Intelligent Energy Efficient GNSS Assisted and Lora- Based Positioning for Wildlife Tracking

Mekala Madhuri[1],Tirakala Ajay[2],Kadiyala Mounika[3],Malleboina Hema Latha[4], Kolluru Rajitha[5]

Department of Electronics and Communication Engineering PBR VISVODAYA INSTITUTE OF TECHNOLOGY & (SCIENCE, KAVALI AUTONOMOUS) SPSR Nellore (Dt.), Andhra Pradesh – 524201

Abstract - Wildlife tracking plays a vital role in conservation, behavioral analysis, and ensuring the safety of both animals and humans. This project presents an intelligent GNSS-based wildlife tracking system with geo-fencing and wireless alert mechanisms. A GPS module is used to continuously monitor the real-time location of the animal. A predefined geographical fence is set, and when the animal crosses this boundary, the system automatically detects the event. An Arduino microcontroller processes the location data and transmits the boundary-violation information to a receiver unit using a LoRa module for long-range, low-power communication. Upon detection of a geo- fence breach, an alert message containing location details is sent to conservation authorities through a GSM module, and a buzzer is activated for immediate local alert indication. This system enables accurate location tracking, timely detection of boundary violations, and efficient alert generation, providing a reliable and energy-efficient solution for wildlife conservation and management.

Key Words: LoRa Communication, Wildlife Tracking, GPS Location Tracking, IoT

1. INTRODUCTION

Wildlife conservation has become increasingly important due to habitat loss, human– animal conflict, and environmental changes. Monitoring the movement and behavior of wild animals helps researchers understand migration patterns, habitat utilization, and potential threats. Traditional wildlife tracking systems often rely on basic GPS devices that periodically transmit location data. However, these systems may consume high power, lack intelligent boundary monitoring, and fail to provide real-time alerts. The proposed system, Intelligent Energy Efficient GNSS Assisted and LoRa- Based Positioning for Wildlife Tracking, integrates Global Navigation Satellite System (GNSS) technology with LoRa communication for long-range, low-power data transmission. The system uses an Arduino microcontroller to process real-time location data and implement geo-fencing. When an animal crosses a predefined boundary, the system immediately triggers alerts via GSM communication and activates a buzzer for local indication.In addition, the proposed system focuses on improving the efficiency and reliability of wildlife tracking by reducing power consumption and ensuring long-term operation in remote areas. The use of LoRa technology enables communication over large distances without the need for existing network infrastructure, making it highly suitable for forest and rural environments. The integration of GNSS ensures accurate positioning, while the Arduino microcontroller provides effective processing and control of the system. This combination allows continuous monitoring of animal movement with minimal human intervention. Furthermore, the system is designed to be cost-effective and scalable, allowing deployment across multiple animals and regions. By providing timely alerts and precise location data, the system helps authorities take quick action, thereby minimizing human-animal conflicts and supporting wildlife conservation efforts.

2. LITERATURE SURVEY

Lavric & V. Popa This paper surveys recent advancements in the Internet of Things (IoT) with a focus on Low-Power Wide-Area Networks (LPWANs), specifically LoRa technology. It discusses how LoRa enables long-range wireless communication with minimal energy consumption, making it suitable for distributed monitoring applications. The authors review LoRa modulation techniques, network architecture, deployment challenges, and performance parameters. The survey demonstrates that LoRa is a promising solution for applications requiring low power and extended communication range—attributes that are critical for wildlife tracking systems operating in remote environments. **R. Kays, M. C. Crofoot, W. Jetz & M. Wikelski** This research article explores the role of terrestrial animal tracking in ecological and environmental science. It highlights how GPS/GNSS-based sensors have revolutionized the ability to collect high- resolution movement data over long time periods. The authors discuss the scientific benefits of tracking animal behavior, habitat use, and migration patterns. Challenges such as data transmission, battery longevity, and maintaining device performance in harsh field conditions are also addressed. The study underlines the need for advanced tracking systems that balance accuracy with energy efficiency.

3. EXISTING SYSTEM

Wildlife tracking has become an important research area with the help of modern technology. Various models and techniques are used to monitor animal movement and behavior. One of the most widely used methods is the GPS/GNSS-based tracking system, where animals are fitted with collars that record their location accurately.This method helps in studying migration patterns and habitat usage, but it consumes more battery power. To overcome this issue, researchers use LoRaWAN technology, which provides long-range communication with low energy consumption. It is very useful in remote forest areas where network connectivity is limited.Another important technique is the use of sensor-based monitoring systems. These systems include sensors like accelerometers and temperature sensors to track animal activity and health conditions. The collected data is transmitted to base stations for analysis. Some researchers also use hybrid models that combine GPS and LoRa technologies. In these systems, GPS is used for accurate location tracking, while LoRa is used for low-power data transmission.

4. PROPOSED SYSTEM

The proposed system design of the intelligent energy-efficient GNSS and assisted LoRa-based positioning system for wildlife tracking focuses on providing a reliable and low- power solution for monitoring animals in remote areas. The system is divided into two main parts: a transmitter unit attached to the animal and a receiver unit located at the monitoring station.The transmitter unit consists of a GNSS/GPS module, a microcontroller, a LoRa communication module, and a power management system. The GNSS module is responsible for collecting accurate location data in the form of latitude and longitude, which is then processed by the microcontroller. After processing, the data is transmitted over long distances using the LoRa module, which is specifically chosen for its low power consumption and wide coverage capability. This design ensures continuous and real-time tracking of wildlife while minimizing energy consumption.Overall, the proposed system is cost-effective, scalable, and suitable for deployment in forest and remote environments where conventional communication technologies may not be available.

5. RESULTS

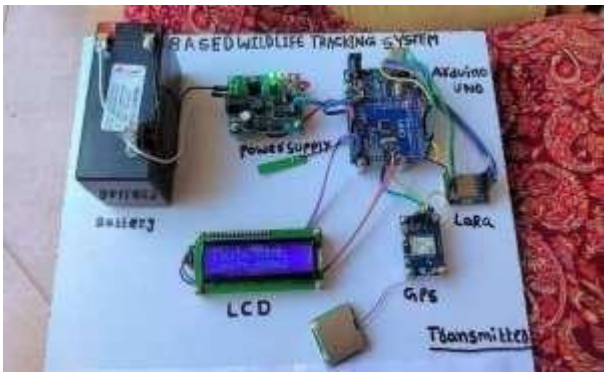

Fig 1: Transmitter LoRa Animal Tracking

The figure 1 shows the transmitter section is attached to the animal and is responsible for collecting location data and sending it wirelessly using LoRa technology. unit works in remote forest areas where there is no mobile network coverage.The GPS module continuously receives signals from satellites and determines the exact position of the animal in terms of latitude and longitude coordinates.

Fig 2: Display Animal Location

This figure 2 shows the display section of the system shows the animal's ID, name, and location in a clear format using an LCD. After receiving data through the LoRa module, the Arduino Uno processes the information. It extracts the animal ID, name, latitude, and longitude values. The first line of the LCD displays the animal ID and name, while the second line shows the location coordinates.

Fig 3: Output of Animal Location

The figure 4.21 Shows final output of the LoRa-based wildlife tracking system shows the real-time location of the animal after successful data transmission and processing. The GPS module in the transmitter collects the latitude and longitude, which are sent through the LoRa communication system to the receiver. The Arduino Uno at the receiver processes this data and displays the animal ID, name, and location on the LCD screen. Additionally, the same information can be sent as an SMS to the user's mobile phone

6. CONCLUSION

The Intelligent Energy Efficient GNSS Assisted and LoRa-Based Positioning System for Wildlife Tracking provides a reliable and practical solution for modern wildlife conservation challenges. By integrating GNSS technology for accurate positioning and LoRa communication for long-range, low-power data transmission, the system ensures continuous monitoring even in remote forest areas.The implementation of geo-fencing enables automatic detection of boundary violations, reducing the risk of human–animal conflict. Instant alert mechanisms using GSM communication ensure timely response from conservation authorities. Additionally, the use of energy-efficient components enhances battery life, making the system suitable for long-term deployment . Overall, the proposed system improves tracking accuracy, reduces power consumption, enhances communication reliability, and contributes significantly to wildlife safety and environmental management.Furthermore, the proposed system demonstrates a scalable and

adaptable approach that can be extended to various wildlife environments and species. Its ability to operate efficiently in challenging terrains with minimal human intervention makes it highly suitable for real-time ecological monitoring.

ACKNOWLEDGEMENT

The Authors sincerely thank Ms.K.S.Bhanu Rekha (Assistant Professor, ECE, PBR VITS Kavali) for his guidance. Dr. R. Sravanthi (Professor & HoD, ECE) for providing facilities, and Dr. V. Anil Kumar (Principal, PBR VITS Kavali) for the academic environment that enabled this work.

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