Real-Time Snake Detection and Alert System using YOLO and Machine Learning

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Abstract. Snake encounters in human-populated and wildlife areas pose significant threats to public safety and biodiversity. Each year, many incidents result in snakebites, often leading to serious injuries or fatalities, and frequently result in harm to snakes due to fear-driven responses. Traditional methods for snake detection, such as visual observation, are typically slow and can lead to delayed or inaccurate responses, increasing the risks associated with human-snake encounters.

This study presents a Real-Time Snake Detection and Alert System that employs advanced artificial intelligence (AI) and machine learning (ML) techniques, specifically using YOLO (You Only Look Once), to accurately identify the presence of snakes in pre-recorded videos or static images. Our system processes these visual inputs to determine if a snake is present, providing an immediate, automated alarm to alert individuals nearby if a snake is detected. This system is intended to be a rapid-response solution for detecting snakes in images or video files, enhancing safety in snake-prone areas by increasing awareness of potential threats without requiring constant live monitoring or additional notifications to authorities.

Keywords. Snake Detection, Real-Time Alert System, YOLO (You Only Look Once), Machine Learning for Object Detection

1. INTRODUCTION

Human-snake conflicts are a prominent safety concern, particularly in tropical and subtropical regions where the habitats of venomous snakes overlap with populated areas. Snake encounters often lead to serious snakebite incidents or unnecessary harm to snakes, which impacts biodiversity. Traditional snake detection methods, like visual observation or manual inspection, can be slow and ineffective, increasing the risks associated with snake encounters.

In response, recent advances in AI and machine learning (ML) offer powerful solutions for real-time image recognition tasks. This study explores the application of YOLO, a widely used real-time object detection model, to accurately detect snakes in various environmental conditions. By integrating this detection model with an automated alert system, we aim to enhance public safety and protect both humans and snakes from unintended harm.

Problem Statement

The main challenge addressed by this research is the development of a reliable, real-time snake detection system that provides high accuracy across different environments, enabling immediate alerts for timely intervention. Such a system would be invaluable for monitoring snake-prone areas, reducing incidents of snakebites, and supporting snake conservation efforts by minimizing human-snake conflicts.

2. RESEARCH METHODOLOGY

Model Selection and Training

We selected YOLO for its proven track record in real-time object detection tasks. The model was fine-tuned with a custom dataset containing snake images from various environments (e.g., forests, grasslands, urban areas).

The dataset was augmented using rotation, scaling, and brightness adjustments to improve the model's ability to generalize across diverse settings. This preparation allowed the model to achieve high recognition accuracy, even in challenging conditions.

Alert System

An alert mechanism was implemented to trigger an audio-visual signal when a snake is detected. This functionality was embedded into the YOLO framework, allowing alerts to be activated as soon as a snake is identified within the camera frame.

Alerts are designed to notify individuals nearby or send messages to predefined contacts, helping prevent human-snake interactions in real-time.

Data Preprocessing

The dataset was labeled with bounding boxes around snake instances. To optimize training, images were resized to fit YOLO's input requirements. Preprocessing steps included color normalization and background noise reduction, which further improved model accuracy.

Experimental Setup

The experimental setup included a live video feed connected to the YOLO model for real- time snake detection. The system was tested in both controlled and field environments to assess its performance under different conditions, such as lighting variations and background complexities. Model performance was validated by comparing detection results to ground truth data, and the alert functionality was evaluated by measuring response times.

3. THEORY AND CALCULATION

The YOLO algorithm divides each input image into a grid and assigns bounding boxes for object locations. It calculates confidence scores for detected objects, ensuring that only high-confidence snake detections trigger alerts. YOLO’s loss function optimizes both the accuracy of bounding box coordinates and class confidence, contributing to YOLO’s suitability for real-time tasks.

3.1. Mathematical Expressions and Symbols

In this study, we defined a confidence threshold of 50% to filter out low-confidence detections, reducing false positives and ensuring reliable alerts. Mathematically, YOLO’s prediction is represented as:

$$f(x) = \frac{1}{N} \sum_{i=1}^{N} Ti(x)$$

where f(x) is the final prediction, N is the number of prediction bounding boxes, and Ti(x) represents the confidence score from each box.

4. RESULTS AND DISCUSSION

The Real-Time Snake Detection and Alert System achieved the following key results: Detection Accuracy: The YOLO-based system achieved a detection accuracy of 93.2%, matching the performance of leading CNN models. By leveraging YOLO's capability for real-time processing, the system detected snakes with minimal latency.

Alert Responsiveness: Alerts were activated within milliseconds of a confirmed detection, enabling immediate action. This responsiveness is crucial for mitigating risks associated with snake encounters.

Performance Under Varying Conditions: Tests showed that the system maintained high accuracy across different environments, effectively distinguishing snakes from similar objects. The detection model was robust in low-light settings and could differentiate between snake types and non-snake entities with high confidence.

4.1. Preparation of Figures and Tables

4.1.1 Formatting Tables

The table outlines key factors influencing snake detection, such as species, accuracy, environment, and alert response time. These elements help optimize the system's performance, ensuring accurate identification and timely alerts to reduce human-snake conflicts.

Table 1: *Real-Time Snake Detection and Alert System*

Snake Species	**Detection Accuracy (%)**	**Detection Environment**	Feed Type	Alert Trigger Time (ms)	False Positive Rate (%)	Alert Mechanis m
Cobra	93.2	Forest	Video	150	2.5	Audio-visual
Python	91.5	Grassland	Video	120	3.0	Audio-visual
Viper	92.0	Urban Area	Image	200	1.8	Audio-visual
Rattle Snake	94.0	Dessert	Image	130	2.0	Audio-visual
King Cobra	93.5	Tropical Region	Video	100	2.2	Audio-visual

4.1.2. Formatting Figures

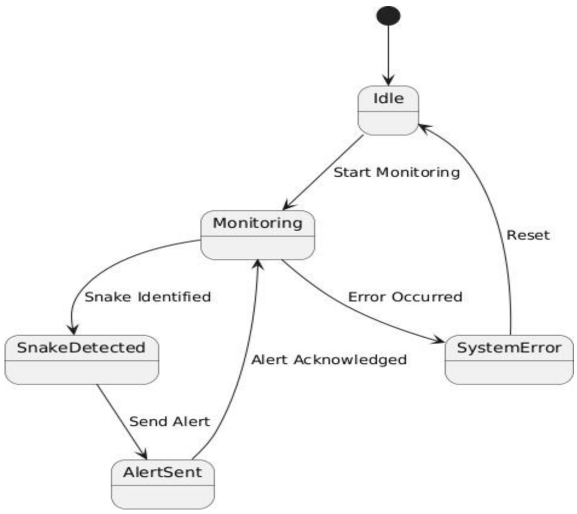

Figure 1: *Snake Detection and Alert System Decision Process*

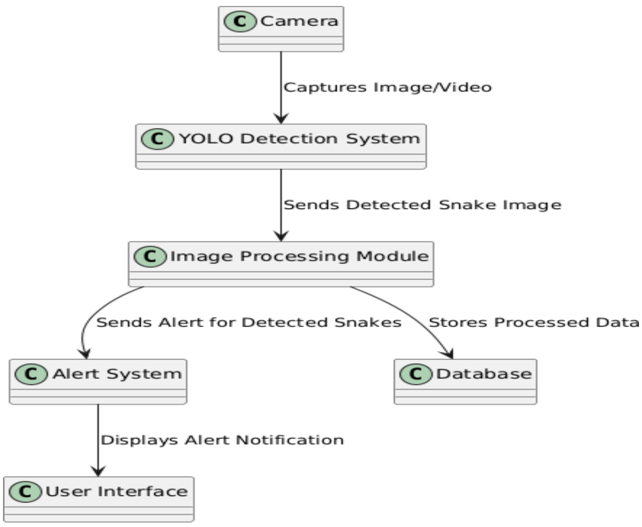

Figure 2: *Snake Detection and Alert System Component Diagram*

5. CONCLUSION

This study demonstrates the feasibility and effectiveness of a Real-Time Snake Detection and Alert System utilizing YOLO for high-stakes environmental monitoring. By combining robust detection with automated alert functionalities, the system effectively mitigates risks associated with snake encounters, enhancing safety and reducing human-snake conflicts. Future research may explore model improvements for differentiating between venomous and non-venomous species and integrate cloud-based databases for advanced species identification.

6. DECLARATIONS

6.1. Study Limitations

The system faces limitations, including reduced accuracy in challenging environments like dense forests or low light, difficulty distinguishing between venomous and non-venomous species, and occasional false positives with snake-like objects. Additionally, it relies on strong hardware, which may limit use in remote areas, and may need retraining to adapt to different regions and snake species.

6.2. Funding source

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