IJETIR

ISSN (Online) 2583-0554

International Journal of Emerging Technologies and Innovative Research (IJETIR)

Volume 5, Issue 12, December 2025

Impact Factor: 5.731

The Real-Time Recognition of Objects and Alert Generation System for Automated Animal Intrusion Identification Using YOLOv5 and Deep Learning

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Abstract: *Identification of Animal Intrusions With the help of YOLOv5 (You Only Look Once version 5), a cutting-edge real-time object detection model, an advanced Animal Intrusion Detection System (AIDS) is intended to monitor and stop animal intrusions in a variety of settings, including homes, farms, wildlife reserves, and other sensitive areas. Since unwanted animal invasions can result in crop damage, livestock loss, and other financial losses for property owners, the system was created to provide a reliable, automated, and seamless method of protecting valuable assets. The ultimate objective is to combine computer vision and machine learning to develop a workable system that can quickly alert humans while simultaneously identifying, categorizing, and detecting animals in real time. This system can swiftly analyze video streams to identify animals and differentiate between different species thanks to the YOLOv5 model, which is renowned for its rapidity, accuracy, and effectiveness. This makes it possible to prevent incursions in a proactive manner. YOLOv5 ensures a fast and accurate detection system, lowering false alarms and boosting reliability..*

Keywords: real-time animal recognition, deep learning, automated safety systems, YOLOv5, and object identification

I. INTRODUCTION

The detection of animals intruding into private property or restricted areas has long been a major obstacle for a number of stakeholders, including farmers, wildlife reserve managers, and ecological observation agencies. Animal incursions may lead to a variety of harms, including crop destruction, livestock losses, and ecological disturbance, whether they occur on agricultural land or in protected wildlife areas. In order to preserve agricultural resources, protect animals, and manage environmental resources usually this issue must be resolved. Conventional animal detection techniques are becoming insufficient for large- scale, real-time operations as the need for effective monitoring systems grows.

Automated animal recognition is now possible thanks to recent developments in computer vision and machine learning. It is now possible to develop systems that can accurately identify and categorize objects in real time thanks to machine learning (ML). These technologies significantly improve the performance and efficacy of animal control techniques, reduce the need for manual monitoring, and enable quicker responses to invasions. For applications like animal intrusion detection, deep learning-based computer vision algorithms are ideal because they have demonstrated efficacy in recognizing and classifying objects in video streams. Machine learning models like YOLO, which stands for You Only Look Once, have proven particularly effective at identifying animals as they move across the image, which requires agility as well as precision.

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YOLOv5 is especially made to offer both high speed and precision, which makes it perfect for use in real- time monitoring systems where timely detection and minimal false alarms are critical.

The revised version forecasts the borders and likelihood of classes formed by splitting photos for every grid cell. This is essential for real-time surveillance of large areas as it enables rapid object detection. YOLOv5 can be modified to recognize specific animals based on their size, shape, and gait, extending its applicability to a variety of environments such as protected areas, farms, and nature reserves. Numerous animal species can be identified by it.

II. RELATED WORKS

To protect crops from unwanted animal incursions, Smart Crop Guard, an artificial intelligence-based tool, was developed. It uses deep learning and machine vision to identify people, birds, pets, and wild animals in real time through live video. With the help of IOT, even remote fields can be efficiently monitored. The system's Actual Time Collaboration and Switching Modes use internet-based and mobile models to teach the camera to identify animals. It eliminates the need for electric fences by instantly alerting farmers and turning on secure constraints like sound or ultrasonic devices when an animal is detected. In a range of testing scenarios, this approach has demonstrated encouraging outcomes in increasing crop safety while supporting peaceful coexistence with wildlife. [1]

Conflicts between humans and wildlife continue to threaten the environment, endanger farmers, and cause major financial losses—making it a serious challenge for sustainable farming. Traditional methods like electric fences, loud noises, or human patrols often fail, proving costly and sometimes even harmful to animals. This research presents a smarter alternative: an AI-based system that integrates deep learning and computer vision, IOT, and ultrasonic technology to detect and deter animals safely and effectively. Using YOLO v11 and Open CV, it analyzes live video to recognize threats and automatically triggers ultrasonic sound waves that gently scare animals away without harm. The system also monitors animal movement patterns and sends instant alerts through SMS, email, or mobile apps, offering farmers a more reliable, eco-friendly, and affordable way to protect their fields. [2]

Wild animals often wander into residential or agricultural areas, posing safety risks and causing property damage. This study aims to develop a machine learning framework that can automatically detect animals in surveillance footage and alert the concerned authorities. Using the YOLO (You Only Look Once) object detection algorithm, two approaches were explored—one focused on wildlife conservation and the other on detecting animal intrusions in human spaces. Both YOLOv5 and YOLOv8 models were tested, with YOLOv8 delivering higher accuracy at around 80%. These approaches highlight the potential of AI in improving animal monitoring, behavior analysis, and safety in both natural and human environments. [3]

Smarter detection systems are needed because human- animal conflicts, such as crop damage and urban disturbances, are becoming more frequent. This study improves detection accuracy by over 16% over conventional techniques by using a UWB-based wireless sensor network with CNN and SVM/Softmax classifiers to distinguish between humans and animals. [4]

Early and effective identification of animal invasions in farming regions is essential because they result in large crop losses and endanger farmers' safety. This study suggests employing deep learning model named YOLOv5 to identify four typical animal species involved in these incursions. It does this by obtaining crucial information from pictures using a strong CSP backbone. With a high detection accuracy of around 94% map, the system showed great promise as a dependable, cutting-edge approach to resolving human-animal conflict in agriculture. [5]

Rapidly identifying animal invasions is essential in today's agriculture to prevent crop loss. Unlike traditional systems, this study offers a clever alternative that use a Wireless Sensor Network (WSN) in conjunction with YOLOv5 models for deep learning that are created and operated on Google Co lab to precisely identify animals in real-time, enabling farmers to take quicker and more efficient action. [6]

As farmland continues to expand into wild areas, animal attacks on crops have become a major cause of declining agricultural productivity. Many Indian farmers face heavy losses from wildlife but can't afford constant surveillance, relying instead on outdated and ineffective methods. This study offers a cost-effective, machine learning-based solution that analyses farm images using the Watershed technique, extracts features with a 2D Gabor filter bank, and accurately

identifies animal intrusions with Support Vector Machines—helping farmers protect their crops without harming wildlife. [7]

This research presents an intelligent Animal Intrusion identification System that precisely detects animals entering farmland by utilizing the cutting-edge YOLOv8 object identification algorithm. It supports biodiversity, lessens confrontations between people and wildlife, and protects crops by providing farmers with real-time alerts. YOLOv8 is a useful instrument for both agriculture and animal conservation because of its high speed and precision, which guarantee effective and dependable monitoring. [9]

When wild animals invade farms or settlements in quest of food, it can lead to major issues, including agricultural damage, animal injuries, and occasionally even human danger. This idea provides a clever way to identify animals as soon as they come by using cameras and sound detection. By combining sound analysis with deep learning and image identification with YOLO, the technology quickly alerts local authorities so they can take action before any damage is done. [10]

As humans continue to expand into wildlife habitats, encounters with wild animals have become more frequent, often leading to damaged crops, safety risks, and strain on both people and animals. To help manage this, the study presents a smart system that uses a mix of YOLOv5 and CNN to detect when an animal enters a human area and accurately identify what kind of animal it is. Tested across various situations, the system shows a strong 92.5% accuracy, making it a promising tool to prevent conflicts and protect both communities and wildlife. [11]

Effectively detecting animal invasions is crucial to preventing damage from wild animals in sensitive locations such as farms and wildlife sanctuaries. Because these incursions are unpredictable, traditional techniques like manual monitoring or basic sensors frequently fail to meet the needs of the situation. The Fast R-CNN model, which is well known for its outstanding performance in object identification and classification, is used to process the video directly on the device. Across three primary datasets, Fast R-CNN consistently outperformed other models, such as YOLO and SSD, in terms of accuracy and reliability, making it a powerful tool for real-time animal detection in the field. [12]

This project presents a "Animal Intrusion Detection in Farms" system that is intended to notify farmers when animals enter their fields in response to the growing demand for improved farm security. The system recognizes and detects animals crossing limits by scanning real-time farm camera footage using Open CV and computer vision. It instantly provides alarms in the event of an intrusion, enabling farmers to take prompt action and safeguard their cattle and crops. This system provides a dependable, scalable method of improving farm safety with less human labor by automating surveillance and guaranteeing precise detection even in varying weather conditions. [13]

Intruding wild animals can seriously harm farms by causing crop loss, property damage, and safety hazards. This study introduces a clever Internet of Things system that detects and records animals entering the field using ultrasonic sensors and an E-vehicle with a camera that is controlled by a Node MCU microcontroller. Through a smartphone app, farmers receive real-time notifications that enable them to take prompt action, making the system a dependable and effective way to monitor and safeguard land. [14]

Farming is rapidly advancing, and there's a growing need for smarter tools that support both productivity and animal care. With its Automated Animal Detection and Monitoring System, Farm Guard offers a cutting-edge solution to enhance conventional farm management. By combining sensors, cameras, and AI-powered image processing, it monitors animal movement and behavior in real time without disturbing them. Using Arduino technology, the system sends early alerts about potential intrusions, helping farmers take quick action and prevent conflicts. [15]

III PROPOSED WORK

An acquisition of Input is: The system can receive still photos or continuous video streams from security cameras positioned throughout the field. The main source for real- time analysis is these inputs.

Data pre-processing: The YOLOv5 model requires a standard input dimension of 640 x 640 pixels, which is the fixed resolution at which every frame is resized. Normalizing the pixel intensities to a range of [0, 1] stabilizes and improves the convergence of the neural network.

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YOLOv5 uses a series of convolutional layers to automatically extract hierarchical features from input frames. These features allow the network to effectively find and identify a wide range of objects, from low-level edges and textures to high-level semantic representations.

Grid-Based Predictions for Object Identification: The YOLOv5 model divides each frame into a grid and then predicts bounding boxes, objectness scores, and class probabilities for each grid cell. This single-stage architecture ensures real-time performance while maintaining high detection.

Optimization by Class: The model is trained and optimized to identify specific object classes, such as people, cars, elephants, cows, birds, and dogs. Using unique datasets with domain-specific annotations, the model is improved for applications involving environmental and wildlife monitoring.

Suppression That Is Not Maximum After-Processing (NMS) To handle multiple detections of the same object, NMS eliminates superfluous overlapping bounding boxes. The box with the highest confidence score is retained to ensure accurate localization and classification.

Production and Categorization of Output The final output of the model includes predicted class labels, bounding boxes, and confidence scores for each detected object in a frame. These results are used to evaluate and classify potential intrusion events.

System for Instantaneous Warnings When the system detects a legitimate intrusion (e.g., such as the presence of unauthorized personnel or animals), it triggers automated alerts, such as SMS, phone calls, or local alarms, to facilitate prompt response and action.

Recording and Archiving of Data: For documentation and further analysis, the system stores relevant detection data in a centralized database, such as captured image frames, object labels, bounding box coordinates, timestamps, and confidence levels.

B. INTERGRATION OF WEB APPLICATION

Backend Web Development of a web application

Use Flask to create a backend that can handle image uploads without detection:

1. Install Flask via pip.
2. Develop protocols for uploading photos and processing identifications.
3. Load the YOLOv5 model into the backend code.

Front-end technology for web applications

• To create a user interface that is easy to use, utilize HTML and JavaScript:

Provide a space for users to upload images.

• After processing, dynamically display detection findings on the webpage.

Features of Integration

• SMS Alerts: When certain animals are identified, send notifications via APIs such as Twilio

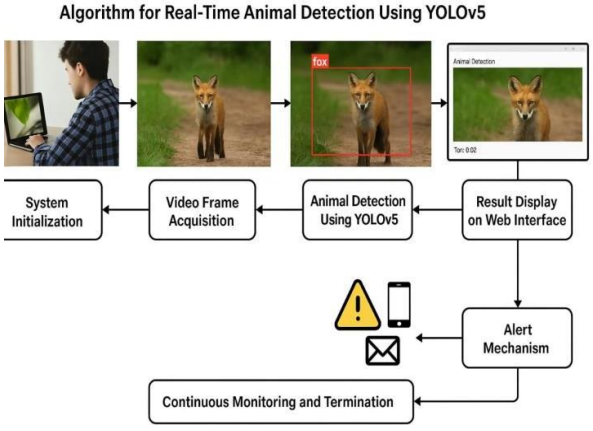

Fig. 1 shows the animal intrusion identification model design using YOLOv5.

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C. SYSTEM DESIGN

Data Collection

• COCO Dataset: contains pictures of different animals, such as dogs, cats, birds, etc., with labels.
• Open Images Dataset: Contains a wide range of labeled objects, including wildlife.
• Cagle: Offers numerous animal-focused datasets uploaded by the community.
Custom Image and Video Data
• Capture via Cameras: Use cameras in intrusion- prone areas to collect live feed data. Video frames can later be extracted for processing and annotation.
• Drones and Wildlife Cameras: Obtain footage from farms, forests, or other targeted environments.
The system uses YOLOv5, a cutting-edge object detection model, to spot animals in real time. Its main purpose is to quickly identify and classify animals entering restricted areas like farms, industrial sites, or residential properties, and then send immediate alerts to help prevent damage or danger.

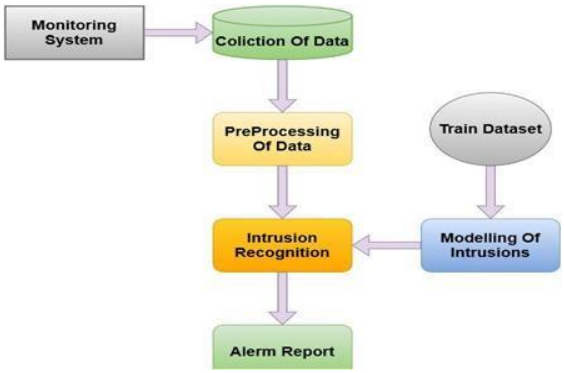

Fig. 2 The System Design of Animal intrusion detection using YOLOv5

IV. IMPLEMENTATION

Mathematical Representation of the Algorithm Let:
V = {Ft} A video stream as a series of frames Ft recorded at time t is represented by Tt=1
Dt=YOLOv5 (Ft): the detection result on frame Ft using the YOLOv5 model
Dt = {(Bi, Ci, Si)}Nt i=1: the set of detected objects in frame Ft
, where
Bi : bounding box for object i
Ci : class label (e.g., animal type)
Si : confidence score of detection
θ: confidence threshold for a valid detection
At = {(Bi, Ci, Si) ∈ Dt : Si ⩾ θ ∧ Ci ∈ A: set of valid animal detections at time t, where A is the set of predefined animal classes
Talert : minimum time interval between consecutive alerts Algorithm Steps :
1. Initialization:
t←1, start video stream V, initialize last alert time Tlast=−Talert
2. Frame Capture :
For each time step t, capture frame Ft
3. Object Detection:
Dt=YOLOv5(Ft)
4. Filter Animal Detections:
At = {(Bi, Ci, Si) ∈ Dt : Si ⩾ θ ∧ Ci ∈ A}

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5. Display:
Overlay Bi and Ci from At on Ft and stream to the web interface
6. Alert Trigger:
If At ≠∅ and (t −Tlast) ⩾ Talert :
Send alert notification Update Tlast ←t
7. Loop:
t←t+1, repeat until user stops the system

Test Case ID	Test Objective	Input	Expected Output	Actual Output	Test Pass/Fail
TC1	Detect an animal in an image	Image with a single dog	"Dog" detected with confidence	"Dog" detected	Pass
TC2	Detect multiple animals	Image containing a cow and deer	Both animals detected	Both animals detected	Pass
TC3	Detect animals in a video stream	10-sec video with animals	Animals detected frame by frame	Detected in 8/10 frames	Pass

Fig. 3 Functionality Test case

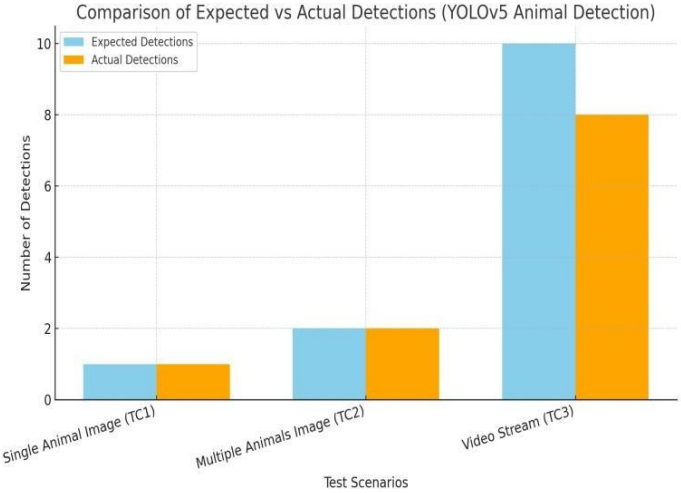

Fig. 4 graph comparing expected vs. actual detections for each test case in the YOLOv5-based Animal Intrusion Detection System

This bar chart visually represents the performance evaluation of our YOLOv5-powered animal detection model across three test scenarios:
TC1 – Single Animal Image: The system successfully detected a single dog in the image, matching the expected output exactly.
TC2 – Multiple Animals: In an image containing both a cow and a deer, YOLOv5 detected both animals correctly, showing strong multi-object detection capabilities.
TC3 – Real-Time Video Stream: Out of 10 frames in a 10- second video, the system successfully detected animals in 8 frames. This minimal fluctuation shows that real-time detection is still very successful, even though obscured features or motion blur may cause rare frame misses.

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V. RESULTS

YOLOv5-based animal detection mechanisms for intrusion usually produce the following outcomes:

1. Spotting Accuracy: excellent recall rates and precision in identifying things, including animals, in real-time situations. The algorithm uses confidence scores and bounding boxes to identify different animal species.
2. Inference performance: Because YOLOv5 optimizes performance, it is suitable for real-time applications. The detecting system is capable of processing pictures or video feeds with efficiency.
3. Illustration: Frequently, outputs consist of annotated photos or videos with labels, bounding boxes, and confidence percentages highlighting any animals that have been identified.
4. Alerts and Notifications: The system can be equipped with alert systems to inform users of incursions that have been detected, which is very helpful for protecting agriculture or animals.

Fig. 5 Animal Intrusion Detection Web Page

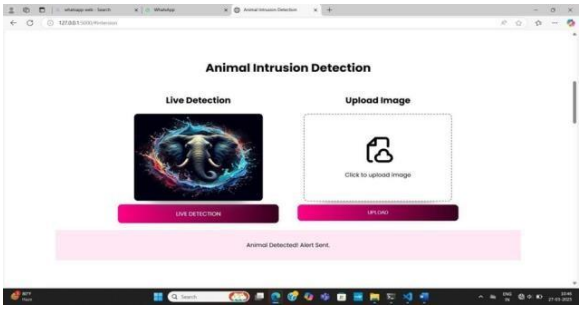

Fig. 6 Displaying Animal Detected Alert Sent

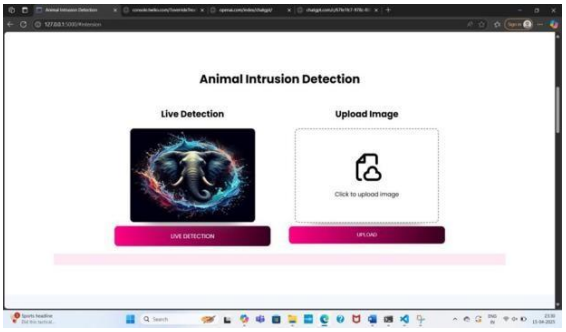

Fig. 7 Uploading an Animal image

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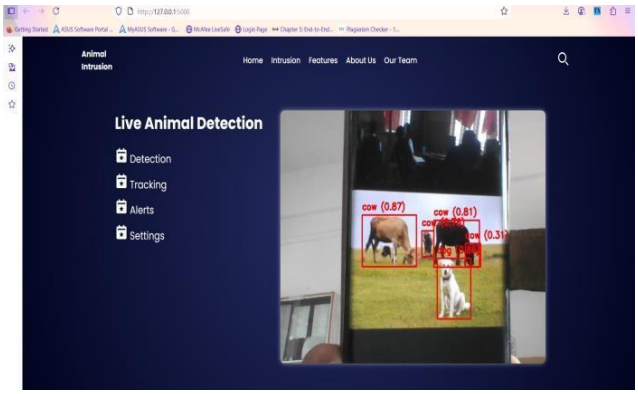

Fig. 8 Live Detected image

VI CONCLUSION

The YOLOv5-powered Animal Intrusion Detection System provides an automated, real-time solution for tracking and identifying animal invasions in a variety of settings, including wildlife conservation zones and agricultural fields. The technology reduces the need for human involvement and speeds up response times by identifying animals with high accuracy and efficiency by utilizing the YOLOv5 object detection algorithm. Through timely alerts and actionable insights, this technology reduces crop loss, improves farm security, and lessens human-animal conflicts. The system is a major breakthrough in intrusion detection, despite issues like high initial setup costs and internet dependence. It may find use in fields other than agriculture, such as urban security and biosphere reserve management.

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