IOT BASED ANTI-POACHING SYSTEM FOR TREES AND WILDLIFE MONITORING SYSTEM IN REMOTE AREAS

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ABSTRACT

The increasing rate of illegal poaching, deforestation, and forest fires poses a serious threat to biodiversity and ecological balance. Traditional forest monitoring methods, which rely heavily on manual patrolling, are often inefficient, time-consuming, and inadequate for large or remote areas. To address these challenges, this project proposes an **IoT-based Anti-Poaching System for Trees and Wildlife Monitoring** that enables real-time surveillance and automated alert mechanisms.

The system is built around an ESP32 microcontroller, which integrates multiple sensors to monitor environmental and security parameters. A combination of sensors, including the MPU6050 for detecting tree vibrations and tilts, PIR sensors for motion detection, and MQ2 gas sensors for identifying smoke and harmful gases, ensures comprehensive monitoring. Additionally, an ESP32-CAM module provides real-time video streaming, while a GPS module enables precise location tracking of events and resources.

All collected data is transmitted to the Blynk IoT platform, allowing remote monitoring through smartphones or web interfaces. The system generates instant alerts when abnormal activities such as illegal tree cutting, unauthorized human presence, or fire hazards are detected, enabling quick response from authorities.

This proposed solution offers a cost-effective, scalable, and intelligent approach to forest protection. By integrating IoT technology with real-time data processing and multi-sensor coordination, the system enhances monitoring efficiency, reduces response time, and supports sustainable wildlife conservation and environmental management.

Keywords

IoT, Anti-Poaching System, Forest Monitoring, Wildlife Protection, ESP32, PIR Sensor, MQ2 Gas Sensor, MPU6050, GPS Tracking, Real-Time Monitoring, Smart Surveillance, Environmental Monitoring, Blynk IoT Platform, Wireless Sensor Networks, Fire Detection

I. INTRODUCTION

Forests play a vital role in maintaining ecological balance, preserving biodiversity, and supporting life by regulating climate and providing essential resources. However, increasing incidents of illegal activities such as poaching and unauthorized tree cutting, along with natural hazards like forest fires, have significantly threatened forest ecosystems. Traditional monitoring approaches, which mainly depend on manual patrolling, are often inefficient, time-consuming, and unreliable, especially in large and remote forest areas. These limitations highlight the need for an advanced and automated monitoring system.

With the rapid advancement of the Internet of Things (IoT), it has become possible to develop intelligent systems capable of real-time data collection, analysis, and remote monitoring. IoT-based solutions enable seamless communication between devices, allowing forest authorities to monitor environmental conditions and detect illegal activities from distant locations. By integrating multiple sensors and wireless communication technologies, such systems can significantly improve monitoring efficiency and reduce response time.

The proposed system introduces an IoT-based anti-poaching solution designed to monitor trees and wildlife in remote forest regions. It utilizes an ESP32 microcontroller as the core processing unit due to its high performance and built-in Wi-Fi capabilities. Various sensors are incorporated to ensure comprehensive monitoring: the MPU6050 sensor detects vibrations and tilts in trees, indicating possible illegal cutting or falling; the PIR sensor identifies motion, helping detect human intrusion or animal movement; and the MQ2 gas sensor detects smoke and harmful gases for early fire detection. Additionally, an ESP32-CAM module enables real-time video surveillance, and a GPS module provides accurate location tracking of incidents.

All sensor data and alerts are transmitted to the Blynk IoT platform, enabling remote access through mobile or web applications. The system generates instant notifications when abnormal conditions are detected, allowing authorities to take immediate action. This integration of sensing, communication, and real-time monitoring provides a smart, cost-effective, and scalable solution for forest protection.

In conclusion, the proposed system addresses the shortcomings of traditional methods by offering an automated, real-time, and multi-functional approach to forest monitoring. It enhances security, minimizes environmental damage, and contributes to sustainable wildlife conservation and ecosystem management.

II. LITERATURE REVIEW

Forest monitoring and anti-poaching systems have gained significant attention due to the increasing threats to biodiversity and natural ecosystems. Traditional methods primarily rely on manual patrolling, which is labor-intensive, time-consuming, and often ineffective in covering large or remote forest areas. These limitations have led researchers to explore automated and technology-driven approaches for efficient monitoring and protection.

Early systems focused on basic sensor-based monitoring, where environmental parameters such as temperature, humidity, and motion were measured using standalone sensors. Although these systems improved detection capabilities, they lacked real-time communication and remote accessibility, limiting their effectiveness in critical situations. With the advancement of embedded systems, platforms such as Arduino and Raspberry Pi enabled local data processing and alert generation. However, these systems still faced challenges related to scalability, connectivity, and integration of multiple sensing components.

The emergence of Internet of Things (IoT) technology has significantly improved forest monitoring solutions by enabling continuous data transmission and remote access. IoT-based systems allow authorities to monitor environmental conditions in real time through cloud platforms such as Blynk and ThingSpeak. Motion detection using Passive Infrared (PIR) sensors has become a widely adopted technique due to its reliability and cost-effectiveness in detecting human or animal movement. Similarly, sensors like MPU6050 accelerometers are used to detect vibrations and tilts in trees, helping identify illegal logging activities. Gas sensors such as MQ2 are commonly employed for detecting smoke and harmful gases, enabling early forest fire detection.

Wireless Sensor Network (WSN)-based approaches have also been explored for habitat monitoring and anti-poaching applications. These systems use distributed sensor nodes to monitor environmental conditions and detect intrusions. Some models utilize PIR sensors for motion detection and transmit alerts through web-based interfaces. Others incorporate solar-powered sensor nodes with temperature and humidity sensors for continuous monitoring. While these systems provide wide coverage, they may suffer from limitations such as unreliable performance under low sunlight conditions, communication delays, and inability to differentiate between authorized and unauthorized personnel.

Acoustic-based systems have been proposed to detect illegal activities such as tree cutting by analyzing sound patterns, including chainsaw noise. These systems can identify suspicious activities and convert detected signals into GPS coordinates for location tracking. Additionally, satellite-based monitoring approaches have been used to observe large-scale deforestation by analyzing changes in forest cover. Although these methods are useful for long-term analysis, they lack real-time detection capabilities and immediate response mechanisms.

RFID-based systems have also been introduced for tracking valuable trees and forest resources. In such systems, each tree is tagged with an RFID chip, and forest officials use handheld devices to monitor and update data. While this approach improves identification and tracking, it requires manual intervention and is not effective for real-time detection of illegal activities.

Despite various advancements, existing systems still face several challenges, including limited coverage in remote areas, high implementation costs, lack of integration among multiple sensors, and delayed response due to absence of real-time alerts. Many systems are reactive rather than proactive, detecting issues only after significant damage has occurred.

III. METHODOLOGY

1. System Architecture Design

The system is built around the **ESP32 microcontroller**, which serves as the central processing and communication unit. It connects with multiple sensors, communication modules, and output devices to create an integrated monitoring platform. The architecture includes sensing units (MPU6050, PIR, MQ2), a camera module (ESP32-CAM), a GPS module, and IoT connectivity through the Blynk platform.

2. Sensor Data Acquisition

Different sensors are deployed to capture various environmental and security-related parameters:

- **MPU6050 Sensor:** Detects vibrations and tilts in trees to identify illegal cutting or falling events.
- **PIR Sensor:** Monitors motion to detect human intrusion or animal movement in restricted areas.
- **MQ2 Gas Sensor:** Detects smoke and harmful gases for early fire identification.
- **GPS Module:** Provides real-time location data for tracking incidents and resources.

3. Data Processing and Analysis

The ESP32 processes incoming sensor data and compares it with predefined threshold values. If the sensor readings exceed normal limits (e.g., unusual vibration, motion detection, or gas concentration), the system identifies it as an abnormal event. This decision-making process ensures accurate detection while minimizing false alarms.

4. Real-Time Monitoring and Communication

The processed data is transmitted via Wi-Fi to the **Blynk IoT platform**, enabling remote monitoring through mobile or web applications. This allows forest officials to access live sensor data, system status, and alerts from anywhere in real time.

5. Video Surveillance Integration

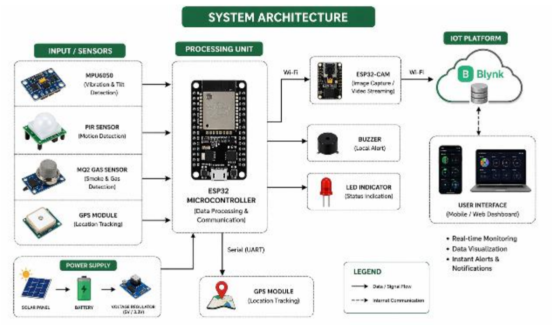
An **ESP32-CAM module** is incorporated to capture images or stream live video when an abnormal condition is detected. This provides visual confirmation of events such as poaching or forest fires, improving decision-making and response accuracy.

6. Alert and Notification Mechanism

The system generates alerts in two ways:

- **Local Alerts:** Buzzers and LEDs are activated to indicate abnormal conditions on-site.
- **Remote Alerts:** Notifications are sent to the Blynk application, informing authorities instantly.

IV. SYSTEM ARCHITECTURE



V. RESULTS & DISCUSSION

The system successfully monitored multiple parameters simultaneously using integrated sensors. The **MPU6050 sensor** accurately detected abnormal vibrations and tilts in trees, which can indicate illegal cutting or falling events. The **PIR sensor**effectively identified motion in restricted areas, enabling the detection of human intrusion and animal movement. The **MQ2 gas sensor** responded efficiently to the presence of smoke and harmful gases, allowing early detection of potential forest fires.

The **ESP32-CAM module** provided real-time image capture and video streaming, offering visual confirmation of detected events. The **GPS module** successfully delivered accurate location data, enabling authorities to identify the exact position of incidents. All collected data was transmitted to the Blynk IoT platform, where it was displayed in real time, allowing remote monitoring through mobile devices or web interfaces.

The system generated **instant alerts** whenever abnormal conditions were detected. Notifications were successfully delivered to the IoT platform, while local alerts such as buzzers and LEDs were triggered simultaneously. This ensured that both on-site and remote monitoring were effective.

The results indicate that the proposed system significantly improves the efficiency of forest monitoring compared to traditional methods. The integration of multiple sensors provides a

comprehensive monitoring solution, addressing various threats such as illegal logging, poaching, and forest fires within a single platform. Real-time data transmission and alert mechanisms reduce response time, enabling quicker action by authorities.

One of the major advantages observed is the **reliability of IoT-based communication**, which allows continuous monitoring even in remote locations. The use of the ESP32 microcontroller enhances system performance due to its built-in Wi-Fi capability and efficient data processing. Additionally, the inclusion of video surveillance improves situational awareness by providing visual evidence of incidents.

However, some limitations were observed during testing. The accuracy of sensors can be affected by environmental conditions such as extreme weather, temperature variations, or interference. For example, PIR sensors may occasionally detect unintended motion, and gas sensors may require calibration for accurate readings. Network connectivity in remote forest areas may also impact real-time data transmission.

Despite these challenges, the system proves to be a **cost-effective, scalable, and intelligent solution** for forest protection. By combining sensing technologies, real-time monitoring, and IoT communication, it enhances detection accuracy, minimizes delays, and supports proactive forest management.

VI. CONCLUSION

The proposed IoT-Based Anti-Poaching System for Trees and Wildlife Monitoring provides an effective and intelligent solution to address the growing challenges of illegal poaching, deforestation, and forest fires. By integrating multiple sensors, real-time data processing, and IoT-based communication, the system overcomes the limitations of traditional forest monitoring methods, which rely heavily on manual patrolling and delayed response mechanisms.

The use of the ESP32 microcontroller, along with sensors such as MPU6050, PIR, and MQ2, enables continuous monitoring of environmental conditions and suspicious activities. The addition of GPS tracking and ESP32-CAM enhances the system by providing accurate location information and visual verification of events. Real-time data transmission to the Blynk IoT platform ensures remote accessibility and instant alert notifications, allowing authorities to take timely and appropriate action.

The system demonstrates improved efficiency, reduced response time, and enhanced accuracy in detecting threats such as illegal tree cutting, unauthorized human movement, and forest fires. Its cost-effective and scalable design makes it suitable for deployment in large and remote forest areas.

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