Smart Laser Repellent Technology for Sustainable Farming

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***Abstract*— Agriculture plays a major role in the Indian economy, but crop damage caused by birds and wild animals is a serious problem for farmers. Traditional methods such as scarecrows, fencing, and manual monitoring are not fully effective and require continuous human effort. This paper presents a Smart Laser Repellent Technology for Sustainable Farming using Artificial Intelligence, IoT, and renewable energy. The proposed system uses a webcam and a YOLOv8/TensorFlow-based object detection model to identify animals entering the farm area in real time. Once an animal is detected, the system activates a laser module and siren to scare away the intruder without causing any physical harm. An ESP32 microcontroller controls the servo motors, laser module, and siren system. The entire setup is powered using a solar panel, making it suitable for remote agricultural fields. The proposed system provides automated monitoring, real-time detection, reduced labor cost, and eco-friendly crop protection for smart farming applications. (*Abstract*)**

***Keywords*— Smart Farming, Laser Repellent, ESP32, YOLOv8, IoT, Animal Detection, Sustainable Agriculture.**

I. INTRODUCTION

Agriculture is one of the most important sectors contributing to the economy and food production. Farmers face major crop losses due to the intrusion of birds and animals such as monkeys, cows, peacocks, dogs, and wild animals. Traditional crop protection methods like fencing, scarecrows, noise makers, and manual guarding are often ineffective, labour-intensive, and expensive. Therefore, there is a need for an intelligent and automated crop protection system that can operate continuously without human supervision.

The proposed Smart Laser Repellent Technology for Sustainable Farming provides an efficient and non-lethal solution for protecting crops. The system combines Artificial Intelligence, Internet of Things (IoT), and renewable energy technologies to detect and repel intruding animals automatically. A webcam continuously captures video frames from the agricultural field, and the YOLOv8/TensorFlow model processes the frames to identify animals in real time. Once the animal is detected, the ESP32 microcontroller activates a laser module and siren system to scare away the intruder safely.

The project also uses servo motors for laser positioning and a solar-powered energy system for sustainable operation in remote farming areas. The proposed system reduces manual effort, minimizes crop damage, and supports modern smart farming techniques.

II. LITERATURE SURVEY

1. Srividya Nagaraj and S. Krishnamurthi (2025)
The authors developed a deep learning-based bird detection system for agricultural fields using image processing techniques. The system automatically detected birds and activated deterrent mechanisms to reduce crop damage. Our project implements AI-based intrusion detection and extends it using a laser-based non-lethal repellent system for sustainable farming.

2. Yu-Chieh Chen et al (2024)
The authors proposed a bird repellent system using deep learning and a rotating laser mechanism to scare birds away safely. The system achieved accurate bird detection and automatic laser control. Our project implements the laser repellent concept using embedded systems and servo motors for real-time crop protection.

3. K. Senthil Kumar and R. Prakash (2023)
The authors developed an IoT-based crop monitoring system using sensors to detect animal intrusion and send alerts to farmers. The system focused on remote monitoring and real-time notifications. Our project adopts sensor-based intrusion detection and adds automatic laser and siren activation for immediate response.

4. P. R. Babu and S. Manikandan (2022)
The authors designed an automated pest control system using image processing techniques to identify pests in agricultural fields. The system reduced manual effort and chemical pesticide usage. Our project implements automated image-based detection and replaces chemical control with a non-lethal laser repellent mechanism.

5. R. Iqbal and M. Hassan (2021)
The authors proposed a smart agriculture monitoring system using wireless sensor networks for real-time field monitoring and intrusion detection. The system improved monitoring efficiency through wireless communication. Our project adopts the sensor-based monitoring concept and integrates it with automatic laser repellent action.

6. Rakhmatulin I (2021)
The author developed a neural network-based pest detection and laser control system for agricultural applications. The system combined AI detection with automated laser mechanisms. Our project implements AI-based detection and

uses low-power lasers for safe animal repelling instead of pest elimination.

7. S. Patil and V. Deshpande (2020)
The authors developed a smart farming system using embedded systems and IoT technologies for agricultural automation. The system improved efficiency through automated monitoring and control. Our project applies embedded system automation for controlling sensors, servo motors, and laser modules for crop protection.

8. J. Park and H. Lee (2019)
The authors analyzed the effectiveness of low-power laser systems for bird control in agricultural fields. The study confirmed that lasers effectively repel birds without causing physical harm. Our project implements low-power laser repellent technology integrated with AI-based animal detection.

9. M. S. Rao and K. Reddy (2018)
The authors designed renewable energy-powered smart agricultural systems using solar energy and low-power components. The work focused on sustainability and energy efficiency. Our project adopts renewable energy concepts for supporting solar-powered intelligent crop protection systems.

10. L. Wang and Z. Zhang (2017)
The authors discussed vision-based object detection techniques for outdoor surveillance systems under varying environmental conditions. The research improved detection accuracy in real-world outdoor environments. Our project adopts these vision-based detection techniques for identifying animals and birds in agricultural fields.

III. OBJECTIVES

The main objectives of the proposed system are:

1. To develop an AI-based animal detection system for agricultural fields.
2. To provide automated crop protection using laser and siren deterrence.
3. To reduce manual monitoring and labor dependency.
4. To implement a non-harmful and eco-friendly animal repellent system.
5. To use solar energy for continuous and sustainable operation.
6. To improve farming productivity and crop safety.

IV. PROBLEM STATEMENT

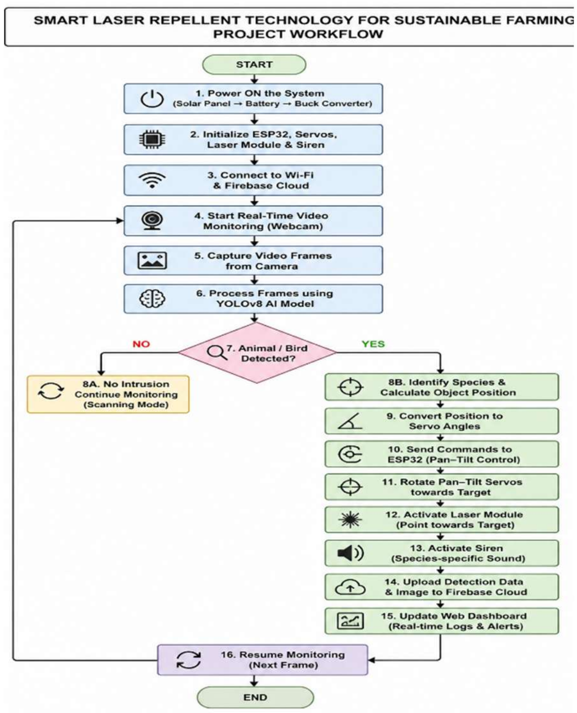
Existing System Problem Statement

Existing crop protection methods such as scarecrows, manual guarding, sound makers, and chemical repellents are ineffective and require continuous human effort. Animals and birds gradually become habituated to these methods, leading to crop damage and economic loss. Most systems also lack intelligent real-time detection and automatic response mechanisms.

Proposed System Problem Statement

The proposed system develops a Smart Laser Repellent Technology for Sustainable Farming using AI, IoT, and embedded systems. The system detects animals and birds in real time using image processing techniques and automatically activates a low-power laser and siren to repel intruders safely. The proposed system reduces manual effort, improves crop protection, and provides an eco-friendly and non-lethal solution for sustainable agriculture.

V. WORKING METHODOLOGY



The workflow of the **Smart Laser Repellent Technology for Sustainable Farming** describes the complete operation of the system from initialization to real-time animal detection and repellent activation. The system is designed to automatically monitor agricultural fields and protect crops from birds and animals using Artificial Intelligence, IoT, and laser technology.

Power ON the System

The system starts by receiving power from the solar panel and rechargeable battery setup. The buck converter regulates the voltage and provides stable power to the ESP32 microcontroller, servo motors, webcam, laser module, and siren system.

Initialize ESP32 and Components

After power is supplied, the ESP32 initializes all connected hardware components such as servo motors, laser module, siren, and communication modules. This step ensures that every device is ready for operation.

Connect to Wi-Fi and Firebase Cloud

The ESP32 connects to the Wi-Fi network and establishes communication with the Firebase cloud database. This enables real-time data transfer, monitoring, and remote access through the web dashboard.

Start Real-Time Video Monitoring

The webcam continuously monitors the agricultural field and captures live video streams. This allows the system to observe animal movement in real time.

Capture Video Frames

The live video stream is divided into multiple image frames. These frames are sent to the AI processing system for analysis and object detection.

Process Frames using YOLOv8 AI Model

The captured frames are processed using the YOLOv8 deep learning model. The model identifies animals or birds such as monkeys, cows, peacocks, dogs, or crows entering the field.

Animal or Bird Detection Decision

The system checks whether an animal or bird is detected.

- If no intrusion is detected, the system continues scanning and monitoring the field continuously.
- If an animal is detected, the system proceeds to the next stages for repellent activation.

No Intrusion – Continue Monitoring

When no animal is present, the system remains in monitoring mode and continuously scans the field for future intrusions.

Identify Species and Calculate Object Position

If an intruder is detected, the AI model identifies the species and calculates the exact position of the animal within the camera frame.

Convert Position to Servo Angles

The detected object coordinates are converted into pan and tilt angles required for the servo motors to align the laser accurately toward the target.

Send Commands to ESP32

The calculated servo angle data is transmitted to the ESP32 microcontroller for pan-tilt movement control.

Rotate Pan-Tilt Servos

The servo motors rotate the pan-tilt mechanism so that the laser module points directly toward the detected animal.

Activate Laser Module

The laser module is activated and directed toward the animal. The laser light acts as a non-harmful visual deterrent.

Activate Siren

The siren module produces sound to scare away the animal. Different sounds can be used depending on the detected species.

Upload Detection Data to Firebase

The system uploads detection details, images, timestamps, and intrusion information to the Firebase cloud database for storage and monitoring.

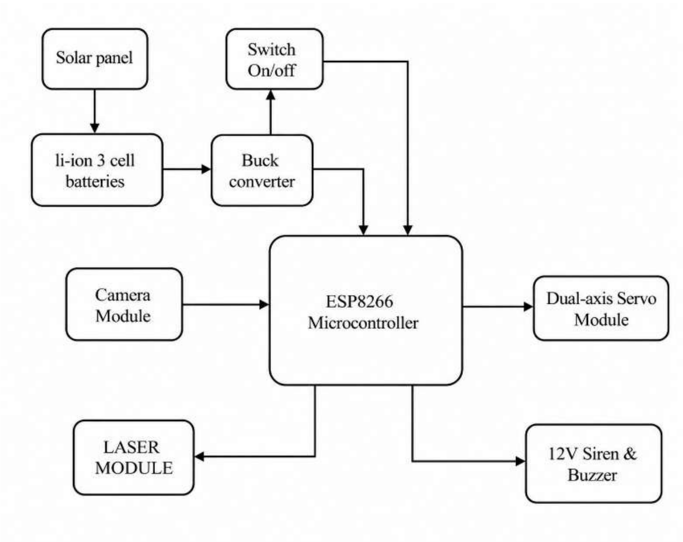
Update Web Dashboard

The web dashboard is updated with real-time logs, alerts, and monitoring information so that farmers can view field activity remotely.

Resume Monitoring

After the repellent action is completed, the system returns to monitoring mode and continues scanning the next video frames for new intrusions.

VI. BLOCK DIAGRAM



The Smart Laser Repellent System works to protect crops from animals and birds automatically. The solar panel provides power to charge the Li-ion battery, and the buck converter regulates the voltage for proper operation. The ESP8266 microcontroller is the main control unit of the system. The camera module detects animals or birds entering the field. Based on the detection, the microcontroller controls the dual-axis servo motor to move the laser module toward the target. At the same time, the 12V siren and buzzer are activated to create sound and scare away the animals. The switch is used to turn the system ON and OFF. This system helps in protecting crops without harming animals and supports sustainable farming.

VII. SYSTEM COMPONENTS

A. ESP32 Microcontroller

The ESP32 microcontroller acts as the main control unit of the system. It receives commands from the object detection system and controls the servo motors, laser module, and siren. The ESP32 also supports Wi-Fi communication, enabling IoT-based monitoring and control.

B. Webcam

A USB webcam is used to continuously capture live video from the agricultural field. The captured frames are processed using a deep learning model for animal detection.

C. Servo Motors

MG996R servo motors are used in a pan-tilt mechanism to rotate the laser module toward the detected animal position. The movement provides accurate targeting of intruders.

D. Laser Module

A 650nm Class-2 laser module is used as a non-lethal deterrent system. The laser light scares birds and animals without causing physical harm.

E. Siren Module

The 12V siren module produces sound-based deterrence to repel animals from the farming area.

F. Solar Power System

The system uses a 5W solar panel, rechargeable battery, and buck converter for sustainable energy supply. This enables continuous operation in remote agricultural locations.

VIII. ADVANTAGES

- Provides real-time animal detection and protection.
- Reduces crop damage effectively.
- Fully automated operation with minimal human intervention.
- Environment-friendly and non-harmful system.
- Uses renewable solar energy.
- Reduces labor cost for farmers.
- Suitable for smart farming applications.

IX. APPLICATIONS

- Agricultural farms
- Fruit gardens
- Vegetable cultivation fields
- Smart farming systems
- Bird control systems
- Wildlife intrusion prevention

X. Future scope

The Smart Laser Repellent System can be improved in the future by adding advanced technologies to make it more accurate and efficient. Artificial Intelligence and image processing can be enhanced to identify different animals more precisely and take suitable action based on the type of animal. IoT and mobile applications can be added for remote monitoring and control by farmers from anywhere. Real-time alerts through SMS or notifications can also be provided.

The system can be expanded by using multiple cameras and sensors to cover larger agricultural fields. GPS integration can help in tracking multiple devices placed in different farm locations. Better solar power management and stronger weather-resistant design can improve long-term outdoor performance. In the future, this system can also be connected with smart irrigation, soil monitoring, and crop health analysis to create a complete smart farming solution.

XI. CONCLUSION

The Smart Laser Repellent Technology for Sustainable Farming provides an effective solution for protecting crops from birds and wild animals. Traditional methods like scarecrows, noise makers, and chemical repellents are often less effective and may harm the environment. This system uses a smart and automated method to detect animals and repel them safely without causing physical harm.

The project uses components like camera module, ESP8266 microcontroller, laser module, servo motors, siren, and solar power system for continuous operation. When an animal is detected, the system activates the laser and siren to scare it away. This reduces crop damage, saves labor cost, and improves farm productivity.

Overall, the system is eco-friendly, cost-effective, and supports sustainable farming. It shows how IoT and embedded systems can be used in agriculture to help farmers and improve crop protection efficiently.

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