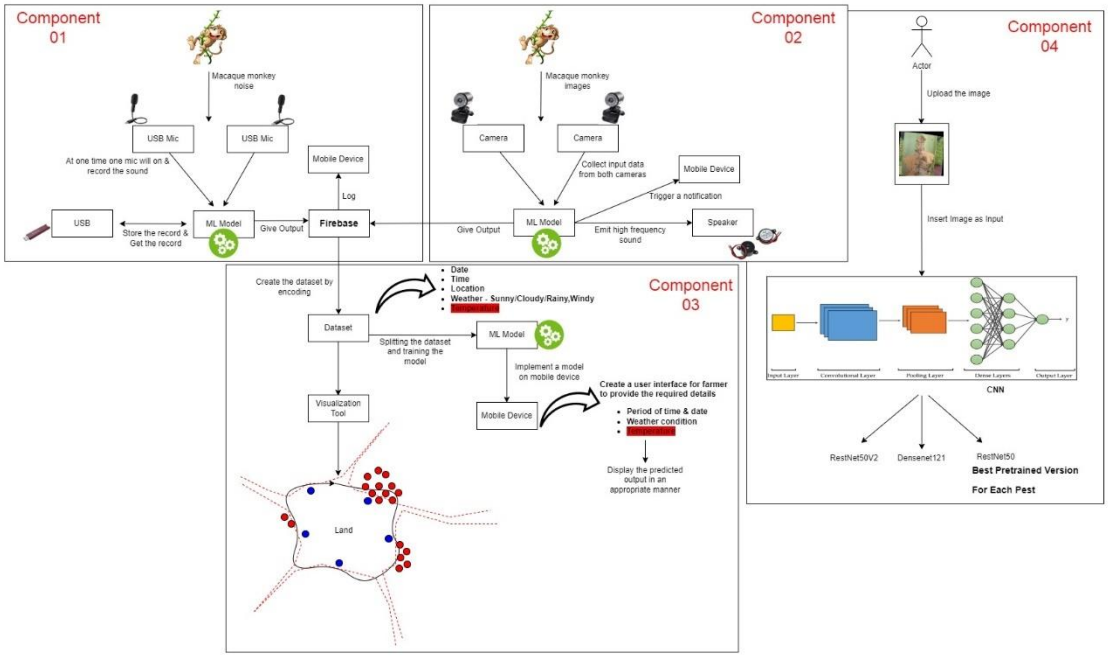

Figure 10:Overall System Diagram

3.2. Individual System Diagram

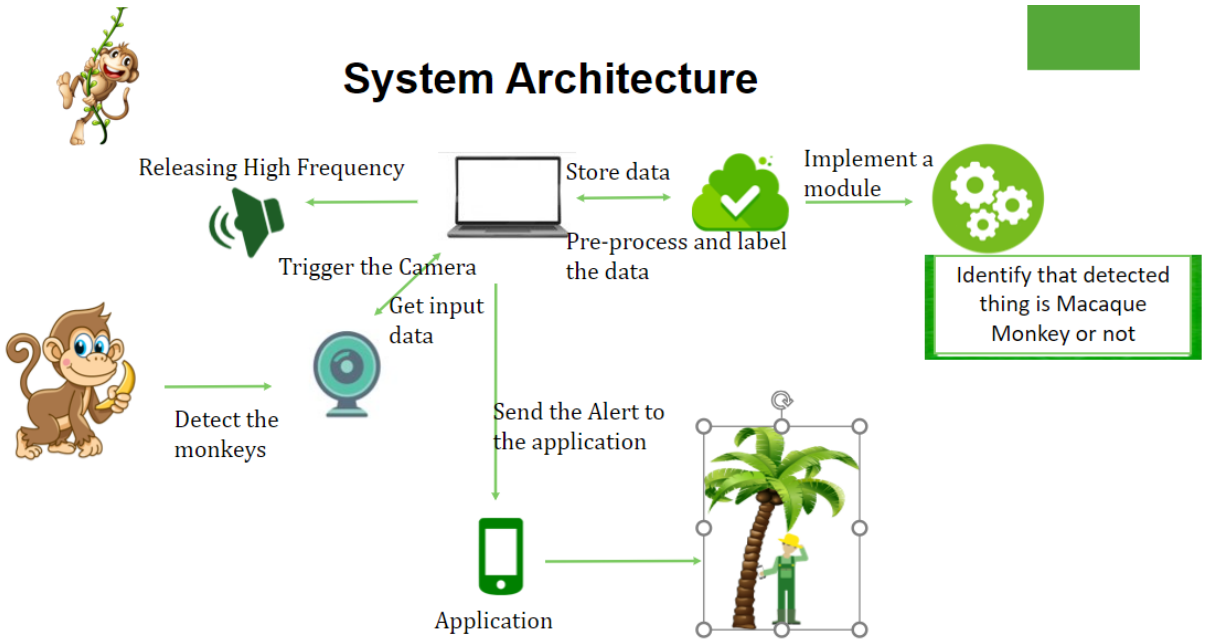

Figure 11:Individual System Diagram

4. PROJECT REQUIRMENTS

3.2. Functional Requirements

- Feature Extraction - Time domain extraction.
- Machine Learning Model - Implement a suitable machine learning algorithm or model.
- Behavior Prediction and Forecasting - Deploy the trained model to predict the monkey behaviors based on their arrival patterns.
- Visual User Interface - Develop a user-friendly interface to interact with the system to obtain behavioral predictions or analysis results.
- Model Updates - Implement a mechanism to update and retrain the machine learning model periodically to accommodate changes in monkey behavior patterns.

3.3. Non-Functional Requirements

- Accuracy
- Usability
- Reliability
- User-friendliness
- Efficiency

3.4. Expected Outcome

The expected outcome includes confirmation of macaque crop raiding, a non-harmful repelling system, reduced crop damage, farmer alerts, and a sustainable, ethical approach to wildlife management.

3.5. Tools and Technologies

Programming language

- Python

Tools

- Version controlling – SourceTree
- Visual Studio Code
- Google Colab
- Data Visualization Tool

Database Service

- Microsoft Azure

Algorithms

- CNN

3.6. Work Breakdown Chart

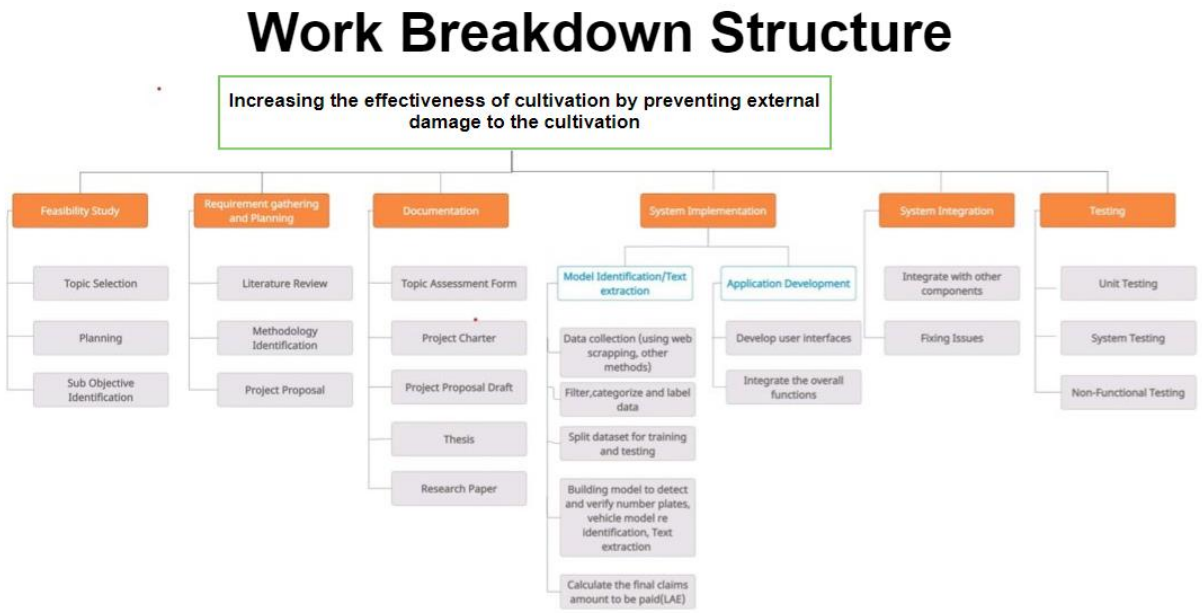

Figure 12:Individual Work Breakdown Chart

4. BUDGET AND BUDGET JUSTIFICATION

The component's overall cost estimation is shown in the table below.

Description	Amount (LKR)
Web Camera * 2	6000.00
Buzzers * 2	500.00
Internet	2000.00
Others	5000.00
Total	13,500.00

Table 2:Budget and Budget Justification

5. GANTT CHART

Figure 13:Gantt Chart

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