Intelligent Motion based Animal Repulsion System for Agriculture

Ruban M.[1], Gokul Mani N.[2], Samynathan R.[3], Prabhakaran M.[4], Revathy M.[5]

Department of Electronics and Communication Engineering, PSNA College of Engineering and Technology, Dindigul, India.

Email: [1]rubanm1202@gmail.com, [2]gokulmaninl21@gmail.com, [3]samynathanr21ec@psnacet.edu.in, [4]prabhakaranm21ec@psnacet.edu.in, [5]revathim@psnacet.edu.in

Abstract

The protection of crops from birds and animals is a significant concern for farmers worldwide. Birds and animals such as crows, sparrows, goats, and cows often cause substantial damage to crops, leading to financial losses and reduced yields. Traditional methods of crop protection, such as scarecrows or chemical repellents, have limitations in their effectiveness and sustainability. This research has developed a prototype designed for the detection and repulsion of birds and animals within agricultural environments. The prototype features a motion detection system and an object detection model, which activates a repellent that generates a certain frequency to disturb the birds and animals. This prototype consists of PIR sensors as detectors to detect movement and a camera to capture real-time footage for object detection. If and only if the detected object is a bird or an animal, a signal is sent to the Arduino. The Arduino then determines the respective frequency to be played through a frequency-generating system. The intrusion will be repelled by the emitted ultrasonic waves.

Keywords: PIR Sensor, Camera, Object Detection Model, Arduino, Frequency.

1. Introduction

The age-old challenge of protecting crops from the depredations of birds and animals has plagued farmers for centuries. Traditional methods, ranging from scarecrows and netting to chemical repellents, often prove inadequate, offering limited effectiveness and sometimes posing environmental risks. However, the advent of the Internet of Things (IoT) has ushered

DOI: https://doi.org/10.36548/jaicn.2025.2.006
Received: 19.05.2025, received in revised form: 17.06.2025, accepted: 02.07.2025, published: 11.07.2025

in a new era of intelligent crop protection, offering a sustainable and efficient approach to minimizing losses and maximizing yields. A Smart Crop Protection System, powered by IoT technology, provides a comprehensive and adaptable solution to this persistent agricultural challenge.

At the heart of this system lies a network of interconnected sensors, strategically deployed across the farmland. These sensors act as the vigilant sentinels of the crops, constantly monitoring the environment and detecting the presence of potential threats. Different types of sensors can be integrated into the system, depending on the specific needs of the farm and the types of animals causing damage. Motion sensors can detect movement in the fields, triggering alerts when animals approach. Acoustic sensors can identify the specific sounds of birds or animals, allowing the system to differentiate between harmless wildlife and destructive pests. Sophisticated cameras, coupled with computer vision and machine learning algorithms, can identify specific species and even assess the level of threat they pose, enabling targeted responses. Environmental sensors can monitor factors like temperature, humidity, and light levels, which can influence animal reactions and inform the system's response strategies.

The system's response mechanisms are designed to be both effective and humane, deterring animals without causing them harm. These mechanisms can be tailored to the specific needs of the farm and the target animals. Auditory deterrents can emit sounds that are unpleasant to the target animals but harmless to humans and other wildlife

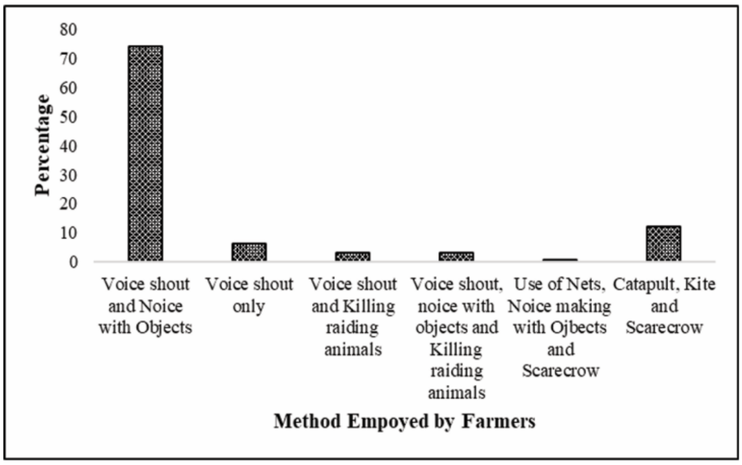

Figure 1. List of Traditional Techniques Used to Prevent Birds from Raiding Rice Farms.[15]

The Smart Crop Protection System represents a significant advancement in agricultural technology. By leveraging the power of IoT, this system offers a sustainable, efficient, and humane way to protect crops from the damaging effects of birds and animals. It not only benefits farmers by increasing yields and profitability but also contributes to a more sustainable and environmentally friendly approach to agriculture. As technology continues to evolve, we can expect even more sophisticated and effective IoT-based solutions to emerge, further revolutionizing the way we protect our crops and ensure food security for a growing population. Fig 1 shows the list of traditional techniques used to prevent birds from raiding rice farms.

2. Literature Review

Crop protection and smart agriculture have experienced significant growth with the integration of machine learning (ML), Internet of Things (IoT), and edge computing technologies. Marichamy et al. [1] explained ML-based approaches for crop protection against animal intrusion, referencing the requirement for data-driven models to improve accuracy and efficiency in the identification of hazards to crops. Similarly, Balakrishna et al. [4] suggested the complementarity of IoT and ML techniques to detect and prevent animal trespass and provided real-world applications that enhance real-time monitoring and response systems.

The Internet of Things (IoT) is a component of modern intelligent smart agricultural systems. Sahitya et al. [2] discussed smart crop security systems based on IoT, showing how networked sensors and appliances can provide rich environmental and security data. Yuliana et al. [3] focused on intelligent bird detection and repeller systems based on IoT, emphasizing real-life examples for reducing bird damage to crops in rice fields. The present work is also complemented by studies like Obaideen et al. [5], who offered a review of smart irrigation practices using IoT, emphasizing the applicability of IoT technology across agriculture to enhance the management of agricultural resources.

The increased importance of machine learning is also evident in crop yield prediction and disease detection. Hamim et al. [6] provided a comprehensive review of ML approaches for crop yield prediction, presenting fundamental trends and research challenges that future studies will follow. Sunil et al. [9] presented the utilization of deep models, including neural networks, aimed directly at crop protection against birds, demonstrating the effectiveness of advanced neural networks in image detection and pattern recognition. To validate this, Gohil et al. [10] conducted a comprehensive survey on the detection of plant diseases, outlining several ML and image processing methods for facilitating early diagnosis and treatment.

Reinforcement learning was employed creatively for crop protection as well. Lee et al. [7] proposed an anti-adaptive harmful bird repellent approach using reinforcement learning, learning and adapting strategies of repelling in conformity with the behavior of birds such that the system becomes more efficient over time. The same idea is adopted by Adami et al. [8], proposing a smart animal repellent system with embedded edge-AI that focuses on localized and low-latency AI processing in agricultural settings.

IoT deployment for ML extends to overall smart agriculture. Rezk et al. [12] illustrated an affordable IoT-based smart agriculture system powered by ML algorithms for environmental monitoring and predictive analytics. This overall concept is supported by Aiman et al. [13], who merged smart irrigation and plant disease diagnosis through image processing, displaying multi-faceted smart agriculture platforms.

The use of UAVs and advanced communication protocols for crop monitoring is also gaining popularity. Dineshkumar et al. [14] discussed genomics FANET recruitment protocols using UAVs in crop yield fields, with suggestions pointing toward advancements in aerial monitoring and data acquisition complementing ground-monitoring systems.

Lastly, the overall context of smart city technologies, including geo-information and data analysis for mobility, provides relevant insights to smart agricultural systems. Ang et al. [11] enumerated these emerging technologies and suggested that ML and IoT integration in urban infrastructures could result in improved agricultural solutions.

3. Methodology

The system proposed in this work is an automatic ultrasonic sound animal or bird detection and repelling system. Detection is carried out through two subsystems, namely, a detection module and a repellent module.

In Figure 2, the detection module consists of an object detection model and a PIR (Passive Infrared) sensor. The PIR sensor detects the movement of the bodies within the field it is directed at. When the sensor detects movement, the object detection model is triggered. The object detection model, which is based on a deep learning algorithm (YOLOv5), processes images from a camera attached to it to identify whether the detected motion is from an animal or bird with high precision.

This approach offers confident detection with minimal false alarms. The object detection model identifies the object, and upon verification of whether it is a bird or an animal, enables the repellent module.

The repellent module, also shown in Figure 2, uses an ultrasonic wave transmitter controlled by an oscillator circuit. Once the animal or bird is detected by the detection module, the oscillator circuit generates a specific ultrasonic frequency. It feeds the signal into the ultrasonic transmitter, generating high-frequency sound waves designed to repel animals and birds without harming them.

This method provides an automated, low-maintenance, and species-specific wildlife scare system for agricultural fields, gardens, and other similar environments.

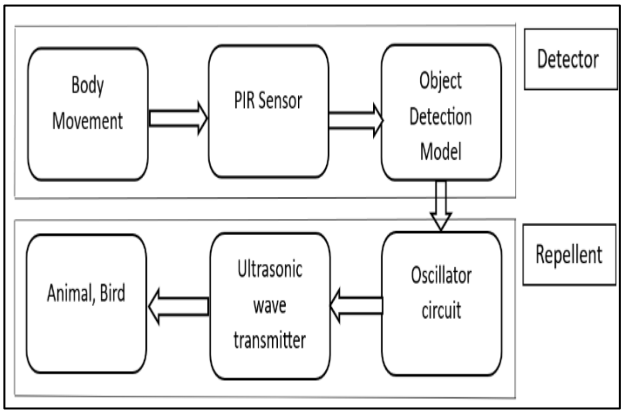

Figure 2. Block Diagram of the Detector and Repellent

The purpose of the prototype is illustrated with a simple flow chart diagram in Figure 3.

The steps are as follows:

Motion is sensed by the PIR sensor. The PIR sensor sends a signal to the Arduino microcontroller. The Arduino activates the camera mounted on a servo motor to capture images of the scene. The captured images are processed with the assistance of the YOLOv5 object detection model. When an animal or bird is detected by the Arduino, it triggers the frequency-generating circuit. The frequency-generating circuit produces two ultrasonic frequencies and transmits them using a speaker or an ultrasonic wave transmitter. The audio output serves as the repellent signal to drive away the animal or bird.

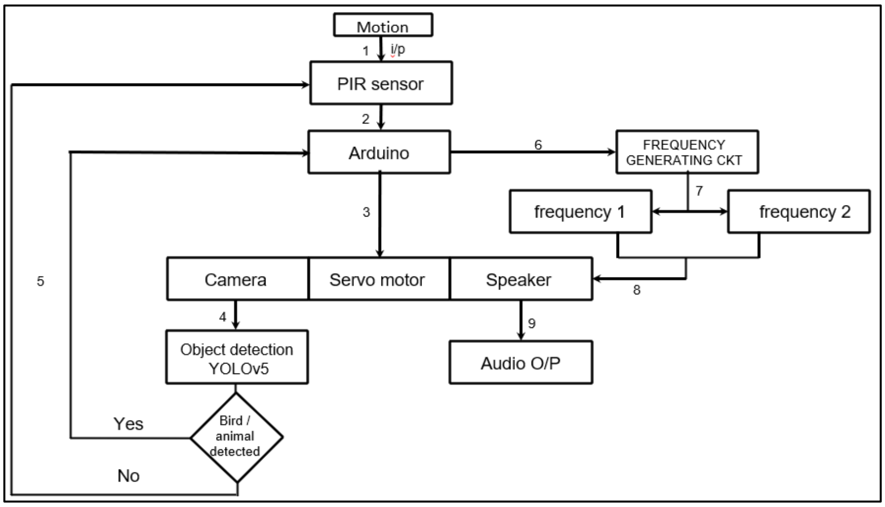

Figure 3. Flowchart of Prototype System

The servo motor integration with the camera facilitates quicker dynamic targeting to provide greater detection coverage. The use of YOLOv5 ensures accurate classification under fluctuating light and environmental settings. Ultrasonic frequencies can be programmed based on species-specific deterrent requirements.

Hardware Components: PIR sensor, Arduino board, camera, servo motor, frequency generator circuit, speaker/ultrasonic transmitter.

Software Components: YOLOv5 model for object detection in real time, Arduino IDE for microcontroller programming.

Power Supply: Designed to be powered by ordinary DC sources for field applications.

4. Requirements

4.1 PIR Sensor

Passive Infrared Detection: PIR sensors are the cornerstone of the system's ability to detect motion. A PIR sensor simply receives infrared radiation. Living beings, including birds and animals, emit heat in the form of infrared light. PIR sensors are tuned to detect changes in this infrared radiation, which occur when a warm body moves within their field of view. Fig 4 shows the block diagram of the PIR KC7783R.

Each PIR sensor offers a 180-degree detection arc. To achieve complete 360-degree surveillance of the target area, multiple PIR sensors are strategically positioned. Their placement is crucial for minimizing blind spots and ensuring comprehensive coverage. Factors like the size of the field, the typical movement patterns of the target pests, and potential obstructions are all considered when determining sensor placement. PIR sensors often come with adjustable sensitivity and range settings. This allows farmers to fine-tune the system to their specific needs. Sensitivity can be adjusted to minimize false triggers from small animals or excessive heat fluctuations. Range adjustment allows the system to focus on a specific area.

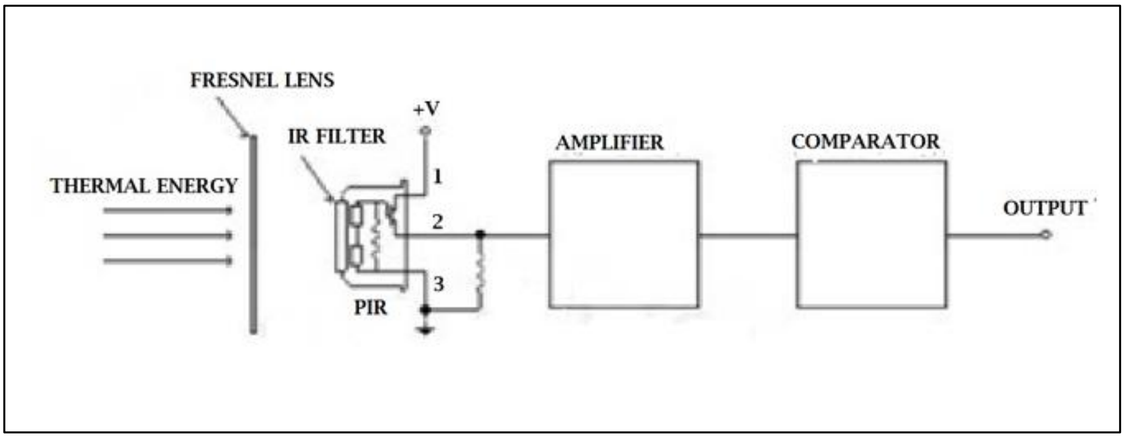

Figure 4. Block Diagram PIR KC7783R [16]

4.2 The Microcontroller

A Versatile Platform: The Arduino acts as the central processing unit of the system. It's a small, low-cost, yet powerful microcontroller that's easily programmable. The Arduino receives signals from the PIR sensors, processes this information, and makes decisions based on the preprogrammed logic. The Arduino's functionality is defined by the code written for it. This code dictates how the Arduino interprets the signals from the PIR sensors, when it activates the servo motor and the ultrasonic generator, and how it integrates the input from the object detection system. The flexibility of Arduino programming allows for customization and fine-tuning of the system's behavior.The Arduino is capable of processing information and making decisions in real-time. This is essential for a responsive pest control system. The Arduino reacts quickly to signals from the PIR sensors, ensuring that the deterrents are activated promptly when a potential threat is detected.

4.3. Servo Motor

The servo motor is responsible for the mechanical movement of the camera and, potentially, the ultrasonic emitter. Servo motors are known for their ability to provide precise angular positioning. The Arduino commands the servo motor to rotate to a specific angle, allowing the camera to be pointed directly at the source of the motion detected by the PIR sensors. The system is designed to track the movement of the detected animal. As the animal moves, the PIR sensors continue to send signals to the Arduino. The Arduino, in turn, adjusts the servo motor's position, ensuring that the camera (and potentially the ultrasonic emitter) remains focused on the target. The servo motor's movement is not solely based on the PIR sensor input; it also works in conjunction with the visual object detection system. Once the camera is pointed in the general direction of the motion, the object detection system takes over to fine-tune the targeting.

4.4 Camera

The camera provides real-time visual information about the scene. This video feed is crucial for the object detection system to identify and classify the objects present in the field. The camera's image quality and resolution are important factors in the effectiveness of the object detection system. Higher resolution images provide more detail, allowing the YOLOv5 model to identify and classify objects more accurately. The camera's field of view and focus are also critical considerations. The field of view should be wide enough to cover the area of interest, while the focus should be sharp enough to capture clear images of potential pests. Fig 5 shows the circuit diagram of the proposed model.

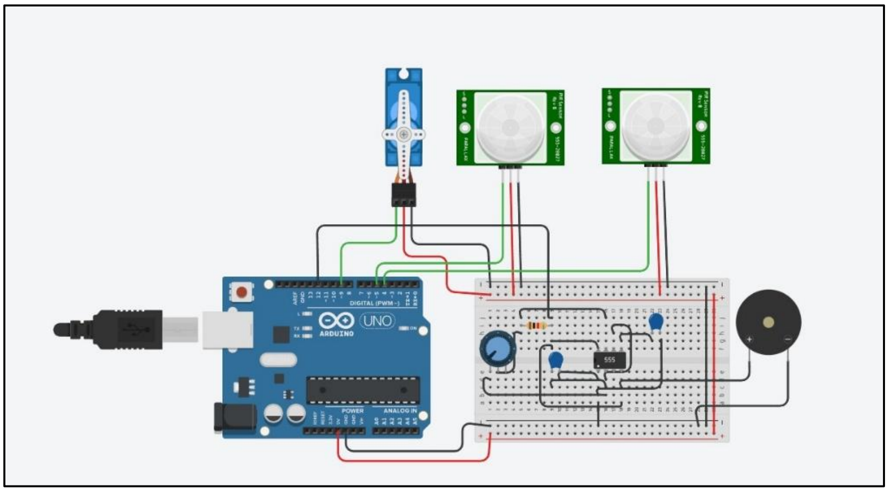

Figure 5. Circuit Diagram of the Proposed System

4.5 Artificial Intelligence for Object Detection

Initially, we considered YOLOv3, which was widely used in early smart farming projects. However, after evaluating our specific needs, such as real-time detection, small object accuracy, and lightweight performance, we found that YOLOv5 was a significantly better fit.

YOLOv5 (You Only Look Once version 5) uses artificial intelligence and deep learning to analyse images and videos, identifying and classifying objects within the frame. In this system, YOLOv5 is trained to recognize specific objects, namely birds and animals (with a particular emphasis on cows).

Table 1. Comparative Analysis of YOLO Models and Custom Implementation for Real-Time Wildlife Detection

Feature	YOLOv3	YOLOv5	Our Project Implementation
Accuracy	Moderate (Good at larger objects)	High (Better precision for small/partial objects)	Detects birds and animals more accurately
Speed	Slower on edge devices	Faster and optimized for real-time detection	Ensures quick detection in real-time field environment
Model Size	Large (Slower on low-power devices)	Lightweight and scalable (nano, small, medium, large versions)	Can run efficiently on Arduino-supported devices
Framework Support	Darknet (older)	PyCharm (modern & flexible)	Easier to integrate with modern tools and libraries

One of the key advantages of YOLOv5 is its speed. It can process images and videos in real-time, making it ideal for applications like this pest control system, where timely responses are essential. YOLOv5 is known for its high accuracy in object detection. It can reliably distinguish between different types of animals, minimizing false triggers. Its efficiency allows it to run on relatively low-power devices, making it suitable for integration into a system like this.

4.6 The Ultrasonic Deterrent

The IC 555 timer, configured as an astable multivibrator, is the heart of the ultrasonic frequency generation circuit. The 555 timer is a versatile integrated circuit that can be used to generate a variety of waveforms, including square waves. The frequency of the ultrasonic sound waves is determined by the values of the capacitors and the variable resistor connected to the 555 timer. The variable resistor allows for fine-tuning of the frequency. Ultrasonic transducer characteristics can influence the final frequency, and it might need some slight adjustments. A frequency counter is very helpful for precise tuning.

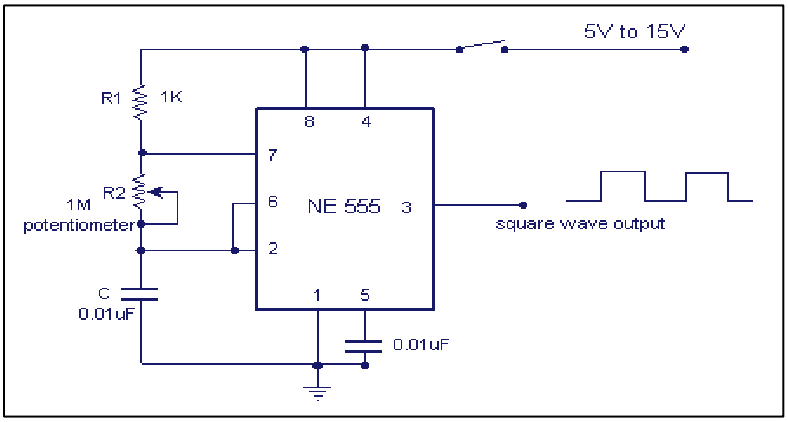

Figure 6. Variable Frequency Oscillator Circuit

4.7 Emitting the Sound Waves

The ultrasonic transducer is a device that converts the electrical signals generated by the 555 timer into ultrasonic sound waves. It acts like a tiny speaker that produces sounds at frequencies beyond the range of human hearing. Ultrasonic transducers often have some degree of directionality, meaning that the sound waves are emitted more strongly in one direction than others. This directionality can be utilized to focus the ultrasonic sound towards the target animals. The amplitude and intensity of the ultrasonic sound waves are important factors in their effectiveness. The amplitude determines the loudness of the sound, while the intensity measures the amount of energy carried by the sound waves. Fig 6 shows the Variable Frequency Oscillator Circuit.

4.8 System Integration and Control

The Arduino acts as the central coordinator, managing the flow of signals between all the different components. It receives input from the PIR sensors, processes the visual data from the camera via YOLOv5, and controls the servo motor and the ultrasonic generator.

The system requires a power source to operate. The Arduino, the servo motor, the camera, and the ultrasonic generator all have specific power requirements. The power management system ensures that each component receives the correct voltage and current. For outdoor deployment, the system needs to be housed in a weatherproof enclosure to protect the electronic components from the elements. The enclosure should be designed to allow the PIR sensors and the camera to function effectively.

5. Testing and Results

The efficacy of the Smart Crop Protection System was rigorously evaluated through a series of field tests conducted over a period of [Number] weeks at [Location/Farm Name]. The primary objective of these tests was to assess the system's ability to detect and deter target pests (birds and cows in this specific implementation) while minimizing false positives and ensuring the safety of non-target species.

5.1 Testing Methodology

The testing area encompassed a region where a history of crop damage from birds and cows had been observed. The system, comprising strategically placed PIR motion sensors, a camera unit, an Arduino microcontroller, a servo motor, an ultrasonic frequency generator, and an ultrasonic transducer, was deployed to cover the designated area.

The testing protocol involved:

Baseline Data Collection: Prior to system activation, baseline data on the frequency and extent of crop damage caused by birds and cows were collected through visual inspection and farmer reports. This provided a benchmark against which the system's performance could be measured.

System Activation and Monitoring: The Smart Crop Protection System was activated and operated continuously throughout the testing period.

Assessment of Crop Damage Reduction: Throughout the testing period, regular assessments of crop damage were conducted. This involved comparing the level of damage in the protected area with the baseline data and with control areas (if any) where the system was not deployed.

5.2 Result

Detection Accuracy: The PIR motion sensors effectively detected the presence of animals entering the protected area. The combined 360-degree coverage ensured minimal blind spots.

Table 2. PIR Testing Result

No	Distance (cm)	Motion Detectors
1	10	Responding
2	60	Responding
3	100	Responding
4	160	Responding
5	200	Responding
6	260	Responding
7	300	Responding
8	360	Responding
9	400	Responding
10	460	Responding
11	500	Responding
12	560	Not Responding
13	610	Not Responding
14	660	Not Responding

Table 2 represents the results of the tests performed to determine the response of the PIR sensor concerning a change in distance.

Table 3. Data Observations Birds' Response Against Changes to Frequency.

No.	Frequency (KHz)	Response
1	23.62	Not Responding
2	26.11	Not Responding
3	28.78	Responding
4	30.20	Responding
5	36.78	Responding

6	40.30	Responding
7	42.10	Responding
8	45.03	Responding
9	50.80	Responding
10	52.93	Responding
11	55.32	Not Responding
12	57.90	Not Responding

From the above data observation (Table 3), the frequency range from 28 KHz to 52 KHz can be used for repelling birds. This is within the ultrasonic range, meaning it's inaudible to humans but likely perceptible to many birds and animals. The specific frequency chosen might be based on research about the most effective frequencies for repelling the target.

Object Classification Accuracy: The YOLOv5 object detection model demonstrated a high degree of accuracy in distinguishing between birds, cows, and other non-target objects. The percentage of predictions is approximately 90% for birds and animals.

System Reliability: The system operated reliably throughout the testing period, with minimal downtime. The remote monitoring capabilities allowed for the prompt identification and resolution of any technical issues.

The figures below (Fig. 7 and Fig. 8) show the live detection of cows and birds by the YOLOv5 model.

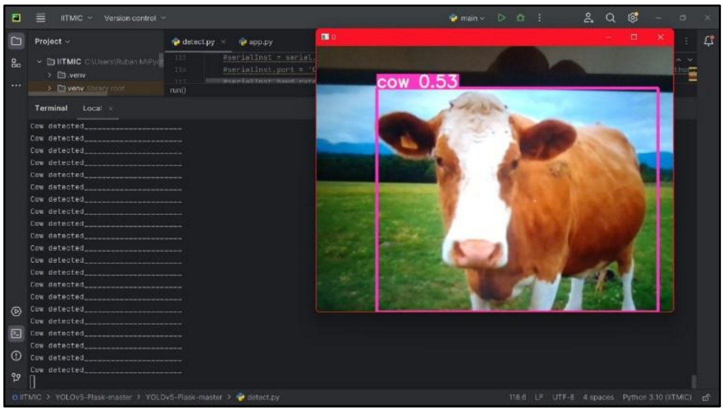

Figure 7. Detected Live Transition (Cow)

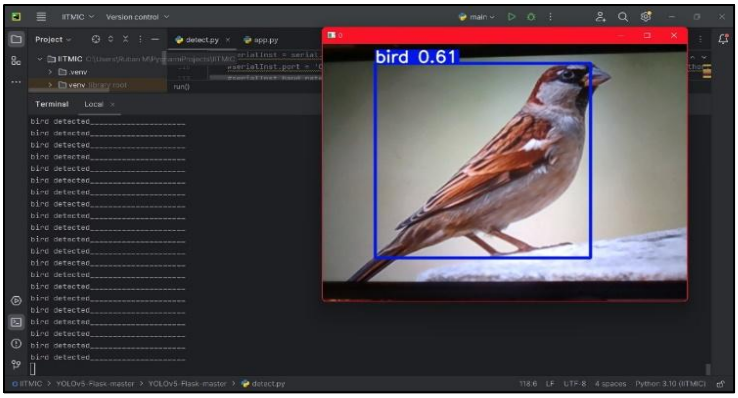

Figure 8. Detected Live Transition (Bird)

The figure also shows the output rendered on the Python console, which is logged and used to give an input signal to the Arduino.

6. Conclusion

The results of the field tests demonstrate the effectiveness of the Smart Crop Protection System in mitigating crop damage caused by birds and cows. The system's combination of motion detection, AI-powered object recognition, and targeted ultrasonic deterrence provides a robust and sustainable solution for farmers. The low false positive rate and the absence of any negative impact on non-target species further highlight the system's advantages. Future research could focus on optimizing the ultrasonic frequency for different pest species, integrating weather data to predict pest activity, or developing a more robust enclosure for extreme weather conditions. Overall, the Smart Crop Protection System offers a promising approach to safeguarding crops and enhancing agricultural productivity.

Finally, this prototype demonstrates the transformative potential of technology to address critical challenges in agriculture. The solution is that it not only protects crops from damage but also promotes a more sustainable and humane approach to farming. By minimizing losses and maximizing yields without harming birds and animals, this project paves the way for a future where agriculture and conservation go hand in hand, ensuring food security and environmental stewardship for all.

References

[1] Marichamy P, Karuppasamy P, Heera B, Leena Keresi R, Kanagalakshmi M, “Crop protection from animals based on machine learning”. E3S Web of Conferences 399, 04018 (2023).

[2] Sahitya, M. Siva, L. Vinay, Bindeshwar Prasad Sah, P. Srilatha, and BS Kiruthika Devi. "An Investigation on Smart Crop Protection System Utilizing Internet of Things." In 2022 8th International Conference on Signal Processing and Communication (ICSC), IEEE, 2022, 43-48.

[3] Yuliana, Mike, Ilyas Cahyaning Fitrah, and Moch Zen Samsono Hadi. "Intelligent bird detection and repeller system in rice field based on internet of things." In 2023 IEEE International Conference on Communication, Networks and Satellite (COMNETSAT), IEEE, 2023, 615-621.

[4] Balakrishna, Kempegowda, Fazil Mohammed, C. R. Ullas, C. M. Hema, and S. K. Sonakshi. "Application of IOT and machine learning in crop protection against animal intrusion." Global Transitions Proceedings 2, no. 2 (2021): 169-174.

[5] Obaideen, Khaled, Bashria AA Yousef, Maryam Nooman AlMallahi, Yong Chai Tan, Montaser Mahmoud, Hadi Jaber, and Mohamad Ramadan. "An overview of smart irrigation systems using IoT." Energy Nexus 7 (2022): 100124.

[6] Hamim, AM Asik Ifthaker, Abdul Mohaimin, Rashedul Arefin Ifty, and M. Jamshed Alam Patwary. "Advances in Machine Learning for Crop Yield Prediction: A Comprehensive Review of Techniques, Trends, and Challenges." In 2025 International Conference on Electrical, Computer and Communication Engineering (ECCE), IEEE, 2025, 1-6.

[7] Lee, Cheol Won, Azamjon Muminov, Myeong-Cheol Ko, Hyung-Jun Oh, Jun Dong Lee, Young-Ae Kwon, Deayoung Na, Sung-Phil Heo, and Heung Seok Jeon. "Anti-adaptive harmful birds repelling method based on reinforcement learning approach." IEEE Access 9 (2021): 60553-60563.

[8] Adami, Davide, Mike O. Ojo, and Stefano Giordano. "Design, development and evaluation of an intelligent animal repelling system for crop protection based on embedded edge-AI." IEEE Access 9 (2021): 132125-132139.

[9] Sunil, Devika, R. Arjun, Arjun Ashokan, Firdous Zakir, and Nithin Prince John. "Smart Crop Protection System from Birds Using Deep Learning." In Emerging Technologies in Data Mining and Information Security: Proceedings of IEMIS 2020, Volume 2, Springer Singapore, 2021, 621-632.

[10] Gohil, Mr Kathan, Amita Tailor, and Anjali Solanki. "A Comprehensive Survey on Plant Disesases Detection."

[11] Ang, Kenneth Li-Minn, Jasmine Kah Phooi Seng, Ericmoore Ngharamike, and Gerald K. Ijemaru. "Emerging technologies for smart cities' transportation: geo-information, data analytics and machine learning approaches." ISPRS International Journal of Geo-Information 11, no. 2 (2022): 85.

[12] Rezk, Nermeen Gamal, Ezz El-Din Hemdan, Abdel-Fattah Attia, Ayman El-Sayed, and Mohamed A. El-Rashidy. "An efficient IoT based smart farming system using machine learning algorithms." Multimedia Tools and Applications 80 (2021): 773-797.

[13] Aiman, Ayesha Rahman, D. P. Kushal Gowda, H. M. Manoj, and A. Monica. "Smart Irrigation with Plant Disease Detection Using Image Processing."

[14] R Dineshkumar, P Chinniah, S Jothimani, N Manikandan, A Manjunathan, M Dhanalakshmi. Genomics FANET Recruiting Protocol in Crop Yield Areas UAV. Annals of the Romanian Society for Cell Biology, 1515-1522 (2021).

[15] Wiafe, E. D. "An inventory of birds and extent of damage to rice farms at the Kpong Irrigation Dam in the Lower Volta Basin, Ghana." Ghana Journal of Agricultural Science 58, no. 1 (2023): 1-11.

[16] http://www.glolab.com/pirparts/infrared.html