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Wild Animal Detection Collar Using GPS & LORA Technology

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Abstract: ***The growing number of conflicts between humans and animals, caused by quick urban growth, cutting down forests, and breaking up natural habitats, has become a major issue in recent times. As animals lose their homes, they are pushed closer to people's areas looking for food and shelter, which leads to risky situations that put both people and wildlife in danger. To tackle this problem, this paper describes the creation and use of a Wild Animal Detection Collar that uses GPS and LoRa technology to track animals in real time and send alerts. The system includes a smart collar fitted on the animal, which has an ESP32 microcontroller, a GPS module for precise location tracking, and a LoRa module for sending data over long distances while using very little power. The GPS module regularly gets real-time location data, which is then sent through the LoRa module across several kilometers with minimal power use. The system uses a geofencing feature to set up virtual limits around sensitive areas like villages, farms, or protected regions. If the animal crosses these set boundaries, the system automatically issues an alert and sends the information to a receiving unit. The receiver shows the animal's exact location, how far it is from the boundary, and the alert status, allowing forest officers or nearby people to respond quickly. This system is made to work well in remote forest areas where there is no internet or mobile coverage. It offers a cost-effective, energy-saving, and scalable way to monitor wildlife. The approach not only improves real-time tracking but also helps in reducing human-animal conflicts and supporting efforts to protect wildlife.***

I. INTRODUCTION

Wildlife conservation is crucial for keeping the environment balanced and preserving different species.

However, fast environmental changes from human activities like cutting down trees, expanding cities, mining, and farming have greatly affected natural habitats. As a result, wild animals are increasingly moving towards human areas, causing more frequent conflicts. These conflicts not only put human lives at risk but also threaten the survival of animal populations. In many places, there has been a sharp rise in incidents where elephants, leopards, and other wild animals enter villages or farmland. These events often lead to damage to crops and property, and sometimes even loss of life. Therefore, it is important to create effective systems that can track animal movements and send early warnings to prevent such conflicts.

Traditional methods used for tracking wildlife, like watching manually or using radio signals, are not very accurate or efficient.

Newer systems that use GPS and GSM technologies offer better tracking but have some issues. GSM-based systems rely on mobile networks, which are not always available in remote forest areas. Also, these systems use a lot of power, which reduces how long they can work. To fix these problems, this project introduces a Wild Animal Detection Collar using GPS and LoRa technology. GPS gives precise location data, while LoRa allows long-distance communication with very low power use. Unlike GSM, LoRa doesn't need internet access, making it very suitable for use in remote regions.

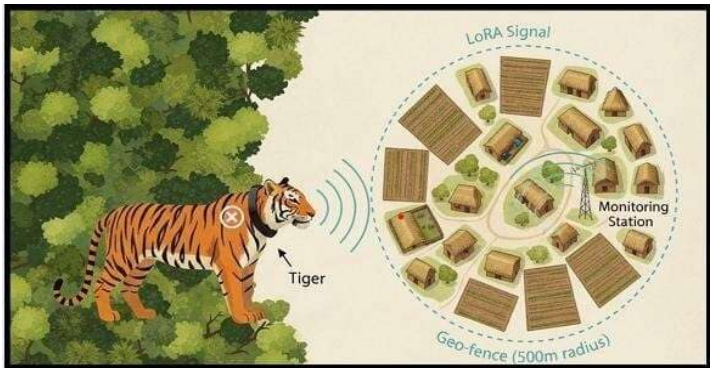


Fig : Conceptual Overview of the LoRa-Based Tracking System

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Another key part of the system is geofencing, which lets you set up virtual borders around important areas.If an animal goes past these borders, the system sends an alert, helping officials respond before any issues happen.The system is designed to be dependable, easy to expand, and uses energy efficiently for protecting wildlife..

II. LITERATURE REVIEW

Extensive research has been done on wildlife tracking and monitoring systems using different technologies.Early tracking systems mainly used GPS and GSM modules.GPS was used to find the location of animals, while GSM sent the data through SMS.These systems could track animals in real-time, but they depended on a stable network and used a lot of power, making them hard to use for long periods in remote forests.[1] Bluetooth Low Energy (BLE) has been suggested as an alternative because it uses less power.BLE allows devices to communicate over short distances, which works well for local tracking.However, its limited range makes it less effective in large forests where animals travel far.[2]

Wireless sensor networks have also been used for tracking animals, with sensors that measure temperature, motion, and heart rate.These systems offer useful data on animal health and behavior but make the system more complex and expensive.[3]Geofencing-based systems have become popular because they can detect when an animal crosses a boundary and send alerts.This helps prevent conflicts between humans and animals by letting officials know if animals are near restricted areas.But these systems work best when there's reliable communication.[4]

More advanced systems use computer vision and machine learning with camera networks to track animals.These systems are very accurate but need complex setups and aren't good for large forest areas.[5]LoRa-based systems have become a promising solution for wildlife tracking.LoRa offers long-range communication with low power use, which is great for remote areas.Studies have shown that LoRa can send data over several kilometers without needing internet.[7]Comparative studies show that LoRa is better than GSM and BLE in terms of range, power efficiency, and scalability.It's especially useful for monitoring large areas continuously.[8]

Recent research on LoRa-based IoT systems shows how well they can support large-scale environmental monitoring.Low Power Wide Area Networks (LPWAN), like monitoringwithminimalinfrastructure. LoRatechnologysupports longrange communicationwhilemaintaininglowpowerconsumption,makingithighlysuitableforwildlifetrackingapplications.Italsoallowsmultiple devicestocommunicateoverwideareas,improvingscalabilityin forest environments. [9] Regular wireless systems, LPWAN technologies last longer and are more cost-effective, which is important for long-term wildlife tracking.[10]

Wildlife monitoring systems that use both GPS and LoRa have shown big improvements in real-time tracking and alert systems.These systems can accurately find animal locations and send data without needing cellular networks.Using IoT with LoRa improves system reliability, making it perfect for remote wildlife conservation efforts.[11]

III. METHODOLOGY

The system is built to keep an eye on how animals move and send warnings when they go into areas they shouldn’t.

It has two main parts: the transmitter unit, which is a collar put on the animal, and the receiver unit.

The transmitter unit is attached to the animal as a collar.

It has an ESP32 microcontroller, a GPS module, and a LoRa communication module.The GPS module keeps track of the animal's real-time location by finding its latitude and longitude.The ESP32 microcontroller then processes these coordinates.

The system uses the Haversine formula, which is commonly used to calculate the shortest distance between two points on Earth’s surface, to find out how far the animal is from a set geographic boundary.

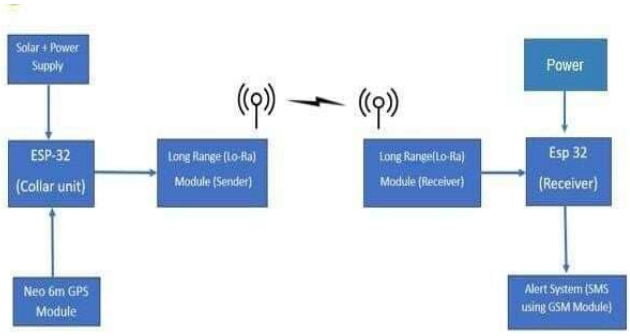


FIg2:BlockDiagram of Transmitter and Receiver Architecture

$$d = 2r \arcsin\left(\sqrt{\sin^2\left(\frac{\phi_2 - \phi_1}{2}\right) + \cos(\phi_1)\cos(\phi_2)\sin^2\left(\frac{\lambda_2 - \lambda_1}{2}\right)}\right)$$

Where:

- d:isthe distance
- r:istheEarth'sradius
- ϕ:Representslatitude
- λ:Representslongitude

Based on this distance, the system checks if the animal is inside or outside the boundary.If the distance is below a set limit, an alert is sent. The LoRa module sends the processed data—like the location, distance, and alert status—to the receiver unit.

LoRa is good for long-distance communication with low power use, which makes it perfect for use in forests. The receiver unit also has an ESP32 microcontroller and a LoRa module.It gets the data from the transmitter and shows it on a screen where users can track the animal's movement.This allows for real-time monitoring, which helps in quickly responding to any issues.This approach ensures that the data is handled well, communication is reliable, and alerts are sent on time.It makes the system very useful for keeping an eye on wildlife..

IV. RESULTS

The implemented system successfully demonstrates real-time tracking of wild animals using GPS and LoRa technology. The transmitter unit continuously captures accurate location data and transmits it to the receiver unit withoutsignificantdelay.Thereceiversystemdisplaysreal-time coordinates and calculates the distance betweenthe animal and the predefined geofence location. When the animal enters the restricted zone, an alert message is generatedimmediately.Thesystemperformseffectivelyin remote areas where GSM-based systems fail due to lack of networkconnectivity.LoRacommunicationensuresstable and long-range data transmission, while maintaining low power consumption . The results confirm that the systemisreliable,efficient,andsuitableforreal-worldwildlife monitoringapplications.



Fig3:MonitoringInterface

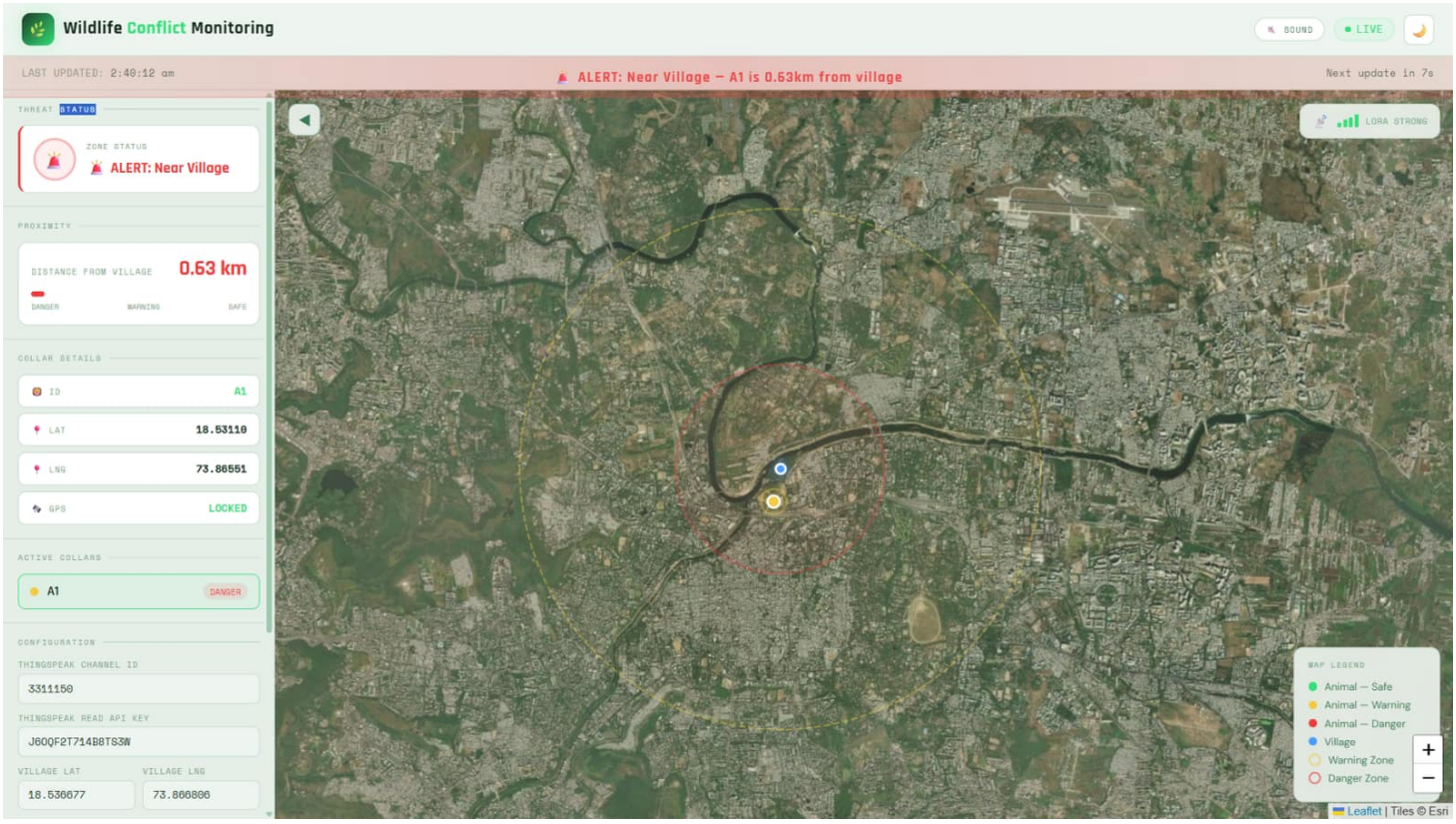


Fig4:-Real-timeMonitoringandGeofenceVisualizationonDashboard

V. DISCUSSION

The proposed Wild Animal Detection Collar system offers an effective and practical way to monitor wildlife in real time using GPS and LoRa technology.The system's operation is explained in Figure 1: LoRa-Based Animal Tracking with Geofence Alert Mechanism. This figure shows how each part of the system works together to provide continuous tracking and send alerts when needed. The system includes a GPS module to track the animal's location, an ESP32 microcontroller to process data, and a LoRa module for long-range communication. This setup ensures that the system works well even in remote forest areas where regular communication methods are not reliable.

Figure 2: Transmitter Unit & Receiver Unit Architecture provides a detailed look at the hardware design. The transmitter unit, which is worn as a collar on the animal, continuously gathers latitude and longitude data through the GPS module. This data is processed by the ESP32 and sent using the LoRa module. The receiver unit, located elsewhere, receives this data and displays it so that it can be monitored. Separating the transmitter and receiver units makes the system easier to scale and allows for tracking multiple animals at the same time.

The system's user experience and ability to monitor animals are shown in Figure 3: Frontend Dashboard. This dashboard shows the animal's real-time location, how far it is from set geofence boundaries, and whether any alerts are active. This interface helps forest officials or users quickly understand the data and make decisions. The dashboard is designed to be simple, clear, and useful, especially during emergencies related to human-animal conflicts.

The system's practical use is shown in Figure 4: Experimental Setup, where the prototype is tested in a real-world environment. This setup checks how well GPS tracking, LoRa communication, and alert generation work. The results show that the system can send data over long distances with little delay and low power use. This proves that LoRa technology is suitable for use in dense forests and rural areas. A big advantage of this system is that it doesn't rely on the internet or cellular networks.

Unlike systems that use GSM, which depend on network connections, this system uses LoRa, making communication more reliable. The use of geofencing means the system only sends alerts when necessary, reducing unnecessary data and saving energy. Even though the system has some limitations, they can be addressed in future improvements.

GPS accuracy might be less in areas with lots of trees because the signal can be blocked. LoRa communication could also be

affected by environmental factors like terrain and vegetation. However, these issues can be solved by using better positioning systems and adjusting communication settings.

Overall, the discussion shows that the proposed system is accurate, efficient, and scalable.

The combination of hardware design, communication technology, and user interface makes it a complete solution for wildlife monitoring and preventing conflicts between humans and animals.

VI. CONCLUSIONS

The Wild Animal Detection Collar, which uses GPS and LoRa technology, offers an effective and dependable way to monitor wildlife in real time. This system allows for precise tracking of animal locations, long-distance communication, and timely alerts through the use of geofencing, making it ideal for use in remote forest areas. A user-friendly dashboard has been created to show live animal positions, their distance from the geofence boundaries, and the status of any alerts, which improves how users interact with and manage the system. The system is also affordable, uses energy efficiently, and can be scaled up, making it a practical tool for wildlife conservation. It helps reduce conflicts between humans and animals and improves safety by providing early warnings and ongoing monitoring.

Using LoRa communication greatly reduces the need for cellular networks, ensuring reliable data transmission in areas with poor connectivity.

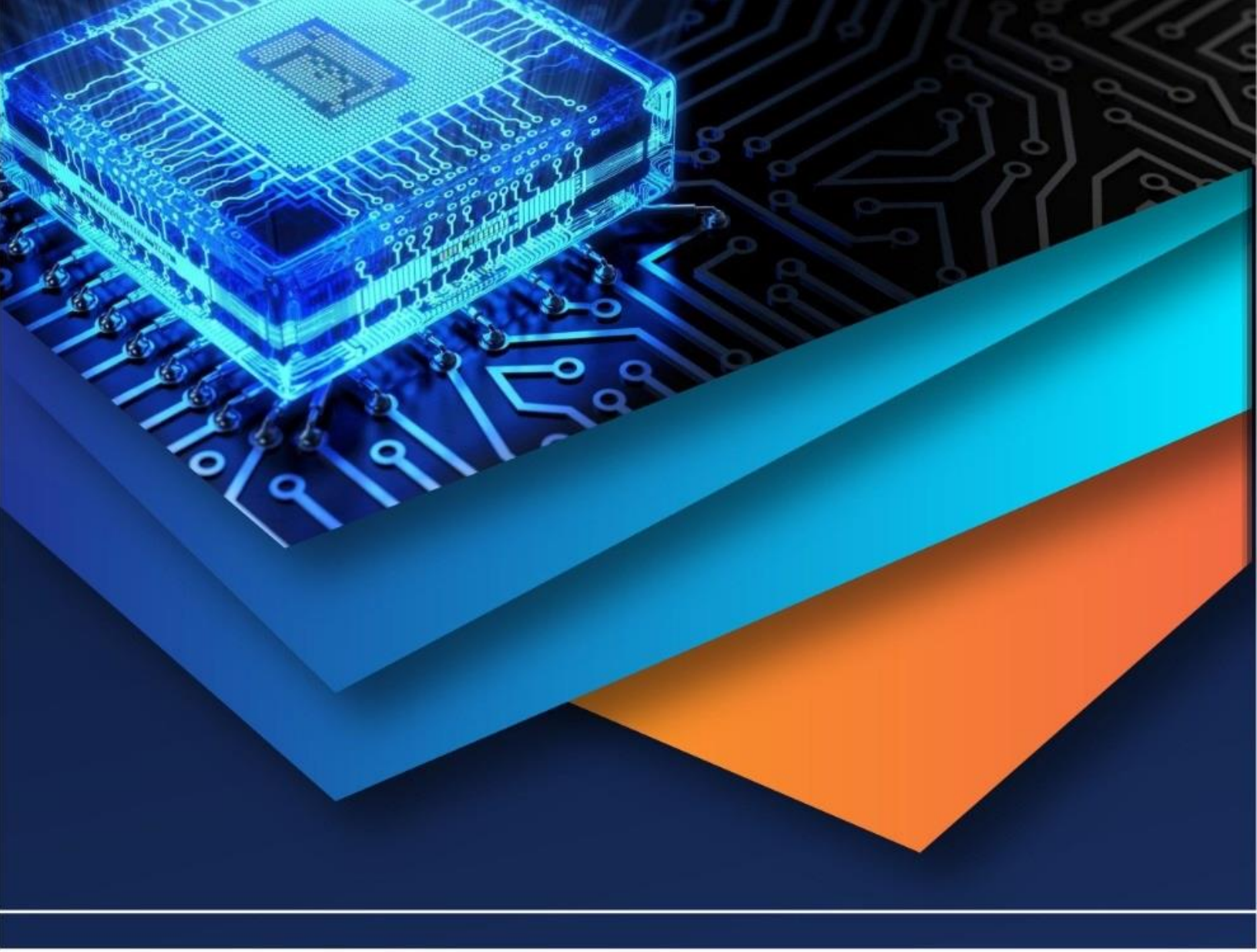
The system uses an ESP32 processor to handle GPS data efficiently while keeping power usage low. Its modular design makes it easy to use across various animal species and locations. The solution supports continuous tracking and helps forest officials keep an eye on animal movements, study migration trends, and respond quickly to possible dangers.

The system can also be expanded by adding cloud storage to save historical tracking information and analyze movement patterns.

Adding health sensors and solar power sources can make the system more reliable and longer-lasting, enhancing its sustainability. Future improvements may include using machine learning to predict animal movements, developing a mobile app for quick alerts, and enabling tracking of multiple animals at once. These enhancements will make wildlife conservation more effective, support better decision-making based on data, and help create smarter wildlife management systems.

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