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## International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

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# AI-Assisted Ultrasonic Monkey Deterrent with Real-Time Monitoring

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**ABSTRACT:** Monkey intrusion is one of the biggest problems faced in agricultural and residential areas leading to crop destruction and a threat to human safety. An AI-assisted ultrasonic monkey deterrent system with real-time monitoring is described in this article. An ESP32-CAM module captures the images, and performs on-device classification using associated Edge Impulse-trained model. The presence of monkeys is identified through confidence scores, and an ultrasonic deterrent system is triggered without harming animals. For remote monitoring, detection data is collected in a cloud database. The system being proposed is low-cost, energy-efficient and lowers reliance on constant human supervision.

**KEYWORDS:** Edge AI, ESP32-CAM, Monkey Detection, Ultrasonic Deterrent, Real-Time Monitoring

## I. INTRODUCTION

It has become a big problem in villages and towns where, due to monkey encroachments, crops are destroyed, property is damaged and human lives are endangered. As case since urbanization is increasing and human-wildlife interface is expanding leads to enhance conflict incidences, so monitoring and control required. Regular methods to scare away monkeys including manual guarding, fright techniques and sound-based deterrents are generally ineffective, labor intensive and context dependant. These systems require human presence 24 hours a day, seven days a week and have no real-time monitoring or automated response. Some of these tried-and-true tactics can, in fact, be damaging to animals or the environment.

Recently, with the advancements in Artificial Intelligence (AI) and Embedded Systems; smart and automatic solutions have been designed for the real-time monitoring. Famous examples include edge AI, which allows embedded devices to execute machine learning models locally, performing computations at far higher speeds and lower latencies than any cloud dependency. Thus, makes it suitable for real-time applications at a low cost. In this study, we introduced a real-time monitoring AI-assisted ultrasonic monkey deterrent system. This particular setup used an ESP32-CAM module, and was able to capture images and classify them through a trained model on Edge Impulse. An ultrasonic device is triggered whenever the monkeys are detected in order to non-lethally deter them. To this end, it is networked with a cloud platform that keeps the data associated with these detections and allows remote monitoring. We proposed an immense way to eradicate animal human conflicts in the smarter and efficient manner possible by automated nature with minimum human interfacing that would lead towards less disturbance for a single being.

## II. LITERATURE REVIEW

Here we propose an AI-assisted monkey deterring system which automatically detects and repels monkeys from the agriculture and residential areas. This combines embedded systems, artificial intelligence, and IoT technologies for real-time monitoring and response [1]. However, some existing works on animal intruder detection have developed different techniques with building low-cost hardware based machine learning applications. These existing works have been further enhanced with improvements in efficiency, edge processing for reduced latency and activation of deterrents in real-time.



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The system is designed to maximize the benefits gained in previous implementations while limiting the drawbacks. Some of the main advantages for similar AI-based detection systems are:

- Low-cost hardware implementation using ESP32-CAM
- An on-device inference for processing image in real-time
- Easy for Cloud Platforms to integrate may be used to monitor
- Reduced dependency on manual intervention

But these systems also show some weaknesses:

- Embedded devices have limited processing power
- Lower accuracy than high-performance systems
- Sensitivity to external factors, for example lighting

Ultrasonic deterrent systems have also been applied a lot for avoiding animals and being non-invasive [2]. These systems output high-frequency sound waves that are unpleasant to animals, but are inaudible to humans. They offer an environmentally friendly solution to dangerous deterrent techniques and are easily translatable to natural situations.

Some of the advantages of ultrasonic deterrent systems include:

- Tested – Safe & Non-Harmful to Animals and Humans
- Cost-effective and easy to deploy
- Environmentally friendly solution

Nonetheless, these systems are accompanied by certain challenges :

- Limited effective range of operation
- Animals can acclimate themselves to ultrasonic frequencies.

In wildlife monitoring systems, IoT provides enhanced real-time detection and alert mechanism [3]. These IoT-based systems rely on cameras, sensors and cloud platforms to monitor environments and alert users when animals are identified. Such systems help with remote access and lessen the demand for ever-present human monitoring.

Benefits of IoT based systems are:

- Real-time monitoring and alert notifications
- Remote accessibility through cloud platforms
- Scalability for large deployment areas

However, these systems also come with some limitations:

- Dependence on stable internet connectivity
- Increased system cost due to extra parts

With recent developments in AI-based surveillance technology, various deep learning models have been applied for more accurate animal detection [4]. These systems use edge computing devices for classification tasks and the activation of automated responses like alarms or deterrents.

Pros of AI-based surveillance systems include:

- High detection accuracy
- Ability to classify multiple objects
- Automated decision-making capability

For these kinds of systems, you have challenges like:

- High computational and power requirements
- Increased hardware cost

Even with these limitations, AI, IoT and ultrasound technologies integrating provides a promising approach for animal intrusion detection in real time. A novel system has been proposed which combines all these technologies to



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accomplish a monkey deterrent that is ecologically sound, efficient and automated with minimal human effort and increased reliability.

### III. PROPOSED METHOD

#### Problem Statement

Monkey intrusions into fields and residential areas have resulted in crop damage, loss of property, safety concerns etc. Urbanization, deforestation and human occupied areas are expanding, with the natural habitat of monkeys shrinking in the process making them enter human populated lands for food & shelter. Such growing interactions between humans and wildlife have caused recurring conflicts that concern both livelihoods and public safety.

Current deterrence methods are predominantly manual, inefficient, and non-automated. Continuous human effort and resulting inconsistent results of manual guarding, scare tactics & noise-based methods are big challenges in avoiding unwanted visitors. Furthermore, these methods do not allow for real-time monitoring or intelligent decision making.

Hence, an intelligent automated and non-invasive system is required that will detect monkeys presence at real time and respond to the condition accordingly while remaining safe reliable and with no human intervention.

#### Objectives

- Build a smart monkey detector using ESP32-CAM module for capturing images and predicting whether it has monkeys or not.
- Develop an automated confidence score based decision-making criteria for monkey versus non-monkey classification.
- Create an ultrasonic deterrent system that automatically activates and repels monkeys without anaesthetic.
- Implement a cloud-based monitoring system using Firebase to save detection data and provide access from remote locations.
- Develop a fully automated cost-effective and efficient real-time monitoring solution with least human availability.

#### Architecture Diagram

**1. System Initialization:** When we give power to ESP32-CAM module, the system is up. The code to load the AI model trained with Edge Impulse on device and initialize the ultrasonic transmitter module. All components are prepared for real-time operation by the system.

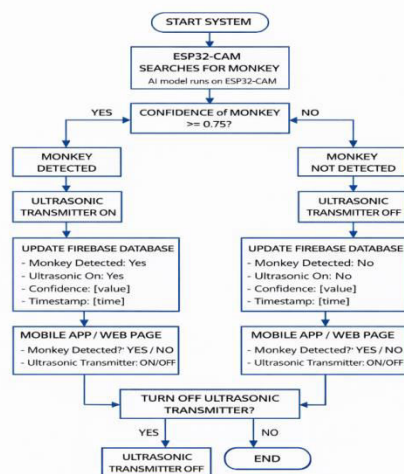


Fig.1. Architecture diagram



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2. **Wi-Fi Connectivity:** The ESP32-CAM is connected to a Wi-Fi network with a set username and password. This connection allows to developers communicate with Firebase Realtime Database for the purpose of saving and retrieving system data.
3. **Camera Activation and Image Capture:** After connection, it will constantly take Photos from the surroundings. The embedded AI model processes these images locally.
4. **AI-Based Image Classification:** Process the image through Edge Impulse model running on ESP32-CAM. The output from the model is two classes: monkey and no monkey, along with confidence scores.
5. **Decision Logic Implementation:** It then checks how confident it is in the monkey class. The system confirms the presence of a monkey if confidence is greater than or equal to all previously specified parameters, if not treated as no detection (e.g., 0.75).
6. **Ultrasonic Deterrent Activation:** The ESP32 uses PWM signals to turn on the ultrasonic transmitter when a monkey is detected. The transmitter transmits high-frequency sound waves that are unpleasant to monkeys, but harmless to humans and animals.
7. **Firestore Data Logging:** The Callable Cloud Function updates the Firestore Realtime Database with parameters like status of detection (monkey detected or not), confidence value, ultrasonic transmitter state (ON/OFF), and timestamp. This enables real-time monitoring.
8. **User Interface Monitoring and Control:** These store data are available via the web interface or mobile apps, to check the status of the system. Users may manually turn OFF the ultrasonic transmitter in case of a false trigger.
9. **Continuous Monitoring Loop:** The process of feeding the images to a CNN→CNN to classify the incoming images →a model decision using rules or an algorithm→response(e.g.,notifier) is repeated continuously, and hence real-time detection along with minimal human intervention phase where machine acts autonomously.

### IV. IMPLEMENTATION OF THE SYSTEM

#### Requirements for Software and Hardware

##### Software Requirements

**Edge Impulse:** The machine learning model for monkey detection was... That is, a dataset with images of monkeys both in the wild and non-monkey scenes are gathered and subsequently uploaded to Edge Impulse. Labeling the data into two classes, monkey and not a monkey.

Image preprocessing and feature extraction are performed using built-in DSP blocks after the labeling. These features are then used to train a classification model. To validate the performance of the trained model, calculating accuracy metrics and a confusion matrix.



Fig.2. Model Accuracy



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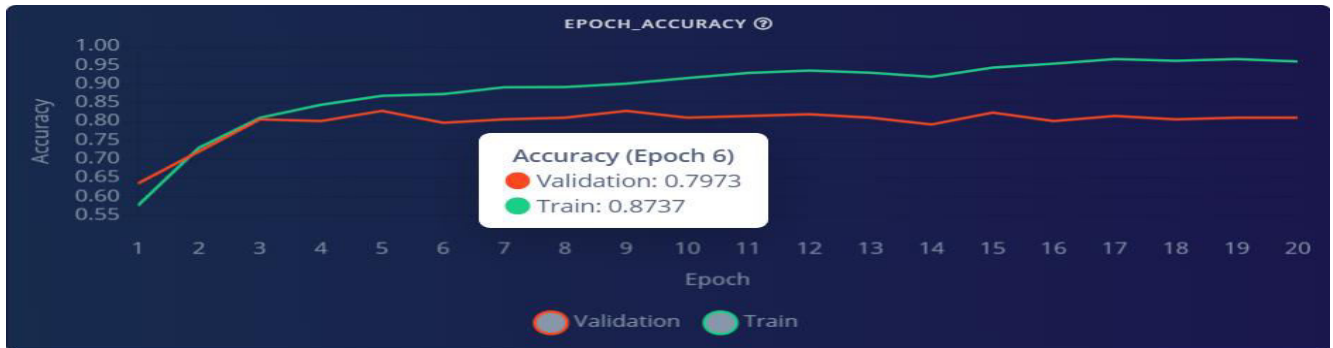


Fig.3. Training Graphs

When the model is satisfactory accurate, it is however optimized for embedded systems and exported as a C/C++ library. We will see real-time image classification in ESP32-CAM firmware without having to connect to the cloud, as this exported model is embedded in it.

The trained model achieved an overall classification accuracy of about 81%, with a high detection accuracy of roughly 91% for the *monkey* class, ensuring dependable real-time performance.

**Firestore Realtime Database:** Firestore is used for storing and monitoring system data in real time. The ESP32-CAM then proceeds to send the monkey detected status, confidence value (and ultrasonic transmitter ON/OFF) and timestamp to Firestore after each inference cycle during this project. The data is stored based on device path (for example `/device_1`), making it easy to access and constantly monitor the activity of the system. This guarantees a real time synchronization between the ESP32 and user interface whenever there is an update. Moreover, in case of a false detection, users can remotely monitor and control the system through Firestore by checking detection status or turning OFF the ultrasonic transmitter.

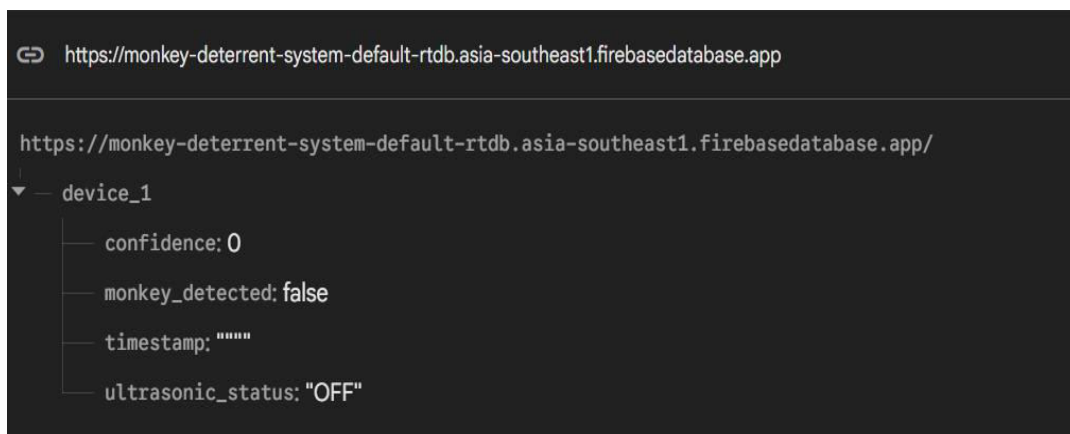


Fig.4. Firebase Realtime Database

**Arduino IDE:** The Arduino IDE is used to create, compile and upload the System code on ESP32-CAM Module. The entire system flow including image capture, AI inference, decision logic, ultrasonic control and communication with Firestore is implemented in Embedded C/C++. With the included Edge Impulse model, it allows the ESP32-CAM to analyze images it captures and output prediction results on-the-fly. From these results, the system then evaluates if its confidence value is greater than the predetermined threshold (0.75) to conclude monkey presence. If this condition is true then ultrasonic transmitter works (using the PWM signal), otherwise it shall remain OFF. Updated data is sent to Firestore after every cycle, and Serial Monitor displays prediction values, classification time and system status for debugging validation.



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### Hardware Requirements

#### 1. ESP32-CAM

The ESP32-CAM is the main processing unit of the system that captures real-time images from its surrounding environment. This processes the images locally with the Edge Impulse AI model and runs classification into monkey and no-monkey. It then makes a control action on the ultrasonic transmitter and stores values for monitoring in Firebase, as well based on prediction results.

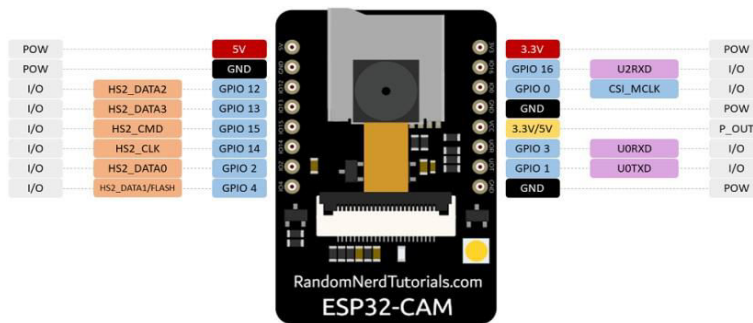


Fig.5. ESP32-CAM

#### 2. FTDI Converter

The USB to serial FTDI converter is used to upload the program code on the ESP32-CAM module. It allows serial communication between computer and ESP32-CAM over the TX and RX pins. While implementing, this is the one used to flash firmware and debug via serial monitor.

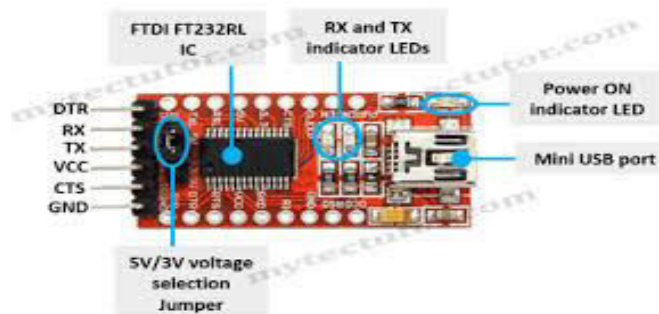


Fig6. FTDI Converter

#### 3. Ultrasonic Transmitter and TIP120 Darlington Transistor

Ultrasonic transmitter which produces high frequency sound waves is used when the monkey is detected. Since the transducer cannot be driven directly from the ESP32, a TIP120 Darlington transistor is used to amplify the PWM signal. It ensures that enough power is provided to the transmitter for it to function properly.



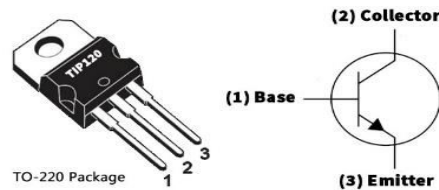
Fig.7. Ultrasonic Transmitter



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### TIP120 Pinout



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Fig.8. TIP120 Darlington Transistor

Table 1: Connections of ESP32-CAM, FTDI, Ultrasonic Transmitter and TIP120 Transistor

Component	ESP32-CAM Pin	Purpose
ESP32-CAM	5V	Power Supply
	GND	Ground
FTDI Converter	TX	RX (U0R) Communication
	RX	TX (U0T) Communication
	VCC	5V Supply
	GND	Common Ground
Ultrasonic Transmitter	Signal	PWM Output (GPIO 12)
	VCC	External Power
	GND	Ground
TIP120 Transistor	Base	Connected to GPIO 12
	Collector	Connected to Transmitter
	Emitter	Ground

### V. RESULT

The proposed system comprises a AI-based ultrasonic monkey repellent with the following capabilities: real-time detection, system respond and cloud monitoring. Several tests were carried out under different environmental conditions to ensure its practical viability. The trained model from Edge Impulse resulted in an overall accuracy of about 81%, and the detection output showed around 91% accuracy for the monkey class, indicating good real-time performance. Traditional sensor-based intrusion detection systems [3] can lead to false positives due to changes in the environment, while the image-based approach proposed here provides a higher reliability in terms of false triggering and yet maintains high accuracy.

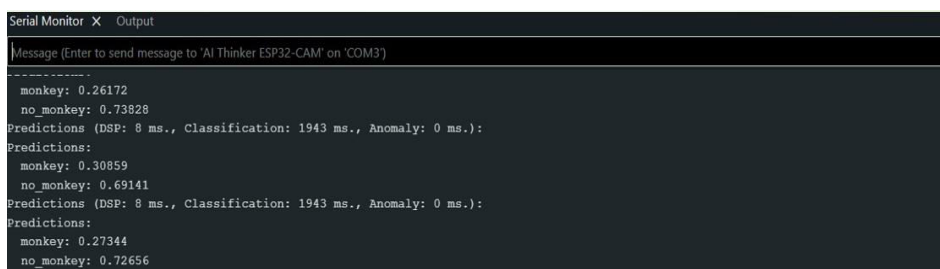


Fig.9a. Model Output when monkey is not detected



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```

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monkey: 0.83594
no_monkey: 0.16406
Predictions (DSP: 8 ms., Classification: 1943 ms., Anomaly: 0 ms.):
Predictions:
monkey: 0.81250
no_monkey: 0.18750
Predictions (DSP: 8 ms., Classification: 1943 ms., Anomaly: 0 ms.):
Predictions:
monkey: 0.69141
no_monkey: 0.30859

```

Fig 9b. Model Output when monkey is detected

As the serial monitor output shows class monkey and no monkey confidence. If this confidence value is above a certain threshold (0.75 in our case), the system accurately detects a monkey and triggers the ultrasonic deterrent. This inference time is acceptable for real-time operation and suggests efficient Edge AI deployment on ESP32-CAM compared to cloud-dependent models [4].

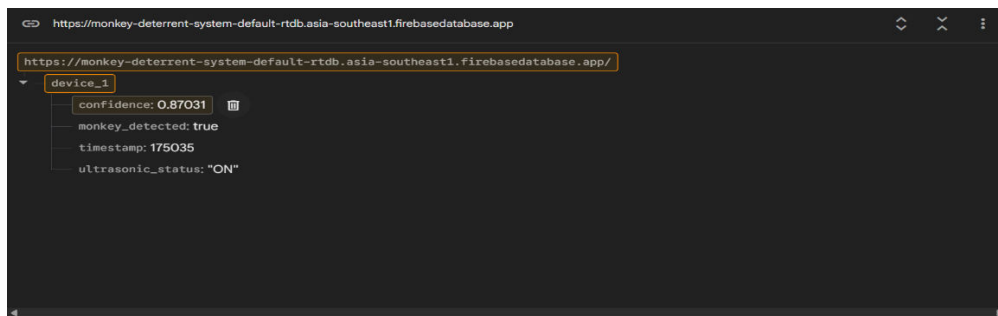


Fig.10. Firebase Data Monitoring When monkey is detected

An instance of Firebase Realtime Database,” that store real-time data like detection status, confidence value, ultrasonic status and timestamp. This allows ongoing monitoring and remote access to system activity. While systems that are not connected to cloud services [2] may be limited in this respect, our approach enhances accessibility allowing users to monitor and control the system.

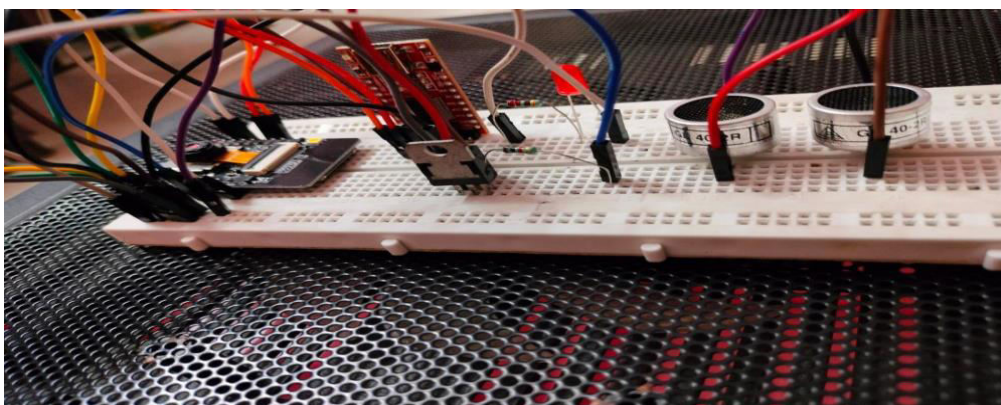


Fig.11. Hardware setup

Ultrasonic transmitter is then activated upon detecting a monkey and it emits high-frequency sound waves to prevent the animal. This effectively eliminates the need for a human response, increasing efficiency and reducing preventable incidents. The proposed system has a faster and more reliable action compared to the traditional manual deterrent methods [1].



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In summary, the results validate that the integration of Edge AI, ESP32-CAM and ultrasonic deterrent message offers a low-cost solution for monitoring monkey intrusion in real time. Compared to existing approaches, the system displays better accuracy, lower latency, and improved monitoring [1][3][4].

### VI. CONCLUSION

Our proposed system is an AI-assisted ultrasonic monkey deterrent that provides efficient and automatic detection of targeted intrusions and repels the invaders in real-time. Utilizing Edge AI with the ESP32-CAM allows for performing on-device image classification, allowing for faster response time and decreasing reliance on cloud processing. These Ultrasonic Plant Protection Pests Repeller is a Non-invasive and Eco-friendly animal repellent solution as it does not harm them.

Under various environmental conditions, the system exhibited reliable performance with acceptable detection accuracy and real-time response. The integration of Firebase not only improves the system, but also provides remote monitoring as well as data logging functionalities, allowing it to be practically deployed on both agricultural and residential fields.

The proposed system can be used to reduce human-wildlife conflict at low cost, energy-efficient and large scale. Future work may focus on increasing accuracy in low light conditions, extending the system functionality to detect multiple animals, and integrating inherent sensors of a fluorescent camera.

### REFERENCES

- [1] L. Arulmurugan, S. Pradeep, V.N. Raghav and S.P. Bharath Kumar, Animal Intrusion Detection Using ESP32-CAM and OpenCV, in International Journal of Innovative Science and Research Technology (IJISRT),(2023).
- [2] T. S. Delwar et al., Real-Time Farm Surveillance with YOLOv8 of Animals Intrusion Detection, Future Internet, (2025).
- [3] T. Manikandan and et al., IoT Based Animal Detection and Alert System for Farm Fields, in proceedings of IEEE Conference, (2024).
- [4] T. Mane, et al., Wild Animal Intrusion Detection System Using Raspberry Pi, in proceedings of the International Journal for Research in Applied Science and Engineering Technology (IJRASET), (2024).
- [5] J. Miao, et al., A Microservice-Based Smart Agriculture System for Animal Intrusion Detection, (2024).
- [6] N. Jain et al., Deep Learning-Based Animal Detection and Tracking System, in the proceedings of Journal of Engineering Science, (2024).
- [7] A. S. M. Hosen et al., "IoT-Based Object Detection System to Guard Agricultural Farms," in Proceedings of ResearchGate Publications, (2023).
- [8] T. S. Delwar, et al., IoT-Based Smart Farm with Animal Detection System, In ResearchGate Publications (2025).
- [9] S. Kumar, et al., AI-Driven Animal Intrusion Detection System for Agriculture Using IoT, in the proceedings of International Journal of Innovative Research in Technology (IJIRT), (2023).
- [10] L. M. Xin, Development of Machine Learning Wildlife Camera Using ESP32-CAM in Proceedings of Pertanika Journal Science & Technology, (2025).



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