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Research

# SMART IOT-BASED CROP PROTECTION SYSTEM TO PREVENT ANIMAL INTRUSION

**J PRAVEEN[1], N. YAMUNA SARASWATHI[2], A. ANITHA[3], M. SHASHI KIRAN[4], M. LINGA SWAMY[5]**

**ASSISTANT PROFESSOR1, UG SCHOLAR[2,3,4&5]**

**jpraveen.pec@gmail.com[1], nys.ece2020@gmail.com[2], anithaavula590@gmail.com[3], modemshashikirand928@gmail.com[4]**

**DEPARTMENT OF ECE, PALLAVI ENGINEERING COLLEGE (UGC AUTONOMOUS) AFFILIATED BY JNTUH, HYDERABAD KUNTLOOR(V), HAYATHNAGAR (M), HYDERABAD, R.R. DISTRICT -501505**

## ABSTRACT

Crop damage caused by wild animals is a major problem in agriculture, leading to significant economic losses for farmers. Traditional protection methods such as fencing, manual monitoring, and scare tactics are often inefficient and labor-intensive. This paper proposes a Smart IoT-Based Crop Protection System designed to detect and prevent animal intrusion in agricultural fields. The system integrates sensors, an ESP32 microcontroller with an embedded camera, and a buzzer alert mechanism to monitor field activity in real time. When an animal is detected, the system triggers alarms and sends alerts to the farmer through IoT communication. The proposed system provides an automated, cost-effective, and energy-efficient solution for protecting crops from animal attacks while minimizing human intervention.

**Keywords:** IoT, Crop Protection, Animal Intrusion Detection, ESP32 Camera, Smart Agriculture, Precision Farming.

## 1.INTRODUCTION

Crop damage caused by animal attacks is one of the major threats in reducing the crop yield. Due to the expansion of cultivated land into previous wildlife habitat, crop raiding is becoming one of the most conflicts antagonizing humanwildlife relationships [1]. With a population of more than 200,000 wild boars (Sus-scrofa) and 300,000 deer in the region of Tuscany alone in Italy, being estimated to be four times more than any other region in Italy, there is an increasing damage of vineyards and farm lands that has resulted in a huge drop in wine production. According to [2], [3] annual production loss in the wine industry is estimated at 130,000 bottles of wine, which amounts to the range of 8,962,250 – 13,036,000 euros, with an annual cost to the government estimated around 2.5million euro per year. In addition to crop damages, up to 1000 road accidents are also caused by these wild animals annually. The current methods used to counter this problem include the use of electrified welded mesh fences (usually 30cm in the ground), chemicals or organic substances and gas cannons. Other traditional methods applied by farmers include the use of Hellikites, Ballons, Shot/Gas guns, String & stone, etc. These solutions are often cruel and ineffective. They also require a vast amount of installation and maintenance cost and some of the methods have environmental pollution effect on both humans and animals [4]. On the other hand, the chemical products used to prevent these animal attacks have an application cost per hectare and their effectiveness is dependent on weather condition, as rain may cause a dilution effect. Technology assistance at various stages of agricultural processes can significantly enhance the crop yield. Sensor

networks express a substantial improvement over traditional invasive methods of monitoring [5]. Our proposed method is based on an animal friendly ultrasounds generator, which does not produce physical or biological harm to the animals nor sounds audible to humans. Moreover, in agriculture and especially in wine production, very small changes in the micro climate can impact the quality of the product. It is vital for agronomists to have a clear view of the meteorological conditions in a very small area of the entire territory usually characterized by very different soil characteristics. Diseases such as Bunch-rot ”Botrytis cinerea” and Peronospora in vineyards [6] can be prevented by an hourly monitoring of the plant and by providing timely based required treatment to the plant. Based on the above problems, a complete system that will both protect and monitor a vineyard is of significant importance. In this work, we present the coordination among heterogeneous sensors and actuators interacting with the cloud to provide an enabling platform for new services in this domain. In particular in the peripheral part, we adopted wireless technologies such as 6LoWPAN, WiFi, Zigbee etc., cooperating with the data center by an advanced IoT gateway. Another important feature that we had to consider is the lifespan of the devices before deployment. As a result, we selected low energy consuming motes equipped with batteries and solar panels for energy harvesting in order to achieve this goal.

## 2.LITERATURE REVIEW

Agricultural crop damage caused by wild animals is a major challenge faced by farmers worldwide. Animals such as elephants, monkeys, wild boars, and deer frequently enter farmland and destroy crops, resulting in economic loss and reduced agricultural productivity. Researchers have proposed several technological solutions using **Internet of Things (IoT), sensors, and artificial intelligence (AI)** to detect and prevent animal intrusion in agricultural fields. The following literature review summarizes significant studies related to smart crop protection systems.

### 1. IoT in Smart Agriculture

IoT technology has become a key component in modern smart farming systems. It enables real-time monitoring of agricultural environments using interconnected sensors, communication networks, and data processing platforms. IoT-based smart farming systems collect data such as temperature, humidity, and motion to monitor farm conditions and improve crop management. These technologies help farmers detect problems early and respond quickly, reducing crop damage and improving productivity.

IoT devices also enable automation in agriculture by integrating sensors with microcontrollers such as Arduino, ESP32, or Raspberry Pi. These devices can communicate with cloud platforms to provide real-time alerts and remote monitoring for farmers.

### 2. Animal Intrusion Detection Systems

Animal intrusion into agricultural land is a significant issue that can threaten food production and farmer livelihoods. Researchers have proposed automated systems that detect animal movement using sensors such as PIR motion sensors, cameras, and thermal sensors. Once the system detects an animal, it sends alerts to farmers through mobile notifications or messaging systems. These early warning systems allow farmers to take immediate action to protect crops.

Recent studies also incorporate image processing and object detection techniques to identify specific animals and reduce false alarms caused by environmental movements.

### 3. IoT-Based Crop Protection Systems

Several IoT-based systems have been developed to protect crops from wild animals. These systems typically use motion sensors, cameras, and communication modules to detect animal presence and trigger deterrent mechanisms such as alarms or flashing lights. When an animal enters the field, the system automatically activates the deterrent and sends notifications to the farmer's mobile device for real-time monitoring.

Such automated systems reduce the need for continuous human monitoring and provide cost-effective solutions for crop protection.

### 4. AI-Based Animal Detection in Agriculture

Artificial intelligence and machine learning techniques are increasingly being used to improve the accuracy of animal detection systems. Deep learning models such as YOLO and convolutional neural networks (CNN) can identify different animal species in real time using camera images. These models help reduce false detections and improve system reliability. For example, AI-based farm surveillance systems have been developed to monitor agricultural fields and detect wildlife intrusion automatically.

By integrating AI with IoT devices, farmers can receive accurate alerts and automated responses when animals approach their fields.

### 5. Automated Deterrent Mechanisms

To prevent animals from damaging crops, researchers have explored various automated deterrent mechanisms. These include ultrasonic sound emitters, flashing lights, and alarm systems that activate when an animal is detected near the field. Such deterrent systems are designed to scare animals away without harming them. Studies have shown that combining multiple deterrent techniques increases the effectiveness of crop protection systems.

Wireless sensor networks and IoT communication technologies are also used to transmit alerts and control deterrent devices remotely.

### 6. Energy-Efficient and Edge-Based Systems

Energy efficiency is an important factor in agricultural IoT systems because farms are often located in remote areas with limited power supply. Researchers have proposed low-power sensor networks and edge computing solutions that process data locally to reduce communication delays and energy consumption. Fog computing and edge-based architectures help detect animal intrusion quickly while minimizing network bandwidth usage. These systems improve reliability and enable real-time responses to wildlife intrusion.

## 3.SYSTEM ANALYSIS

### 3.1. EXISTING SYSTEM

In traditional agricultural fields, farmers use **manual and mechanical methods** to protect crops from animal intrusion. These methods mainly include physical fencing, scarecrows, human monitoring, and sound-producing devices. In some modern approaches, basic electronic sensors such as motion sensors or infrared sensors are used to detect movement around the field. However, these systems have several limitations. Manual monitoring requires continuous human presence and is not practical during night hours or in large farming areas. Traditional scare devices like scarecrows and noise makers lose effectiveness over time as animals become accustomed to them. Basic sensor-based systems can detect motion but cannot accurately identify whether the object is an animal, human, or environmental movement such as wind or falling leaves. Additionally, many existing systems do not

provide **real-time alerts or remote monitoring** capabilities. Farmers may not receive immediate notifications when animals enter the field, which can result in delayed response and crop damage. These systems also lack intelligent decision-making features and visual confirmation of the intrusion.

### 3.1.1 Limitations of Existing System

- Requires manual monitoring by farmers
- High chances of false detection using simple sensors
- No visual confirmation of animals
- Limited automation and remote monitoring
- Ineffective during nighttime or large-area farms

## 3.2 PROPOSED SYSTEM

The proposed system is a **Smart IoT-Based Crop Protection System** designed to automatically detect animal intrusion using an **ESP32 microcontroller integrated with a web camera module**. The system uses computer vision and IoT technology to monitor agricultural fields in real time and alert farmers when animals are detected.

In this system, the **ESP32 camera module continuously monitors the surrounding area** of the farm. When motion is detected, the camera captures images or video frames of the environment. These images are analyzed to determine whether an animal is present in the field. If an animal intrusion is detected, the system triggers a **buzzer or alarm sound** to scare the animal away from the crops.

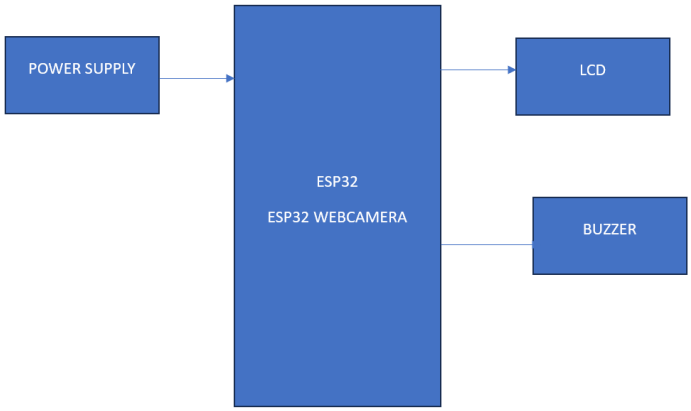
At the same time, the system sends **real-time alerts to the farmer through an IoT platform or mobile application**. The farmer can remotely monitor the field using live images or video captured by the ESP32 camera. This allows quick response and helps prevent crop damage.

The proposed system is **low-cost, energy efficient, and suitable for rural farming environments**. It reduces the need for continuous human supervision while improving the effectiveness of crop protection.

### 3.2.1.Advantages of Proposed System

- Automatic animal detection using ESP32 camera
- Real-time monitoring of agricultural fields
- Instant alert notifications to farmers
- Reduced crop damage from wild animals
- Cost-effective and easy to implement
- Suitable for smart agriculture applications

## 4.IMPLEMENTATION




### 4.1. WORKING

**1. System Overview**

The **IoT-based Crop Protection System** is designed to protect agricultural fields from wild animals such as **monkeys, wild boars, elephants, and deer**. The system uses an **ESP32 microcontroller with an integrated camera (ESP32-CAM)** to monitor the field continuously.

When an animal enters the monitored area, the **camera captures images and uses an AI-based animal detection model** to identify the presence of animals. If an animal is detected, the system activates a **buzzer or alarm** to scare the animal away and can also send a **notification to the farmer through IoT connectivity**.

**2. Main Components**

- **ESP32 Microcontroller** – Main controller for processing and communication
- **ESP32-CAM Module** – Captures images for animal detection
- **Buzzer / Alarm** – Produces loud sound to scare animals
- **Wi-Fi Module (built into ESP32)** – Sends alerts through IoT platform
- **Power Supply / Battery / Solar Panel** – Provides power to the system
- **IoT Cloud Platform (Blynk / ThingSpeak / Firebase)** – Sends alerts to farmers
- **Relay Module (optional)** – Controls additional deterrents like lights or sirens

**3. Working Principle**

**Step 1: Field Monitoring**

- The **ESP32-CAM module** is installed at the edge of the farm field.
- The camera continuously **captures images or video frames** of the surrounding area.
- These images are used to monitor animal movement near crops.

**Step 2: Image Processing and Animal Detection**

- The captured images are processed using an **AI-based object detection model** (such as TensorFlow Lite or YOLO).
- The model identifies objects in the frame and checks whether the object is a **wild animal**.

**Step 3: Animal Identification**

- The AI algorithm analyzes features such as:
  - Shape and body structure
  - Movement patterns
  - Size of the object
- If the detected object matches the **animal category**, the system confirms the presence of a wild animal.

**Step 4: Alert Generation**

- Once the animal is detected:
  - The **ESP32 activates a buzzer or alarm**.
  - The loud sound helps **scare the animal away from the field**.

**Step 5: IoT Notification**

- The ESP32 sends a **real-time alert through Wi-Fi** to the IoT cloud platform.
- The farmer receives:
  - **Mobile notification**
  - **Image of the detected animal**
  - **Time and location of detection**

**Step 6: Continuous Monitoring**

- After the animal leaves the field, the system returns to **monitoring mode**.

- The process repeats continuously to ensure **24/7 crop protection**.

**4. System Workflow**

1. ESP32-CAM continuously monitors the crop field.
2. Camera captures images or video frames.
3. AI model processes images to detect animals.
4. If an animal is detected → buzzer activates.
5. Alert notification is sent to the farmer through IoT platform.
6. System continues monitoring the field.

**5. Advantages**

- Prevents crop damage from wild animals
- Real-time monitoring of agricultural fields
- Automatic animal detection using AI
- Immediate alert to farmers
- Low-cost IoT-based protection system
- Can operate using solar power in remote areas

**6. Applications**

- Smart agriculture farms
- Wildlife-prone agricultural areas
- Remote crop monitoring systems
- Forest border farming areas
- Automated farm security systems

**CONCLUSIONS** In this paper, we presented an integrative approach in the field of Internet of Things for smart Agriculture based on low power devices and open source systems. The goal of this work is to provide a repelling and monitoring system for crop protection against animal attacks and weather conditions. In our future work, we will extend the current functionalities of our system and investigate the chance of incorporating the features of our system to other sectors.

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