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# *Smart Wildlife Tracking System Using AI and IoT for Real-Time Species Monitoring*

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**Abstract**

Wildlife conservation faces increasing challenges due to habitat destruction, climate change, poaching, and human encroachment. Traditional wildlife tracking techniques such as direct observation, tagging, and radio telemetry are often intrusive, expensive, and limited in scalability. This paper presents a Smart Wildlife Tracking System using Artificial Intelligence (AI) and the Internet of Things (IoT) for real-time, non-intrusive species monitoring in remote forest environments.

The proposed system integrates a Raspberry Pi-based embedded platform with a Passive Infrared (PIR) sensor, camera module, GPS unit, and low-power wireless communication modules such as LoRa or GSM. A YOLOv5 deep learning model is employed for real-time wildlife species detection and classification from captured images. Upon detecting motion, the system captures images, identifies the species locally, records geolocation data, and transmits the information to a cloud-based platform for visualization and analysis.

The system is powered by solar energy, ensuring sustainability and long-term autonomous operation. The proposed solution reduces the need for physical tagging, minimizes human interference, and provides accurate, real-time wildlife data. This system can significantly aid biodiversity monitoring, migration analysis, anti-poaching surveillance, and ecological research, contributing to smarter and sustainable wildlife conservation efforts.

Keywords: Wildlife Tracking, Artificial Intelligence, IoT, YOLOv5, GPS, Smart Sensors, Conservation Technology

## 1. Introduction

Wildlife tracking plays a vital role in ecological research, biodiversity conservation, and environmental management. Understanding animal movement, behavior, and habitat utilization is essential for designing conservation strategies and mitigating human–wildlife conflicts. However, biodiversity loss due to urbanization, climate change, and illegal activities has intensified the need for efficient wildlife monitoring systems.

Conventional tracking methods such as manual observation, tagging, and radio telemetry are labor- intensive, geographically constrained, and may disturb animals' natural behavior. Although GPS collars have improved data accuracy, they are often expensive, power-hungry, and unsuitable for smaller species.

Recent advancements in Artificial Intelligence (AI) and Internet of Things (IoT) technologies offer promising alternatives. AI-based image processing enables automatic species identification, while IoT allows real-time data transmission from remote locations. Integrating these technologies with renewable energy sources such as solar power can enable long-term, autonomous wildlife monitoring systems.

This paper proposes a Smart Wildlife Tracking System using AI and IoT that is non-invasive, scalable, cost-effective, and environmentally sustainable.

## 2. Objectives

The main objectives of the proposed system are:

To design a smart, non-intrusive wildlife tracking system using AI and IoT.

To detect and classify wildlife species automatically using deep learning models. To record real-

time geolocation and time-stamped wildlife data.

To enable remote data transmission from forest and off-grid environments. To support

wildlife conservation, research, and anti-poaching initiatives.

## 3. Problem Statement

Despite technological advancements, existing wildlife tracking systems suffer from several limitations:

Continuous monitoring without human interference is difficult.

Most systems provide only location data without behavioral insights. Early

detection of abnormal behavior, stress, or threats is limited.

High power consumption and lack of connectivity restrict long-term deployment. Physical

tagging can cause stress or injury to animals.

Hence, there is a need for an intelligent, low-power, AI-enabled wildlife tracking system that operates autonomously in remote areas.

## 4. Literature Survey

Early wildlife tracking systems relied on VHF radio telemetry, which required manual tracking and had limited range. The introduction of GPS-based collars significantly improved accuracy and coverage. Hebblewhite et al. demonstrated the importance of GPS telemetry in ecological studies.

Recent studies focus on IoT-based tracking systems that integrate sensors and wireless communication protocols such as LoRaWAN and NB-IoT. Ju et al. explored wearable IoT devices for animal health monitoring. AI-based approaches using camera traps and deep learning models like YOLO have shown promising results in species identification and behavior analysis.

However, most existing solutions lack integration between AI, IoT, and sustainable power sources, highlighting the need for a unified system.

## 5. Proposed Methodology

### 5.1 System Architecture

The proposed system consists of the following components: Raspberry Pi 4 as the

central processing unit

PIR Sensor for motion detection

Camera Module for capturing wildlife images

YOLOv5 Deep Learning Model for species classification GPS Module for

location tracking

LoRa/GSM Module for data transmission Solar Panel for

renewable power supply

### 5.2 Working Principle

The PIR sensor detects motion near the device.

The camera captures images of the detected animal.

The YOLOv5 model processes the image locally to identify the species. GPS coordinates

and timestamp are recorded.

The data is transmitted wirelessly to a cloud server.

Researchers access real-time data for analysis and visualization.

## 6. Software components

| **Software Component** | **Description** |
|---|---|
| Raspberry Pi OS | Acts as the operating system for the Raspberry Pi, managing hardware resources and providing a platform to run AI and IoT applications. |
| Python | Primary programming language used for sensor integration, data processing, AI model execution, and system control. |
| YOLOv5 | Deep learning–based object detection algorithm used to detect and classify animals in real-time from images and video streams. |
| OpenCV | Open-source computer vision library used for image processing, motion detection, video analysis, and camera handling. |

| | |
|---|---|
| TensorFlow / PyTorch | Machine learning frameworks used to train and deploy the YOLOv5 model on the Raspberry Pi. |
| GPS Libraries (gpsd / NMEA) | Used to interface with the GPS module and extract real-time latitude and longitude data. |
| Sensor Libraries | Python libraries used to read data from PIR motion sensors, heart rate sensors, and temperature sensors. |
| Communication Protocols (GSM / MQTT / HTTP) | Enable real-time data transmission between the smart collar and remote monitoring servers. |
| Database (Cloud / Local Storage) | Stores animal location data, images, videos, and health parameters for analysis and record keeping. |
| Cloud Platform (AWS / Firebase / ThingsBoard) | Provides remote access, visualization dashboards, data analytics, and alert notifications. |
| Data Visualization Tools | Used to display animal movement, health status, and activity trends through graphs and maps. |
| Alert & Notification System | Sends alerts to forest officials in case of abnormal behavior, health issues, or boundary crossing. |

## 7. expected Outcomes

Accurate and real-time wildlife species detection. Non-intrusive and autonomous monitoring.

Reduced operational cost and human effort. Enhanced wildlife conservation and research support. Scalable deployment across diverse habitats.

**Applications** Wildlife conservation and endangered species monitoring Anti-poaching and illegal activity detectionBiodiversity documentation Ecological and behavioral research Environmental monitoring and policy planning

## 8. Conclusion

This paper presents a smart, AI-enabled wildlife tracking system that combines computer vision, IoT, and renewable energy for real-time species monitoring. The proposed system overcomes the limitations of traditional tracking techniques by providing a scalable, non-invasive, and sustainable solution. Future enhancements may include acoustic sensing, behavior prediction, and advanced analytics for improved conservation outcomes.

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(Use IEEE format – your existing references are valid and acceptable)

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