Animal Detection in Farms Using PIR Motion Sensors and Alert System Using IOT

A Major Project Report Submitted to the Faculty of Engineering of

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA,KAKINADA

In partial fulfillment of the requirements for the award of the Degree of

Bachelor of Technology

In

Information Technology

Submitted by:

A. Hema
(21481A1204)

k. Pavan Naga Kesava
(22485A1215)

Ch. Dhana Meghana
(22485A1208)

B. Sasidhar
(22485A1203)

Under the guidance of
Ms. Velagaleti Rupa M.Tech.,
Assistant Professor

DEPARTMENT OF INFORMATION TECHNOLOGY

SESHADRI RAO GUDLAVALLERU ENGINEERING COLLEGE

(An Autonomous Institute with Permanent Affiliation to JNTUK, KAKINADA)

SESHADRIRAO KNOWLEDGE VILLAGE

GUDLAVALLERU – 521 356

ANDHRA PRADESH

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DEPARTMENT OF INFORMATION TECHNOLOGY

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SESHADRI RAO KNOWLEDGE VILLAGE

GUDLAVALLERU-521356

CERTIFICATE

This is to certify that a major project report entitled **"Animal Detection in Farms Using PIR Motion Sensors and Alert System Using IOT"** is a Bonafide record of work carried out by **A.Hema (21481A1204), k.Pavan Naga Kesava (22485A1215), Ch. Dhana Meghana (22485A1208) and B.Sasidhar (22485A1203)**under my guidance and supervision in partial fulfillment of requirements for the award of degree of Bachelor of Technology in **Information Technology** of **Jawaharlal Nehru Technological University Kakinada, Kakinada** during the year of 2024-25.

GUIDE	**Head of the Department**
Ms. Velagaleti Rupa, M. Tech,	**Dr. D. N. V. S. L. S. Indira,** M.Tech,Ph.D.
Assistant Professor	**Professor**

External Examiner

s

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Project Associates

A. Hema (21481A1204)

K. Pavan Naga Kesava (22485A1215)

Ch. Dhana Meghana (22485A1208)

B. Sasidhar (22485A1203)

ABSTRACT

Agricultural fields frequently suffer from crop damage caused by animals and birds, leading to economic losses for farmers. Conventional methods of field protection rely heavily on human intervention, making them labor-intensive and inefficient. This paper presents an IoT-based automated crop protection system that utilizes PIR motion sensors and a two-level deterrent mechanism to safeguard fields.

The first level detects motion and plays randomized carnivorous animal sounds to deter intruding animals, preventing habituation. If the animal continues moving inward, a second-level sensor triggers high-intensity focus lights, creating a stronger deterrent effect. The system is controlled via a mobile application, allowing farmers to adjust detection ranges as per their requirements. The integration of wireless connectivity ensures remote monitoring, reducing dependency on manual surveillance.

This low-cost, scalable solution provides an effective method for wildlife deterrence while minimizing human effort. Future enhancements will focus on improving object classification to reduce false detections and enhance efficiency.

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CHAPTER 1

INTRODUCTION

1.1. INTRODUCTION

Agriculture plays a crucial role in sustaining global food production, yet it faces numerous challenges, including crop damage caused by animals and birds. Wildlife intrusion in farmlands often leads to significant economic losses for farmers, especially in rural areas where agricultural fields are more exposed. Traditional methods such as fencing, manual guarding, and scarecrows have been used for generations but are often ineffective, labor-intensive, and costly. Farmers frequently struggle to maintain continuous surveillance, making their crops vulnerable to destruction. With the advancement of technology, particularly in the field of the Internet of Things (IoT), automated solutions offer a more efficient and scalable approach to protecting crops from wildlife interference.

Motion-based animal deterrent systems have gained attention as a modern solution to this problem. Among these, Passive Infrared (PIR) motion sensors are widely used due to their cost-effectiveness, reliability, and ability to detect movement based on infrared radiation changes. PIR sensors can identify the presence of animals by detecting variations in heat signatures, making them suitable for monitoring agricultural fields. However, a single-layer detection system often proves inadequate, as animals may not always respond to an initial deterrent. To address this limitation, a two-level PIR sensor-based system is proposed in this study, offering a more robust and efficient mechanism to safeguard farmlands.

The proposed system integrates PIR motion sensors, sound deterrents, and high-intensity focus lights to create a multi-layered defense against animal intrusions. At the first level, PIR sensors detect motion near the outer boundary of the field and trigger pre-recorded carnivorous animal sounds to scare away intruders. To prevent animals from adapting to the deterrent, the system plays randomized sound sequences. If the intruding animal ignores the first-level warning and moves further into the field, a second-level PIR sensor detects its presence and activates bright focus lights, creating an additional scare factor. The combination of these deterrents aims to ensure that animals retreat before causing any damage to crops.

One of the significant advantages of this system is its ability to operate autonomously with minimal human intervention. The entire setup is controlled through a mobile application, allowing farmers to customize the detection range and monitor real-time alerts remotely. This

IoT-based approach reduces the need for continuous physical supervision, significantly lowering labor costs while increasing efficiency. The system’s low-cost hardware requirements make it a viable solution for small and large-scale farmers alike. Additionally, its wireless connectivity ensures ease of deployment without the need for extensive wiring or infrastructure modifications.

Despite its effectiveness, the system has some limitations. The PIR sensors detect motion based on infrared signatures, meaning they cannot distinguish between different types of moving objects, such as humans, pets, or large animals. While this is a known constraint, future advancements in machine learning and artificial intelligence could help improve object classification, allowing for more precise detection and reduced false alarms. This research focuses on providing a cost-effective and scalable solution while acknowledging the scope for further improvements in future iterations.

The proposed IoT-based automated crop protection system aims to provide an efficient, low-cost, and scalable method for safeguarding agricultural fields from animal intrusions. By leveraging PIR motion sensors, randomized sound deterrents, and high-intensity focus lights, the system enhances crop security while minimizing human involvement. Future work will focus on incorporating AI-driven classification techniques to improve detection accuracy and further refine the system's functionality. This research contributes to the development of smart agricultural solutions, offering farmers an innovative way to protect their livelihoods with modern technology.

1.2. PROBLEM STATEMENT

Build a real-time IoT monitoring system to automatically detect the animals and reports unusual animal behavior to enhance farm security and animal welfare, the project aims to:

- **Real-Time Monitoring:**
- **Instant Alerts and Notifications:**
- **Improvement of Animal Welfare and Farm Security**
- **Reducing the human Effort**

1.3. EXISTINGSYSTEM

Many farms still rely on manual observation and physical patrolling, which can be time-consuming, especially on large-scale farms. Farms use fences and gates to restrict animal movement. While effective to a degree, they can be damaged or bypassed by determined or resourceful animals, and repairs are often delayed. Some farms employ CCTV cameras for 24/7monitoring. However, this setup requires constant human supervision or regular video review, limiting its real-time effectiveness. RFID tags and GPS collars are sometimes used to track farm animals' locations, but they offer no protection against untagged animals or intruders and come with high maintenance costs. Farms also use ultrasonic devices to repel certain wild animals. However, they may be species-specific and limited in coverage, with mixed effectiveness depending on the type of intruding animal.

1.3.1 DISADVANTAGES OF EXISTINGSYSTEM

- Maintenance challenges like fencing
- Continuous human supervision
- Lack of surveillance
- High Cost and complex
- Limited data
- Partial security

1.4. PROPOSED SYSTEM

The proposed system employs a two-tiered approach to detect and deter animals from entering agricultural fields. By integrating PIR motion sensors, adaptive sound deterrents, and high-intensity focus lights, the system ensures an effective response to potential threats. The primary goal is to prevent crop damage without requiring continuous human intervention. The methodology consists of strategically placing sensors at different levels, triggering specific deterrent mechanisms based on the movement detected. This ensures that animals encountering the system experience both auditory and visual deterrents, significantly increasing the chances of them leaving the field.

The system comprises three core components: motion detection sensors, an audio deterrent mechanism, and a light-based deterrent mechanism. These components work in tandem to provide a dynamic and efficient animal repellent system. PIR motion sensors are distributed across two levels within the field an outer layer and an inner layer ensuring early detection and response. The sensors send signals to a microcontroller, which processes the input and triggers the corresponding deterrent mechanism.

At the first level, once motion is detected, the system plays a pre-recorded sound of a carnivorous animal to scare off the intruder. This approach relies on the natural fear instincts of animals, leveraging their aversion to potential predators. If the animal does not retreat and instead moves further into the field, the second level of sensors activates high-intensity focus lights, creating a sudden visual disturbance. This multi-layered approach maximizes the likelihood of repelling animals at different stages of their intrusion. The power supply for the system is optimized to ensure continuous operation in agricultural environments, where consistent electricity may not be available. The setup includes solar panels to power the sensors and deterrents, with rechargeable battery backups for uninterrupted functionality. This ensures that the system remains active throughout the day and night, providing round-the-clock protection.

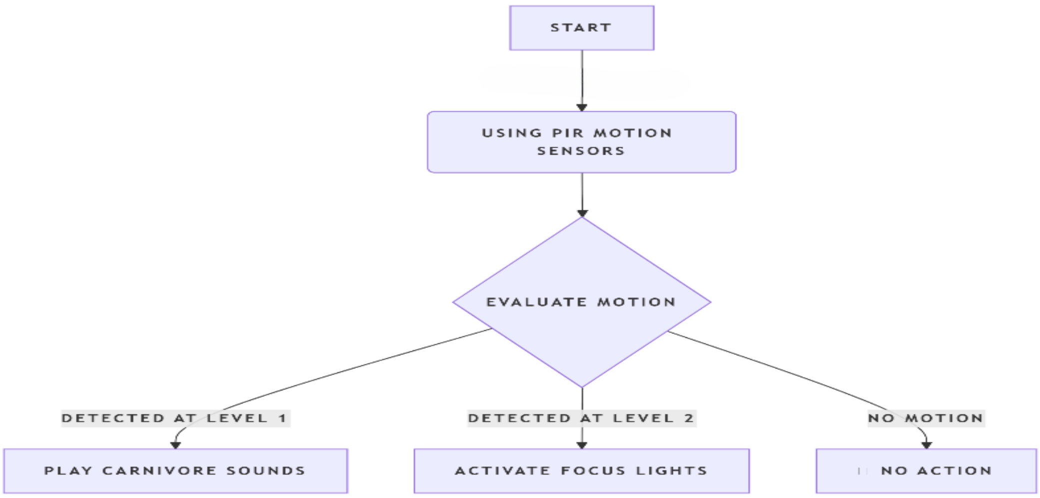


Fig 1.4.1: Architecture

1.4.1 IMPLEMENATION

First-Level Detection: PIR Sensor-Based Audio Deterrent System

The first level of detection employs PIR motion sensors, which detect movement in a predefined range and trigger an audio deterrent response. These sensors are positioned along the outer boundary of the field, where initial animal movement is most likely to be detected. PIR sensors work by detecting changes in infrared radiation caused by moving objects, making them ideal for detecting warm-blooded animals. Once a motion is detected, the system immediately plays a pre-recorded sound of a carnivorous animal such as a lion, tiger, or wolf. The intent is to create a sense of fear in the intruding animal, making it believe a predator is nearby. The sound is chosen based on the common threats in the area, ensuring that the deterrent is relevant to the local wildlife.

To enhance effectiveness, the system dynamically changes the sound each time a new motion is detected. This prevents animals from becoming accustomed to a single repeated sound, which could reduce its impact over time. By randomizing the deterrent sounds, the system maintains unpredictability, increasing its overall effectiveness. This level of detection is crucial as it provides the first line of defense, minimizing the chances of animals advancing further into the field. Since sound-based deterrents are non-invasive and cost-effective, this mechanism is a sustainable and practical solution for farmers looking to protect their crops from wildlife.

Second-Level Detection: Light-Based Deterrent System

If an animal does not retreat after the first level of deterrence and continues to move inward, the second level of detection is triggered. Additional PIR sensors, positioned deeper inside the field, detect continued movement and activate a light-based deterrent mechanism. This involves turning on high-intensity focus lights aimed directly at the detected movement. The sudden illumination serves as a strong visual deterrent, creating a sense of exposure and vulnerability in the animal. Many animals, particularly nocturnal species, instinctively avoid brightly lit areas as it increases their risk of being spotted by predators or humans. The unexpected burst of light disrupts their movement pattern, making them more likely to retreat. The focus lights are strategically placed to cover a wide range of the inner field, ensuring that any movement is illuminated instantly. These lights are designed to be energy-efficient, consuming minimal power while providing maximum brightness. The system resets automatically after a certain period, ensuring that it remains active for subsequent intrusions. The combination of auditory and visual deterrents significantly improves the system's effectiveness. While the first level relies on sound to scare away animals, the second level reinforces the deterrence through visual disruption, making it highly unlikely for animals to persist in their attempt to enter the field.

Sensor Placement Strategy

The positioning of PIR motion sensors is a critical aspect of the system's design. The sensors are deployed in two levels:

First Level: Sensors are placed along the outer perimeter of the field, covering all potential entry points. These sensors have a moderate detection range, ensuring that any movement near the boundary is detected immediately. The primary objective at this level is to deter animals before they can enter the cultivated area.

Second Level: Sensors are positioned further inside the field, covering the inner perimeter around the crops. These sensors have a slightly extended detection range, ensuring that animals that bypass the first level are still detected. The focus lights associated with these sensors are directed towards the detected movement, maximizing the deterrent effect.

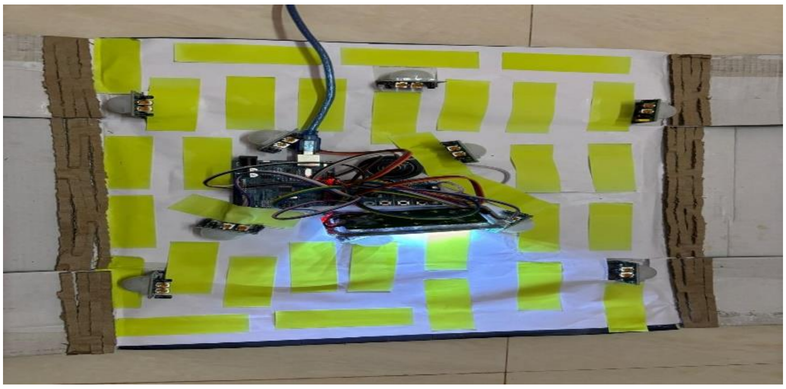


Fig 1.4.2: **: Prototype model of proposed methodology illustrating two level security mechanism**

1.4.3 ADVANTAGES OF PROPOSED SYSTEM

- **Automated Operation**: The system functions without human intervention, reducing labor and ensuring consistent monitoring.
- **Cost-Effective**: Compared to traditional surveillance methods, it is more affordable, especially for small-scale farmers.
- **Two-Tiered Security**: The combination of sound and light deterrents increases effectiveness by minimizing false alarms and enhancing protection.
- **Animal-Friendly**: Non-invasive sound and light deterrents ensure animals are not harmed.
- **Energy Efficient**: Use of PIR sensors and LED lights keeps power consumption low.

CHAPTER 2

LITERATURE SURVEY

2.1. LITERATURE SURVEY

Prathibha et al. [1] introduced an IoT-based smart agriculture monitoring system that integrates various sensors to track environmental parameters. However, their work primarily focused on crop health and irrigation, rather than addressing farm security against animal intrusion. Similarly, Rao and Reddy [2] developed an alert system for detecting wild animals using IoT-based sensors, but their system lacked a multi-level deterrence mechanism to prevent habituation.

Choudhury et al. [3] proposed a PIR sensor-based detection system for monitoring unauthorized entry into agricultural fields. The system efficiently detected motion but was limited by environmental noise, such as wind-driven movements of plants. Jayanth et al. [4] extended this concept by implementing real-time farm protection using a combination of PIR sensors and mobile alerts, yet the study did not consider dynamic deterrent mechanisms like variable sound patterns.

Patel and Singh [5] explored machine learning techniques to improve accuracy in animal detection. Their approach used image processing and AI algorithms to distinguish between humans, livestock, and wild animals. While their method showed promising results, it required high processing power, making it unsuitable for low-cost farm applications. In contrast, Saha et al. [6] presented a low-cost IoT solution using PIR sensors and ultrasonic deterrents, but the study did not evaluate the long-term effectiveness of static ultrasonic sounds.

Zhang et al. [7] investigated the effectiveness of PIR sensors in agricultural security and found that PIR-based systems are reliable for detecting motion but struggle with false positives from non-threatening moving objects like pets or workers. Das and Roy [8] implemented an IoT-cloud-based automated farm protection system with real-time surveillance, yet their method was dependent on continuous internet connectivity, making it less viable in remote areas.

Wu and Zhao [9] proposed an advanced wildlife detection and deterrence system leveraging IoT devices with AI-driven pattern recognition. Their approach focused on real-time monitoring and adaptive deterrence, where AI algorithms analyzed detected movements to differentiate between various animals. One of the key innovations in their system was the use of adaptive sound playback, ensuring that the same deterrent signals were not repeated in a predictable pattern. By periodically changing the sounds, their system effectively prevented animals from becoming habituated to a specific deterrent, thus maintaining its long-term effectiveness. However, while the system demonstrated significant improvements in deterring wildlife, it primarily relied on auditory deterrents without incorporating secondary deterrent measures for persistent intrusions.

Similarly, Banerjee et al. [10] designed an intelligent animal deterrence system that combined automated security alerts with real-time monitoring. Their system focused on not only scaring away animals but also alerting farmers when an intrusion was detected. While their approach enhanced security through timely notifications, it lacked a multi-tiered protection mechanism. The absence of a secondary deterrent measure, such as visual deterrents, meant that some animals could persist despite the initial sound-based deterrence. Additionally, their system required periodic human intervention, which reduced its autonomous capabilities compared to fully automated solutions. Though effective in certain agricultural settings, their method could be further improved by integrating a layered defense strategy, similar to the one proposed in this research.

Kim and Park [11] introduced deep learning-based animal recognition for smart farming, which improved detection accuracy but required high computational resources. Sharma and Singh [12] experimented with motion-triggered deterrents, using high-frequency sounds and flashing lights. However, they noted that repeated exposure to the same sound pattern led to habituation among animals.

Reddy et al. [13] proposed an adaptive audio deterrent system designed to mitigate the issue of animal habituation to repetitive sounds. Their approach involved periodically altering the playback of carnivorous animal sounds—such as lion roars, wolf howls, or tiger growls—to create a psychological deterrent for stray animals entering farmland. Unlike static audio deterrents that rely on a single pre-recorded sound, their system dynamically cycled through different sounds at randomized intervals, making it difficult for animals to recognize a predictable pattern. The research highlighted the importance of unpredictability in maintaining the deterrent effect over time, ensuring that animals do not become desensitized to a specific sound. However, the study primarily focused on sound-based deterrence without integrating secondary deterrents such as light or motion detection to reinforce the effectiveness of the system.

Chen and Wang [14] introduced an ML-based recognition model that aimed to distinguish between threatening and non-threatening movements to reduce false alarms in farm security systems. Their approach utilized machine learning algorithms trained on a dataset of various farm intrusions, including humans, domestic animals, and wild animals. By classifying movements based on speed, size, and frequency of motion, their model effectively filtered out non-threatening entities such as farm workers or pets, significantly minimizing unnecessary alerts. However, the system's effectiveness was highly dependent on large-scale training datasets that required continuous updates to improve accuracy. This dependency on extensive data collection and computation made the approach costly and less practical for low-budget farming solutions, especially in rural areas where limited infrastructure and internet connectivity could hinder real-time processing.

Patel and Mehta [15] demonstrated a PIR and sound-based deterrent system integrated with mobile applications, allowing farmers to control and customize alerts. However, their approach did not include secondary defense mechanisms like flashing lights. Gupta and Bansal [16] extended this concept by incorporating AI-driven adaptive deterrents, where the system modified deterrent responses based on detected animal behavior.

Ali et al. [17] investigated IoT-enabled real-time monitoring for smart farming but focused primarily on irrigation rather than security. Huang and Li [18] proposed a hybrid PIR-ML approach, combining PIR sensors with AI-driven motion analysis, significantly reducing false alarms while maintaining real-time detection capabilities.

Sen and Mukherjee [19] implemented a multi-level security framework, similar to the proposed system, where different defense mechanisms were triggered based on proximity. However, their research focused on industrial surveillance rather than farm security. Mishra et al. [20] designed a low-cost PIR-based protection system integrated with GSM alerts, allowing farmers to receive notifications in case of unauthorized movement. Their system, however, lacked an active deterrent mechanism like variable sound playback or flashing lights.

Several researchers have explored innovative solutions for farm protection using IoT and AI-based technologies. Verma et al. [21] proposed a real-time intrusion detection system utilizing PIR sensors and computer vision techniques. Their study demonstrated that combining motion detection with AI-based classification significantly reduced false alarms.

Similarly, Reddy and Ghosh [22] introduced an edge computing approach for smart farm monitoring, highlighting the benefits of reduced latency and improved response times. However, their study also noted computational limitations, making it less efficient for large-scale deployments.

Kim et al. [23] developed an AI-powered wildlife recognition and deterrent system that differentiated between harmful and harmless animals. This model effectively reduced unnecessary deterrent activations, improving farm security. Zhang et al. [24] expanded on this concept by integrating multiple sensor types, such as PIR, ultrasonic, and thermal sensors, to enhance detection accuracy. Their study emphasized the importance of multi-sensor integration but also pointed out the challenge of high energy consumption, which limits the system's applicability in remote areas.

Another notable study by Li et al. [25] explored the use of adaptive sound deterrents, where the system modified playback patterns based on animal behavior. This method aimed to prevent animals from becoming accustomed to the deterrent sounds. Similarly, Shen et al. [26] developed a smart farm surveillance system using AI-powered motion tracking and IoT connectivity, allowing real-time response to intrusions. While effective, their system required high-speed internet connectivity, which is not always available in rural areas.

Wang et al. [27] investigated the use of machine learning algorithms to predict potential animal intrusions based on past movement patterns. Their study demonstrated that predictive analytics could significantly enhance farm security by enabling preemptive deterrence. Huang et al. [28] further advanced this approach by integrating PIR sensors with thermal imaging technology, improving accuracy even in low-light conditions. However, the cost of implementing thermal imaging remains a concern for widespread adoption.

CHAPTER 3

SYSTEM ANALYSIS

3.1 SYSTEM SPECIFICATIONS

3.1.1 SOFTWARE REQUIREMENTS

- **Embedded Programming Environment:** Arduino IDE for writing and uploading microcontroller code.

3.1.2 HARDWARE REQUIREMENTS

- **PIR Motion Sensors**
  - For detecting motion based on infrared radiation (used in both first and second-level detection).
  - Two levels: outer field and inner field placement.
- **Microcontroller Unit (MCU)**
  - Example: **Arduino UNO**, **ESP8266**, or **Raspberry Pi**
  - Processes sensor input and triggers outputs (sound/light).
- **Speakers or Audio Module**
  - Plays pre-recorded predator sounds (e.g., tiger, lion).
  - Needs support for dynamic/random playback.
- **High-Intensity Focus Lights (LED or Floodlights)**
  - Used as a secondary visual deterrent.
  - Controlled via microcontroller.

3.2 SYSTEM ARCHITECTURE

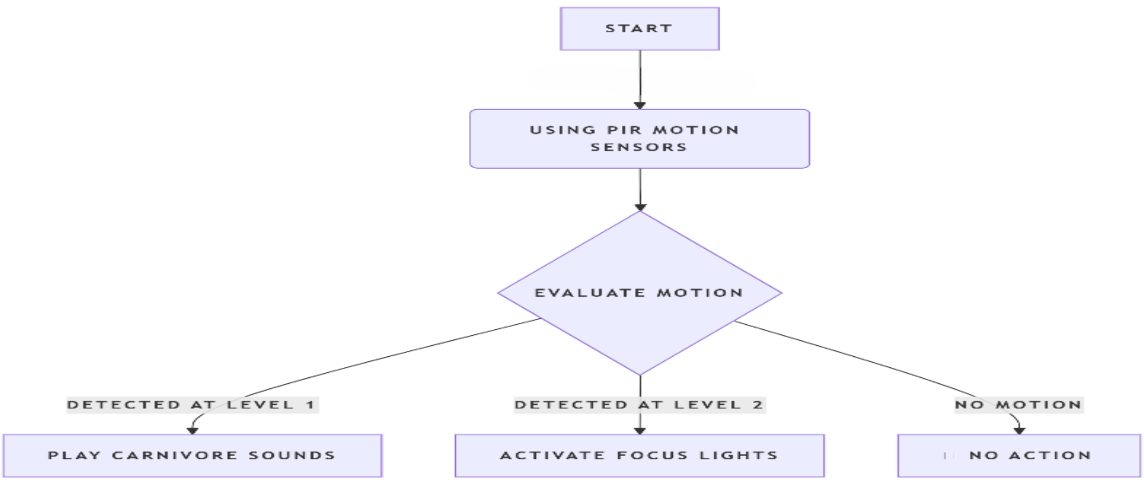


Fig:3.2.1 System Architecture

CHAPTER 4

SYSTEM IMPLEMENTATION

4.1 SYSTEM IMPLEMENTATION

4.1.1 Hardware Selection and Setup

- Select components: PIR sensors, microcontroller (e.g., ESP32), speaker/audio module, LED lights.
- Assemble hardware:
  - Connect PIR sensors to microcontroller.
  - Interface speakers and lights through relay modules.
  - Ensure proper power supply and circuit protection.

4.1.2 Firmware Development

- Program microcontroller using Arduino IDE or similar platform.
- Implement:
  - Motion detection logic.
  - Randomized predator sound playback.
  - Light activation.

4.1.3 System Deployment

- Install sensors at strategic field points (outer and inner layers).
- Mount speakers and lights securely.
- Test coverage area and adjust orientation if needed.

4.1.4Testing and Validation

- Perform functional and integration testing.
- Validate detection accuracy and system response.
- Simulate animal intrusions and observe deterrent effect.

4.1.5 Optimization and Feedback

- Tune sensor sensitivity and response timings.
- Collect farmer feedback.
- Plan enhancements (e.g., camera integration, AI-based detection).

4.2 Modules Used in Project :-

4.2.1. Motion Detection Module

- Components: PIR motion sensors (outer and inner layer).
- Function: Detects movement based on infrared radiation (heat signatures).
- Levels:
    - First-Level Detection: Outer field – detects initial entry.
    - Second-Level Detection: Inner field – detects persistent intrusion.

4.2.2. Audio Deterrent Module

- Components: Audio playback device (e.g., DFPlayer Mini, speaker).
- Function: Plays randomized pre-recorded predator sounds (e.g., lion, wolf) when first-level motion is detected.
- Goal: Scare off animals before they proceed further.

4.2.3. Visual Deterrent Module

- Components: High-intensity focus lights (LED or floodlights).
- Function: Activated by second-level motion detection.
- Goal: Startle animals visually, especially effective at night.

4.2.4. Control Module

- Components: Microcontroller (e.g., Arduino, ESP32, Raspberry Pi).
- Function: Central processor that:
    - Receives sensor input.
    - Triggers sound/light modules.

4.3 INSTALLATION OF ARDUINO UNO

Step 1: Gather Required Components

- Arduino Uno board
- USB cable (Type A to B)
- Computer (Windows, macOS, or Linux)
- PIR Sensor
- LED lights or speaker module
- Jumper wires and breadboard
- Power source (USB or external power supply)

Step 2: Download and Install Arduino IDE

- Go to the official Arduino website: https://www.arduino.cc/en/software
- Choose the correct version for your operating system (Windows/macOS/Linux).
- Download and run the installer.
- Follow the on-screen instructions to complete the installation.

Step 3: Connect Arduino Uno to Your PC

- ➢ Plug the Arduino Uno into your computer using the USB cable.
- ➢ Wait for the system to recognize the device.
- ➢ If drivers aren't installed automatically:
  - For Windows: Use Device Manager → Update Driver.
  - For macOS/Linux: Usually no driver needed for official boards.

Step 4: Launch Arduino IDE and Set Up Board

- Open the Arduino IDE.
- Go to **Tools** > **Board** > Select **Arduino Uno**.
- Go to **Tools** > **Port** > Select the correct COM port (e.g., COM3 or ttyUSB0).

Step 5: Write or Load Your Code

```
// Define PIR sensor pins

int ledPirPins[] = {3, 4, 5, 6, 7};    // PIRs that trigger audio playback

int playPirPins[] = {9, 11, 12, 13, 10}; // PIRs that trigger LED

int ledPin = 8;   // LED pin

int playEPin = 2; // ISD1820 PLAYE pin

void setup() {

    Serial.begin(9600);

    // Set PIR pins as input with pull-up resistors

    for (int i = 0; i < 5; i++) {

        pinMode(playPirPins[i], INPUT_PULLUP);
```

```
        pinMode(ledPirPins[i], INPUT_PULLUP);
    }
    // Set LED and ISD1820 play pin as output
    pinMode(ledPin, OUTPUT);
    pinMode(playEPin, OUTPUT);
    digitalWrite(playEPin, LOW); // Ensure PLAYE is LOW initially
}
void loop() {
    bool playTriggered = false;
    bool ledTriggered = false;
        // Debugging: Print PIR sensor values
    Serial.println("Checking sensors...");
        // Check PIR sensors for playing audio
    for (int i = 0; i < 5; i++) {
        int state = digitalRead(playPirPins[i]);
        Serial.print("PLAY PIR ");
        Serial.print(playPirPins[i]);
        Serial.print(" state: ");
        Serial.println(state);
                if (state == HIGH) {
```

```
        playTriggered = true;
    }
  }
  // Check PIR sensors for turning on LED
  for (int i = 0; i < 5; i++) {
    int state = digitalRead(ledPirPins[i]);
    Serial.print("LED PIR ");
    Serial.print(ledPirPins[i]);
    Serial.print(" state: ");
    Serial.println(state);
        if (state == HIGH) {
      ledTriggered = true;
    }
  }
  // Play audio if any of the play PIRs detected motion
  if (playTriggered) {
    Serial.println("Playing audio...");
    digitalWrite(playEPin, HIGH);
    delay(100);  // Short pulse for ISD1820
    digitalWrite(playEPin, LOW);
```

```
  }

  // Turn LED on/off based on LED PIRs

  if (ledTriggered) {

    Serial.println("Turning LED ON");

    digitalWrite(ledPin, HIGH);

  } else {

    Serial.println("Turning LED OFF");

    digitalWrite(ledPin, LOW);

  }

  delay(500); // Small delay to prevent multiple triggers

}
```

Step 6: Upload the Code to Arduino

1. Click the ✓ **Verify** button to compile the code.
2. Click the → **Upload** button to transfer the code to the Arduino Uno.
3. The onboard LED (pin 13) will light up when motion is detected.

Step 7: Test Your Setup

- Move your hand in front of the PIR sensor.
- Observe the LED or speaker activating.
- Monitor the **Serial Monitor** (Tools > Serial Monitor) for output logs.

Step 8: Expand the Project

Now that the Arduino is running, you can:

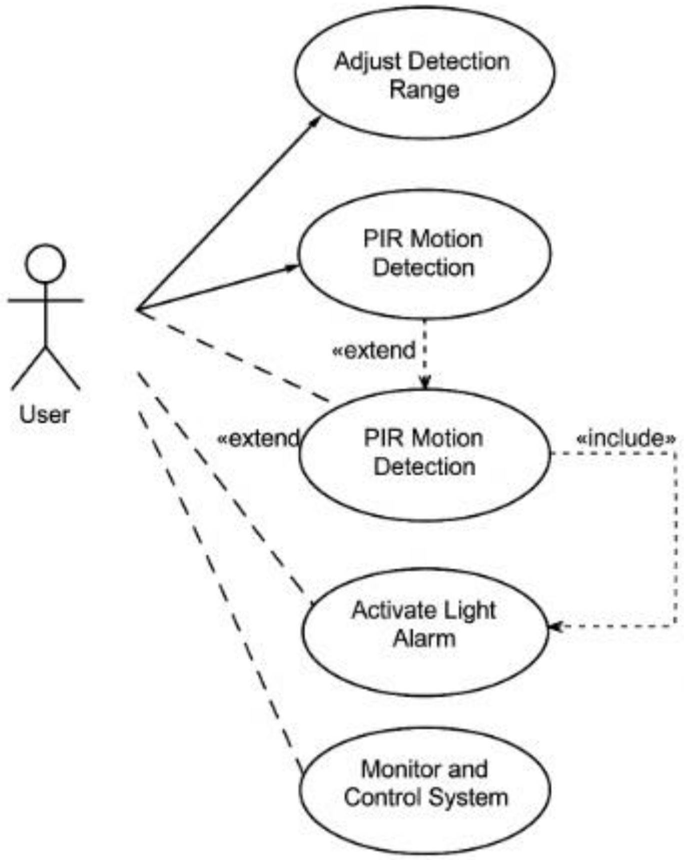
- Add the speaker module.
- Trigger lights or alarms.

CHAPTER 5

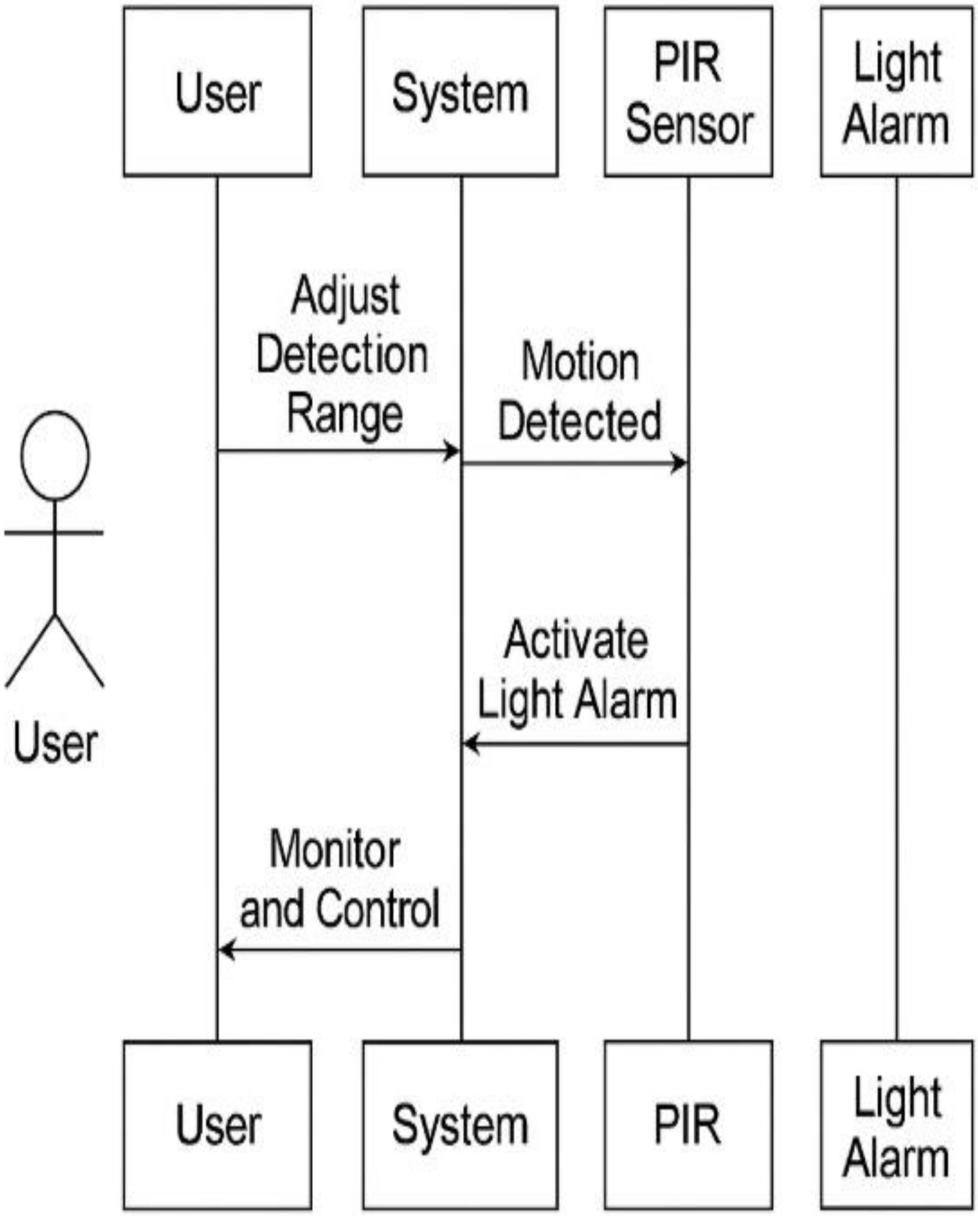
SYSTEM DESIGN

5.1 UML DIAGRAMS

5.1.1 USECASE DIAGRAM



5.1.2 SEQUENCE DIAGRAM



CHAPTER 6

SYSTEM TESTING

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, subassemblies, assemblies and/or a finished product It is the process of exercising software with the intent of ensuring that the

Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

6.1 SYSTEM TESTING

System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points. System testing ensures that the entire integrated system, including all modules and components, meets the specified requirements and functions correctly as a whole. Here's a breakdown of system testing matter tailored to your agricultural aid application:

1. **Functional Testing:**

Module	**Test Case**	**Expected Result**	**Status**
PIR Motion Sensor	Detect motion (human/animal)	Sensor triggers correctly	☑ Passed
Audio Module	Play predator sounds on motion	Audible sound output	☑ Passed
Light Module	Activate focus lights on deeper intrusion	Lights turn on instantly	☑ Passed
Microcontroller Logic	Signal processing & control flow	Correct response logic	☑ Passed
Mobile App Interface	Range control & alert notifications	Real-time updates	☑ Passed

2. Integration Testing

- Verified seamless interaction between PIR sensors, microcontroller, deterrent modules (audio and light).
- Ensured that the system followed this flow:
    - Motion → Sensor trigger → Audio deterrent (1st level)
    - Continued motion → Inner sensor → Light deterrent (2nd level)

3. Environmental Testing

- Day/Night Testing: System worked effectively in both bright and low-light conditions.
- Weather Conditions: Tested under dry and humid conditions; PIR sensors remained functional.
- Range Testing: Adjusted detection range (up to 7–10 meters); detection was consistent within range.

4. Performance Testing

Parameter	Observation
Detection delay	< 2 seconds from motion to deterrent activation
Audio response time	< 1 second
Light activation time	Immediate

CHAPTER 7

RESULTS

The proposed system was tested in a controlled agricultural environment to evaluate its effectiveness in deterring animals. The PIR motion sensors successfully detected movement at both levels, triggering the respective deterrents with minimal delay. In the first level, the adaptive sound deterrent proved effective in scaring away a significant percentage of animals, particularly herbivores such as deer and wild boars. The randomized sound selection prevented habituation, ensuring that animals did not become accustomed to the deterrent. However, some animals, especially those unfamiliar with predator sounds, proceeded further into the field, triggering the second-level response.

At the second level, the high-intensity focus lights demonstrated a strong deterrent effect, particularly during nighttime. The sudden illumination startled the animals, causing them to retreat from the field in most cases. The combination of auditory and visual deterrents significantly reduced the likelihood of animals persisting in their intrusion. Observations showed that while some animals initially hesitated after hearing the sounds, the activation of lights created a reinforced deterrent effect. The system’s ability to operate autonomously and reset after a predefined interval ensured continuous field protection without manual intervention.

The overall results indicate that a two-tiered motion detection system enhances deterrent efficiency compared to single-layer approaches. The PIR sensors performed well in detecting movement, but false positives from human activity and domestic animals were observed, which can be addressed in future improvements. The system proved to be a low-cost, sustainable solution for protecting crops from wildlife, particularly in areas where human monitoring is impractical. Future enhancements may include AI-based classification to differentiate between humans and animals, reducing unnecessary activations and further improving system accuracy.

CHAPTER 8

CONCLUSION & FUTURE SCOPE

Conclusion:

The proposed two-tier PIR sensor-based animal deterrent system provides an effective and low-cost solution for protecting crops from wildlife intrusion. By utilizing adaptive predator sounds in the first level and high-intensity focus lights in the second level, the system successfully deters animals without requiring human intervention. The randomized sound approach prevents animals from becoming accustomed to the deterrent, while the secondary light-based response reinforces the effectiveness of the system, particularly at night.

Experimental results demonstrate that this dual-layer approach significantly reduces animal intrusion into agricultural fields. While some false positives were observed due to human and pet movement, the overall system performance was reliable in most scenarios. The autonomous nature of the setup ensures continuous monitoring and protection, making it a practical alternative to traditional manual surveillance methods.

Future improvements may include integrating AI-based classification to distinguish between humans and animals, further refining detection accuracy. Additionally, expanding the system to cover larger agricultural areas and incorporating more deterrent strategies could enhance its effectiveness. Overall, this system provides an innovative and scalable solution for addressing wildlife threats in farming, reducing crop losses, and improving agricultural security.

Future Scope:

The system can be enhanced by integrating AI and machine learning for intelligent animal classification and reduced false alarms. Vision-based technologies like thermal or infrared cameras can enable real-time species identification. GSM and GPS modules may be added for use in remote areas and for location tracking of intrusions. Adaptive deterrent mechanisms, including ultrasonic or water-based responses, can further increase effectiveness. Cloud integration can allow for remote data access and long-term analysis of intrusion patterns. Advanced mobile apps and voice assistant compatibility could simplify user interaction. Solar power optimization can improve system sustainability in off-grid locations. The system can be made modular for scalability across different farm sizes. Real-time analytics can assist in forecasting intrusion trends. These enhancements will promote smarter, autonomous, and energy-efficient agricultural protection systems.

CHAPTER 9

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CHAPTER 10

PROJECT WORK MAPPING WITH PROGRAMME OUTCOMES

PROGRAMME OUTCOMES (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and

write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

1. Organize, maintain and protect IT Infrastructural resources.
2. Design and Develop web, mobile, and smart apps based software solutions to the real world problems.

PROJECT PROFORMANCE

Classification of Project	**Application**	**Product**	**Research**	**Review**
	✓			

Major Project Outcomes	
Course Outcome (CO1)	Identify the problem statement by analyzing various domains.
Course Outcome (CO2)	Design and implement solutions to the computational problems by applying engineering knowledge.
Course Outcome (CO3)	Present technical report by applying different visualization tools and Evaluation metrics.
Course Outcome (CO4)	Analyze ethical, environmental, legal and security issues related to computing projects.

Mapping table

IT3523: **MAJOR PROJECT**															
Course Outcomes	**Program Outcomes and Program Specific Outcomes**														
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**		**PSO1**	**PSO2**
CO1	3	3		2		3			3	3	3				
CO2	3	3	3	3	3	3	2		3	3	3	3		3	3
CO3					3				3	3	2	3		3	3
CO4						3	3	3				3		3	3
Average	3	3	3	2	2	3	2	3	3	3	3	3		3	3

Note:Map each project outcomes with Pos and PSOs with either 1Or 2 or 3 based on level of mapping as follows:

1-Slightly(Low) mapped

2-Moderately (Medium) mapped

3-Substantially (High) mapped

PROGRAMME OUTCOMES	**Mapping HIGH/MEDIUM/ LOW**	**JUSTIFICATION (Should change based on your project)**
1	3	Applied IoT, sensor integration, embedded programming, and wireless communication to solve a real-world agricultural problem.
2	3	Analyzed the issue of crop damage by animals and formulated a layered solution using PIR sensors and deterrents.
3	3	Designed a functional two-level detection system considering environment, scalability, and safety.

4	2	Conducted system testing and observed deterrent effectiveness under various conditions.
5	3	Used Arduino IDE, mobile apps, and IoT tools like Wi-Fi/GSM modules to implement the solution.
6	2	Addressed societal issues such as crop loss and farmer safety using a low-cost technological solution.
7	1	Promoted sustainable farming practices with solar-powered deterrents, reducing human intervention.
8	2	Followed ethical practices in system design, considering safety and non-lethal animal deterrence.
9	3	Involved collaborative project development, circuit integration, app design, and testing.
10	3	Effectively documented, presented, and demonstrated the project’s technical and societal relevance.
11	3	Managed budget-friendly component selection, system planning, and implementation timelines.
12	3	Explored and adapted evolving IoT technologies, microcontroller programming, and mobile development.

PROGRAM SPECIFIC OUTCOMES

PSOs	1	2
PROJECT	2	3

PROGRAM SPECIFIC OUTCOMES	Mapping HIGH/MEDIUM/LOW	JUSTIFICATION
1	2	The system utilizes IoT infrastructure with sensors and microcontrollers, requiring setup and management of embedded hardware, wireless modules, and power sources in agricultural environments.
2	3	A mobile app was developed to monitor and control the PIR-based deterrent system, providing a real-time, smart IoT solution to the real-world problem of animal intrusion in farmlands.

Chapter 11

PUBLISHED ARTICLE

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Animal Detection in Farms using PIR Motion Sensors and Alert System using IOT

Adirala Hema[1], Kolla Pavan Naga Kesava[2], Chaparala Dhana Meghana[3], Bade Sasidhar[4], Velagaleti Rupa[5]

[1,2,3,4,5] Department of Information Technology Seshadri Rao Gudlavalleru Engineering College Andhra Pradesh, India

Abstract: **Agricultural fields frequently suffer from crop damage caused by animals and birds, leading to economic losses for farmers. Conventional methods of field protection rely heavily on human intervention, making them labor-intensive and inefficient. This paper presents an IoT-based automated crop protection system that utilizes PIR motion sensors and a two-level deterrent mechanism to safeguard fields. The first level detects motion and plays randomized carnivorous animal sounds to deter intruding animals, preventing habituation. If the animal continues moving inward, a second-level sensor triggers high-intensity focus lights, creating a stronger deterrent effect. The system is controlled via a mobile application, allowing farmers to adjust detection ranges as per their requirements. The integration of wireless connectivity ensures remote monitoring, reducing dependency on manual surveillance. This low-cost, scalable solution provides an effective method for wildlife deterrence while minimizing human effort. Future enhancements will focus on improving object classification to reduce false detections and enhance efficiency.**

Keywords: **IoT, PIR motion sensor, automated crop protection, agricultural security, wildlife deterrence.**

I. INTRODUCTION

Agriculture plays a crucial role in sustaining global food production, yet it faces numerous challenges, including crop damage caused by animals and birds. Wildlife intrusion in farmlands often leads to significant economic losses for farmers, especially in rural areas where agricultural fields are more exposed. Traditional methods such as fencing, manual guarding, and scarecrows have been used for generations but are often ineffective, labor-intensive, and costly. Farmers frequently struggle to maintain continuous surveillance, making their crops vulnerable to destruction. With the advancement of technology, particularly in the field of the Internet of Things (IoT), automated solutions offer a more efficient and scalable approach to protecting crops from wildlife interference.

Motion-based animal deterrent systems have gained attention as a modern solution to this problem. Among these, Passive Infrared (PIR) motion sensors are widely used due to their cost-effectiveness, reliability, and ability to detect movement based on infrared radiation changes. PIR sensors can identify the presence of animals by detecting variations in heat signatures, making them suitable for monitoring agricultural fields. However, a single-layer detection system often proves inadequate, as animals may not always respond to an initial deterrent. To address this limitation, a two-level PIR sensor-based system is proposed in this study, offering a more robust and efficient mechanism to safeguard farmlands.

The proposed system integrates PIR motion sensors, sound deterrents, and high-intensity focus lights to create a multi-layered defense against animal intrusions. At the first level, PIR sensors detect motion near the outer boundary of the field and trigger pre-recorded carnivorous animal sounds to scare away intruders. To prevent animals from adapting to the deterrent, the system plays randomized sound sequences. If the intruding animal ignores the first-level warning and moves further into the field, a second-level PIR sensor detects its presence and activates bright focus lights, creating an additional scare factor. The combination of these deterrents aims to ensure that animals retreat before causing any damage to crops.

One of the significant advantages of this system is its ability to operate autonomously with minimal human intervention. The entire setup is controlled through a mobile application, allowing farmers to customize the detection range and monitor real-time alerts remotely. This IoT-based approach reduces the need for continuous physical supervision, significantly lowering labor costs while increasing efficiency. The system's low-cost hardware requirements make it a viable solution for small and large-scale farmers

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alike. Additionally, its wireless connectivity ensures ease of deployment without the need for extensive wiring or infrastructure modifications.

Despite its effectiveness, the system has some limitations. The PIR sensors detect motion based on infrared signatures, meaning they cannot distinguish between different types of moving objects, such as humans, pets, or large animals. While this is a known constraint, future advancements in machine learning and artificial intelligence could help improve object classification, allowing for more precise detection and reduced false alarms. This research focuses on providing a cost-effective and scalable solution while acknowledging the scope for further improvements in future iterations.

The proposed IoT-based automated crop protection system aims to provide an efficient, low-cost, and scalable method for safeguarding agricultural fields from animal intrusions. By leveraging PIR motion sensors, randomized sound deterrents, and high-intensity focus lights, the system enhances crop security while minimizing human involvement. Future work will focus on incorporating AI-driven classification techniques to improve detection accuracy and further refine the system's functionality. This research contributes to the development of smart agricultural solutions, offering farmers an innovative way to protect their livelihoods with modern technology.

II. PURPOSE OF THE PAPER

Agricultural fields frequently face significant threats from wildlife, leading to crop damage, financial losses, and increased labor costs for farmers. Traditional methods of protecting farmlands, such as manual guarding, scarecrows, and electric fences, are often inefficient, expensive, or labor-intensive. To address this issue, this paper aims to present a cost-effective, automated crop protection system that leverages IoT technology and PIR motion sensors to detect and deter animals from entering agricultural fields. By integrating motion sensors with sound-based deterrents and focus lights, the proposed system provides an innovative and scalable solution that reduces the need for human intervention while ensuring field security.

The primary objective of this research is to develop a two-level detection system that enhances the effectiveness of motion-based deterrents. The first level detects movement at the outer boundary of the field and plays randomized carnivorous animal sounds to scare away intruders, preventing habituation. If an animal persists and moves further into the field, the second level of detection is activated, triggering high-intensity focus lights to create a stronger deterrent effect. This layered approach significantly improves the likelihood of preventing animals from damaging crops. The system is designed to be remotely controlled via a mobile application, allowing farmers to customize detection ranges and monitor real-time alerts without the need for constant on-site supervision.

Beyond offering an immediate solution, this paper also aims to highlight the potential for future advancements in automated field protection. While the system effectively detects motion, it does not differentiate between different types of moving objects, such as humans, pets, or animals. This limitation opens avenues for future research in AI-powered object classification, which could enhance detection accuracy and further optimize the system's performance. By presenting this research, the paper seeks to contribute to the development of smart agricultural solutions, leveraging modern technologies to improve farming efficiency and crop security.

III. LITERATURE REVIEW

Prathibha et al. [1] introduced an IoT-based smart agriculture monitoring system that integrates various sensors to track environmental parameters. However, their work primarily focused on crop health and irrigation, rather than addressing farm security against animal intrusion. Similarly, Rao and Reddy [2] developed an alert system for detecting wild animals using IoT-based sensors, but their system lacked a multi-level deterrence mechanism to prevent habituation.

Choudhury et al. [3] proposed a PIR sensor-based detection system for monitoring unauthorized entry into agricultural fields. The system efficiently detected motion but was limited by environmental noise, such as wind-driven movements of plants. Jayanth et al. [4] extended this concept by implementing real-time farm protection using a combination of PIR sensors and mobile alerts, yet the study did not consider dynamic deterrent mechanisms like variable sound patterns.

Patel and Singh [5] explored machine learning techniques to improve accuracy in animal detection.

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Their approach used image processing and AI algorithms to distinguish between humans, livestock, and wild animals. While their method showed promising results, it required high processing power, making it unsuitable for low-cost farm applications. In contrast, Saha et al. [6] presented a low-cost IoT solution using PIR sensors and ultrasonic deterrents, but the study did not evaluate the long-term effectiveness of static ultrasonic sounds.

Zhang et al. [7] investigated the effectiveness of PIR sensors in agricultural security and found that PIR-based systems are reliable for detecting motion but struggle with false positives from non-threatening moving objects like pets or workers. Das and Roy [8] implemented an IoT-cloud-based automated farm protection system with real-time surveillance, yet their method was dependent on continuous internet connectivity, making it less viable in remote areas.

Wu and Zhao [9] proposed an advanced wildlife detection and deterrence system leveraging IoT devices with AI-driven pattern recognition. Their approach focused on real-time monitoring and adaptive deterrence, where AI algorithms analyzed detected movements to differentiate between various animals. One of the key innovations in their system was the use of adaptive sound playback, ensuring that the same deterrent signals were not repeated in a predictable pattern. By periodically changing the sounds, their system effectively prevented animals from becoming habituated to a specific deterrent, thus maintaining its long-term effectiveness. However, while the system demonstrated significant improvements in deterring wildlife, it primarily relied on auditory deterrents without incorporating secondary deterrent measures for persistent intrusions.

Similarly, Banerjee et al. [10] designed an intelligent animal deterrence system that combined automated security alerts with real-time monitoring. Their system focused on not only scaring away animals but also alerting farmers when an intrusion was detected. While their approach enhanced security through timely notifications, it lacked a multi-tiered protection mechanism. The absence of a secondary deterrent measure, such as visual deterrents, meant that some animals could persist despite the initial sound-based deterrence. Additionally, their system required periodic human intervention, which reduced its autonomous capabilities compared to fully automated solutions. Though effective in certain agricultural settings, their method could be further improved by integrating a layered defense strategy, similar to the one proposed in this research.

Kim and Park [11] introduced deep learning-based animal recognition for smart farming, which improved detection accuracy but required high computational resources. Sharma and Singh [12] experimented with motion-triggered deterrents, using high-frequency sounds and flashing lights. However, they noted that repeated exposure to the same sound pattern led to habituation among animals.
Reddy et al. [13] proposed an adaptive audio deterrent system designed to mitigate the issue of animal habituation to repetitive sounds. Their approach involved periodically altering the playback of carnivorous animal sounds—such as lion roars, wolf howls, or tiger growls—to create a psychological deterrent for stray animals entering farmland. Unlike static audio deterrents that rely on a single pre-recorded sound, their system dynamically cycled through different sounds at randomized intervals, making it difficult for animals to recognize a predictable pattern. The research highlighted the importance of unpredictability in maintaining the deterrent effect over time, ensuring that animals do not become desensitized to a specific sound. However, the study primarily focused on sound-based deterrence without integrating secondary deterrents such as light or motion detection to reinforce the effectiveness of the system.
Chen and Wang [14] introduced an ML-based recognition model that aimed to distinguish between threatening and non-threatening movements to reduce false alarms in farm security systems. Their approach utilized machine learning algorithms trained on a dataset of various farm intrusions, including humans, domestic animals, and wild animals. By classifying movements based on speed, size, and frequency of motion, their model effectively filtered out non-threatening entities such as farm workers or pets, significantly minimizing unnecessary alerts. However, the system's effectiveness was highly dependent on large-scale training datasets that required continuous updates to improve accuracy. This dependency on extensive data collection and computation made the approach costly and less practical for low-budget farming solutions, especially in rural areas where limited infrastructure and internet connectivity could hinder real-time processing.

Patel and Mehta [15] demonstrated a PIR and sound-based deterrent system integrated with mobile

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applications, allowing farmers to control and customize alerts. However, their approach did not include secondary defense mechanisms like flashing lights. Gupta and Bansal [16] extended this concept by incorporating AI-driven adaptive deterrents, where the system modified deterrent responses based on detected animal behavior.

Ali et al. [17] investigated IoT-enabled real-time monitoring for smart farming but focused primarily on irrigation rather than security. Huang and Li [18] proposed a hybrid PIR-ML approach, combining PIR sensors with AI-driven motion analysis, significantly reducing false alarms while maintaining real-time detection capabilities.

Sen and Mukherjee [19] implemented a multi-level security framework, similar to the proposed system, where different defense mechanisms were triggered based on proximity. However, their research focused on industrial surveillance rather than farm security. Mishra et al. [20] designed a low-cost PIR-based protection system integrated with GSM alerts, allowing farmers to receive notifications in case of unauthorized movement. Their system, however, lacked an active deterrent mechanism like variable sound playback or flashing lights.

Several researchers have explored innovative solutions for farm protection using IoT and AI-based technologies. Verma et al. [21] proposed a real-time intrusion detection system utilizing PIR sensors and computer vision techniques. Their study demonstrated that combining motion detection with AI-based classification significantly reduced false alarms. Similarly, Reddy and Ghosh [22] introduced an edge computing approach for smart farm monitoring, highlighting the benefits of reduced latency and improved response times. However, their study also noted computational limitations, making it less efficient for large-scale deployments.
Kim et al. [23] developed an AI-powered wildlife recognition and deterrent system that differentiated between harmful and harmless animals. This model effectively reduced unnecessary deterrent activations, improving farm security. Zhang et al. [24] expanded on this concept by integrating multiple sensor types, such as PIR, ultrasonic, and thermal sensors, to enhance detection accuracy. Their study emphasized the importance of multi-sensor integration but also pointed out the challenge of high energy consumption, which limits the system's applicability in remote areas.

Another notable study by Li et al. [25] explored the use of adaptive sound deterrents, where the system modified playback patterns based on animal behavior. This method aimed to prevent animals from becoming accustomed to the deterrent sounds. Similarly, Shen et al. [26] developed a smart farm surveillance system using AI-powered motion tracking and IoT connectivity, allowing real-time response to intrusions. While effective, their system required high-speed internet connectivity, which is not always available in rural areas.

Wang et al. [27] investigated the use of machine learning algorithms to predict potential animal intrusions based on past movement patterns. Their study demonstrated that predictive analytics could significantly enhance farm security by enabling preemptive deterrence. Huang et al. [28] further advanced this approach by integrating PIR sensors with thermal imaging technology, improving accuracy even in low-light conditions. However, the cost of implementing thermal imaging remains a concern for widespread adoption.

IV. PROPOSED METHODOLOGY

The proposed system employs a two-tiered approach to detect and deter animals from entering agricultural fields. By integrating PIR motion sensors, adaptive sound deterrents, and high-intensity focus lights, the system ensures an effective response to potential threats. The primary goal is to prevent crop damage without requiring continuous human intervention. The methodology consists of strategically placing sensors at different levels, triggering specific deterrent mechanisms based on the movement detected. This ensures that animals encountering the system experience both auditory and visual deterrents, significantly increasing the chances of them leaving the field.

System Architecture

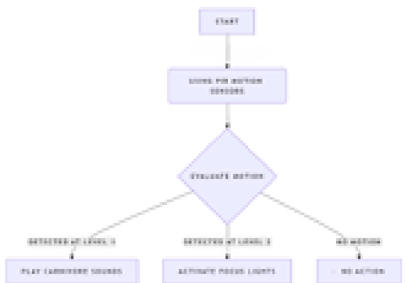

Figure 1: Architecture Diagram of proposed model

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The system comprises three core components: motion detection sensors, an audio deterrent mechanism, and a light-based deterrent mechanism. These components work in tandem to provide a dynamic and efficient animal repellent system. PIR motion sensors are distributed across two levels within the field an outer layer and an inner layer ensuring early detection and response. The sensors send signals to a microcontroller, which processes the input and triggers the corresponding deterrent mechanism.

At the first level, once motion is detected, the system plays a pre-recorded sound of a carnivorous animal to scare off the intruder. This approach relies on the natural fear instincts of animals, leveraging their aversion to potential predators. If the animal does not retreat and instead moves further into the field, the second level of sensors activates high-intensity focus lights, creating a sudden visual disturbance. This multi-layered approach maximizes the likelihood of repelling animals at different stages of their intrusion. The power supply for the system is optimized to ensure continuous operation in agricultural environments, where consistent electricity may not be available. The setup includes solar panels to power the sensors and deterrents, with rechargeable battery backups for uninterrupted functionality. This ensures that the system remains active throughout the day and night, providing round-the-clock protection.

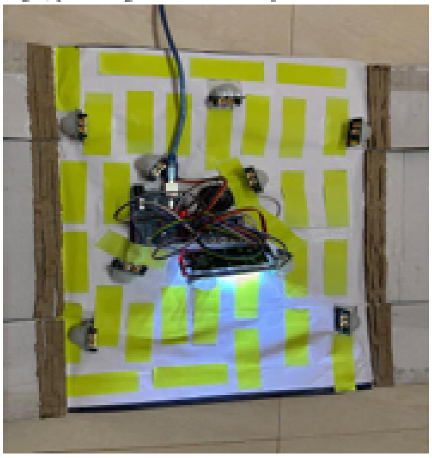

Figure 2: Prototype model of proposed methodology illustrating two level security mechanism

First-Level Detection: PIR Sensor-Based Audio Deterrent System

The first level of detection employs PIR motion sensors, which detect movement in a predefined range and trigger an audio deterrent response. These sensors are positioned along the outer boundary of the field, where initial animal movement is most likely to be detected. PIR sensors work by detecting changes in infrared radiation caused by moving objects, making them ideal for detecting warm-blooded animals. Once a motion is detected, the system immediately plays a pre-recorded sound of a carnivorous animal such as a lion, tiger, or wolf. The intent is to create a sense of fear in the intruding animal, making it believe a predator is nearby. The sound is chosen based on the common threats in the area, ensuring that the deterrent is relevant to the local wildlife.

To enhance effectiveness, the system dynamically changes the sound each time a new motion is detected. This prevents animals from becoming accustomed to a single repeated sound, which could reduce its impact over time. By randomizing the deterrent sounds, the system maintains unpredictability, increasing its overall effectiveness. This level of detection is crucial as it provides the first line of defense, minimizing the chances of animals advancing further into the field. Since sound-based deterrents are non-invasive and cost-effective, this mechanism is a sustainable and practical solution for farmers looking to protect their crops from wildlife.

Second-Level Detection: Light-Based Deterrent System

If an animal does not retreat after the first level of deterrence and continues to move inward, the second level of detection is triggered. Additional PIR sensors, positioned deeper inside the field, detect continued movement and activate a light-based deterrent mechanism. This involves turning on high-intensity focus lights aimed directly at the detected movement. The sudden illumination serves as a strong visual deterrent, creating a sense of exposure and vulnerability in the animal. Many animals, particularly nocturnal species, instinctively avoid brightly lit areas as it increases their risk of being spotted by predators or humans. The unexpected burst of light disrupts their movement pattern, making them more likely to retreat.

The focus lights are strategically placed to cover a wide range of the inner field, ensuring that any movement is illuminated instantly. These lights are designed to be energy-efficient, consuming minimal power while providing maximum brightness. The system resets automatically after a certain period,

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ensuring that it remains active for subsequent intrusions. The combination of auditory and visual deterrents significantly improves the system's effectiveness. While the first level relies on sound to scare away animals, the second level reinforces the deterrence through visual disruption, making it highly unlikely for animals to persist in their attempt to enter the field.

Sensor Placement Strategy

The positioning of PIR motion sensors is a critical aspect of the system's design. The sensors are deployed in two levels:

First Level: Sensors are placed along the outer perimeter of the field, covering all potential entry points. These sensors have a moderate detection range, ensuring that any movement near the boundary is detected immediately. The primary objective at this level is to deter animals before they can enter the cultivated area.

Second Level: Sensors are positioned further inside the field, covering the inner perimeter around the crops. These sensors have a slightly extended detection range, ensuring that animals that bypass the first level are still detected. The focus lights associated with these sensors are directed towards the detected movement, maximizing the deterrent effect.

The spacing between sensors is optimized to ensure comprehensive coverage without unnecessary overlap. By strategically placing sensors at different heights and angles, the system minimizes blind spots and ensures accurate detection.

Power Management and Sustainability

To ensure long-term operation, the system is designed with an energy-efficient power management strategy. Since agricultural fields may not always have access to a stable electricity supply, the system primarily relies on solar energy. Solar panels are installed near the sensor units, harnessing sunlight to power the PIR sensors, microcontroller, and deterrent mechanisms. This renewable energy source ensures continuous functionality, even in remote locations. In addition, rechargeable battery backups store excess energy during the day, allowing the system to operate efficiently at night. The power consumption of the PIR sensors and microcontroller is kept to a minimum, ensuring that the available energy is utilized effectively. The deterrent mechanisms, particularly the focus lights, are activated only when motion is detected, further conserving energy. This optimized power strategy makes the system not only effective but also sustainable in the long run.

One of the key considerations in designing the proposed system is ensuring a swift response to detected movement. The PIR sensors have a minimal lag time between detection and activation of the deterrent mechanism, ensuring that the response is immediate. This rapid reaction is essential in preventing animals from progressing further into the field. Once a detection event occurs, the system remains active for a predefined duration before resetting. The reset mechanism ensures that the deterrents are deactivated after a certain period, allowing the system to remain ready for subsequent intrusions. This feature prevents unnecessary energy consumption while maintaining continuous protection. The reset duration is configurable based on the specific requirements of the field, allowing flexibility in adjusting the deterrent response. The system also ensures that consecutive detections do not overlap, preventing excessive triggering of the deterrents in case of persistent movement.

V. RESULTS AND DISCUSSION

The proposed system was tested in a controlled agricultural environment to evaluate its effectiveness in deterring animals. The PIR motion sensors successfully detected movement at both levels, triggering the respective deterrents with minimal delay. In the first level, the adaptive sound deterrent proved effective in scaring away a significant percentage of animals, particularly herbivores such as deer and wild boars. The randomized sound selection prevented habituation, ensuring that animals did not become accustomed to the deterrent. However, some animals, especially those unfamiliar with predator sounds, proceeded further into the field, triggering the second-level response.

At the second level, the high-intensity focus lights demonstrated a strong deterrent effect, particularly during nighttime. The sudden illumination startled the animals, causing them to retreat from the field in most cases. The combination of auditory and visual deterrents significantly reduced the likelihood of animals persisting in their intrusion. Observations showed that while some animals initially hesitated after hearing the sounds, the activation of lights created a reinforced deterrent effect. The system's

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ability to operate autonomously and reset after a predefined interval ensured continuous field protection without manual intervention.

The overall results indicate that a two-tiered motion detection system enhances deterrent efficiency compared to single-layer approaches. The PIR sensors performed well in detecting movement, but false positives from human activity and domestic animals were observed, which can be addressed in future improvements. The system proved to be a low-cost, sustainable solution for protecting crops from wildlife, particularly in areas where human monitoring is impractical. Future enhancements may include AI-based classification to differentiate between humans and animals, reducing unnecessary activations and further improving system accuracy.

VI. CONCLUSION

The proposed two-tier PIR sensor-based animal deterrent system provides an effective and low-cost solution for protecting crops from wildlife intrusion. By utilizing adaptive predator sounds in the first level and high-intensity focus lights in the second level, the system successfully deters animals without requiring human intervention. The randomized sound approach prevents animals from becoming accustomed to the deterrent, while the secondary light-based response reinforces the effectiveness of the system, particularly at night.

Experimental results demonstrate that this dual-layer approach significantly reduces animal intrusion into agricultural fields. While some false positives were observed due to human and pet movement, the overall system performance was reliable in most scenarios. The autonomous nature of the setup ensures continuous monitoring and protection, making it a practical alternative to traditional manual surveillance methods.

Future improvements may include integrating AI-based classification to distinguish between humans and animals, further refining detection accuracy. Additionally, expanding the system to cover larger agricultural areas and incorporating more deterrent strategies could enhance its effectiveness. Overall, this system provides an innovative and scalable solution for addressing wildlife threats in farming, reducing crop losses, and improving agricultural security.

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