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GauSeva: An IoT-Based Smart Cattle Tracking and Assistance System with Multilingual Farmer Chatbot

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ABSTRACT:

Livestock management in rural agricultural communities is often impacted by challenges such as cattle loss, theft, and significant language barriers in accessing critical information. This paper presents GauSeva, an integrated, low-cost system designed to address these gaps by combining offline Internet of Things (IoT) tracking with an online, AI-powered assistance platform. The system's hardware unit is built upon the Arduino Uno, integrating a NEO-6M GPS module for location sensing and a SIM900A GSM module for communication. This design provides real-time cattle location alerts directly to a farmer's mobile device via SMS, ensuring functionality in areas with limited or no internet connectivity. Complementing the hardware, a React Native mobile application provides a multilingual chatbot powered by the Google Gemini API. This allows farmers to query for information on cattle health, feeding practices, and government schemes in their native regional languages. The system was validated through unit, integration, and system-level testing, confirming the reliability of SMS alerts and the accuracy of the multilingual chatbot. GauSeva demonstrates a practical and scalable solution that reduces livestock loss and empowers farmers by bridging technological and linguistic divides.

KEYWORDS: Internet of Things (IoT), Smart Agriculture, Cattle Tracking, GPS, GSM, AI Chatbot, Multilingual Support, React Native, Farmer Assistance.

I. Introduction

Livestock, particularly cattle, are a cornerstone of agricultural productivity and economic stability for countless rural farmers. However, the management of these assets is fraught with persistent challenges. Farmers frequently face the risk of cattle theft or loss due to animals straying, especially in open grazing areas. Furthermore, a significant information gap exists. Access to vital knowledge regarding animal healthcare, optimized feeding, and available government welfare schemes is often obstructed by technical illiteracy and, most critically, language barriers.

While modern technological solutions for livestock management exist, they often present significant drawbacks for small-scale farmers. Many commercial systems rely on cloud-based analytics and mobile data, rendering them ineffective in remote regions with poor or non-existent internet coverage. Additionally, these systems are often cost-prohibitive and typically feature English-centric interfaces, further excluding a large demographic of non-English-speaking farmers.

This paper introduces **GauSeva**, a hybrid system designed to overcome these specific limitations. The primary contribution of this work is its dual-pronged architecture:

1. An **IoT-based hardware tracker** that operates independently of internet connectivity. It utilizes cost-effective Arduino, GPS, and GSM modules to send critical location alerts via the ubiquitous SMS network .
2. An **AI-powered mobile application** that functions as a multilingual knowledge assistant. By integrating the Google Gemini API into a React Native application, the system offers an accessible chatbot that allows farmers to interact and receive guidance in their own regional language .

This research presents the design, implementation, and testing of this integrated system, demonstrating a cost-effective and accessible solution to enhance cattle security and empower farmers with actionable, language-appropriate information.

II. Related Work and AI Technologies

Recent advancements in smart agriculture have seen the application of IoT and AI to various aspects of livestock management.
The literature reveals two primaries, and often separate, trends relevant to this work.

First, the use of IoT for real-time tracking has been widely explored. Kumbhar and Gavhale (2020) presented a system utilizing GPS and IoT for cattle monitoring, with a focus on geofencing to improve security. Similarly, other studies focus on LPWAN technologies like LoRa for tracking. While effective, many of these systems depend on data connectivity for real-time dashboard updates, which is not always viable in the remote areas targeted by our project. Our system diverges by prioritizing GSM-based SMS alerts as a more robust and accessible communication method in low-connectivity environments.

Second, AI has been increasingly used for farmer assistance. Sharma, et al. (2021) demonstrated an IoT and AI system for predictive health monitoring using wearable sensors. On the software front, Bera and Hota (2020) proposed an AI recommender system for government schemes, while Kumari and Sharma (2022) focused on designing multilingual mobile apps to improve access to agricultural information.

While these studies validate the individual components, a significant gap remains in unifying these concepts into a single, affordable framework. Existing solutions typically focus on either tracking or information dissemination. GauSeva bridges this gap by integrating robust, offline SMS-based tracking with a sophisticated, online multilingual AI chatbot, creating a comprehensive support tool tailored for rural farmers.

III. System Architecture

The GauSeva system is designed with a layered architecture, integrating a self-contained hardware unit for tracking and a software layer for user interaction.

A. HARDWARE TRACKING UNIT

The core of the tracking device is the Arduino Uno microcontroller, which serves as the central processing unit. It manages and processes data from three key peripherals:

GPS Module (NEO-6M): This module acquires real-time geospatial coordinates (latitude and longitude) of the cattle . It communicates with the Arduino via UART serial communication .

Power Module: The entire hardware unit is powered by a rechargeable lithium-ion battery, ensuring portability and sustained operation in the field .

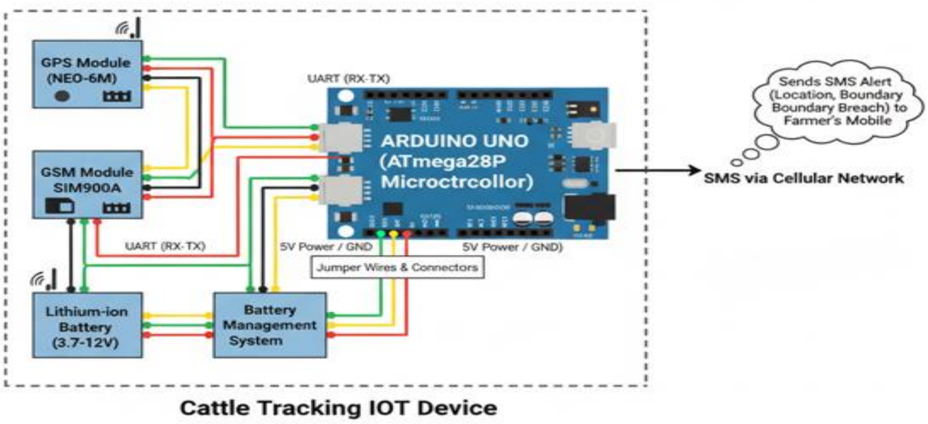

Figure 1. System Architecture of Hardware Tracking Unit

B. COMMUNICATION PROTOCOL

For communication, the system employs a SIM900A GSM module . This module is also interfaced with the Arduino Uno via UART . Upon receiving a trigger from the Arduino (e.g., a boundary breach or a button press), the GSM module sends a pre-defined SMS alert containing the location data to the farmer's registered mobile number . The deliberate choice of GSM/SMS over GPRS/data ensures that the system's primary alert functionality remains operational even in remote areas with no internet access .

The alert mechanism is trigger-based. When the Arduino's firmware detects a critical event (such as a geofence boundary breach determined from GPS data or a manual button press), it constructs and sends a command to the SIM900A module. This command instructs the module to transmit a pre-defined Short Message Service (SMS) alert containing the cattle's current location data to the farmer's registered mobile number. The selection of SMS over GPRS or other mobile data protocols was a deliberate and foundational design choice. The SMS protocol leverages the ubiquitous and highly robust GSM network. It uses cellular control channels, which often remain operational even when data services are unavailable or call quality is poor.

C. MOBILE APPLICATION AND AI CHATBOT

The software component is a mobile application developed using React Native, a cross-platform framework, and tested with Expo Go . The application provides the user interface for the system's secondary function: the AI Farming Assistant . This assistant is a chatbot powered by the Google Gemini API . The app securely communicates with the API, allowing the farmer to send queries in their preferred language . The Gemini API processes the natural language input and returns a contextually relevant, multilingual response, which is then displayed in the app's chat interface . This feature provides farmers with on-demand access to information about subsidies, animal health, and best practices .

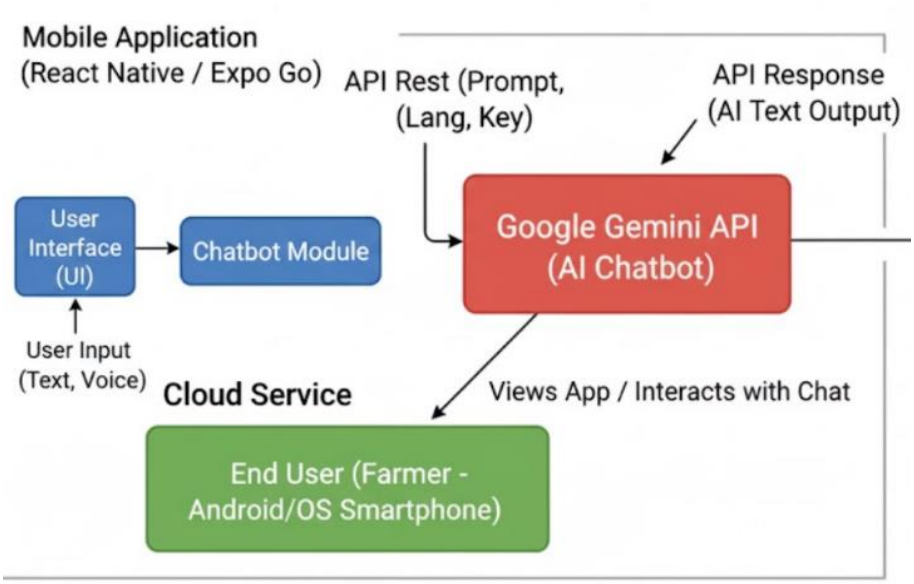

Figure 2. System Architecture of Chatbot

VI. Implementation Details

The system was implemented by integrating the hardware and software components described in the architecture.

A. HARDWARE IMPLEMENTATION

The hardware was assembled with the Arduino Uno (ATmega328P) as the controller . The NEO-6M GPS and SIM900A GSM modules were connected to the Arduino's digital I/O pins using a software serial library to manage UART communication. The system is powered by a 3.7V lithium-ion battery pack . The logic for the microcontroller was developed in the Arduino IDE using Embedded C/C++ . The code is responsible for initializing the modules, continuously parsing NMEA data strings from the GPS, and triggering the GSM module to send an SMS when alert conditions are met.

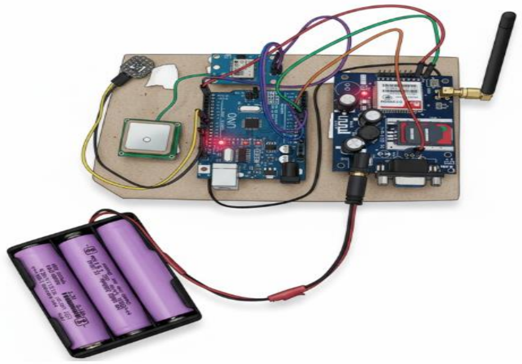

Figure 3. Prototype of Cattle Tracker

B. SOFTWARE IMPLEMENTATION

The mobile application was developed in Visual Studio Code using JavaScript and React Native . The Expo framework was used to streamline the build and testing process on physical devices . For the chatbot, a secure API key for the Google Cloud project was obtained to authenticate requests to the Gemini API . The app's state management handles user input, displays a loading state during the API call, and then renders the multilingual response received from the API .

C. SYSTEM WORKFLOW

The system operates on two parallel workflows:

Tracking and Alert: The hardware unit is powered on and initializes the GPS and GSM modules. The GPS module acquires a satellite lock and begins sending location data to the Arduino. The Arduino processes this data. If an alert is triggered (in our test, via a button press simulating a geofence breach), the Arduino commands the GSM module to send the location via SMS to the farmer.

Chatbot Interaction: The farmer opens the GauSeva mobile app and selects their preferred language. They type and send a message (e.g., "pm kisan"). The app sends this query to the Gemini API. The API processes the request and returns an AI-generated answer, which is then displayed to the farmer.

V. Results and Performance Analysis

The GauSeva system underwent a comprehensive, multi-level testing methodology to validate its functionality and reliability, including functional, non-functional, unit, and integration testing.

A. UNIT TESTING

Each component was tested individually to ensure it met its specifications. As summarized in the testing report, all module passed:

- GPS Module: Successfully retrieved accurate latitude and longitude values.
- GSM Module: Correctly sent and received SMS alerts to the registered test number.
- Arduino Uno: Processed data and triggered outputs correctly.
- Gemini API: Handled queries and provided accurate, context-based multilingual replies.
- React Native App: The UI was responsive and correctly managed chatbot communication.

B. INTEGRATION TESTING

Key subsystems were combined and tested. The (GPS + GSM+ Arduino) integration test successfully verified that location data obtained by the GPS was correctly processed by the Arduino and transmitted via an SMS alert by GSM module. The test (Gemini API + Mobile App) test confirmed that queries from the app were successfully handled by the API and responses were rendered correctly.

C. SYSTEM VALIDATION

End-to-end system testing confirmed the viability of the complete solution.

- Hardware: The final assembled hardware prototype is shown in Fig. 3. The (GPS + GSM + Arduino) integration test successfully verified that raw location data obtained by the GPS was correctly processed and parsed by the Arduino microcontroller. The test further confirmed the Arduino's ability to properly command the GSM module to format and transmit this data via an SMS alert. This successful test validated the entire hardware alert chain, from satellite acquisition to the reception of a valid message(Fig 4).

Figure 4. Alert received at registered mobile number

Software: The mobile application demonstrated full functionality. The language selection feature (Fig.5) worked as intended. The chatbot provided correct and well-formatted answers to queries about government schemes in multiple languages, including English and Kannada (Fig.6).

Figure 5. Language selection feature

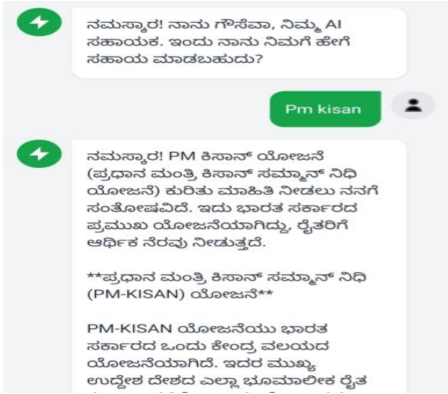

Figure 6. Response by chatbot in kannada

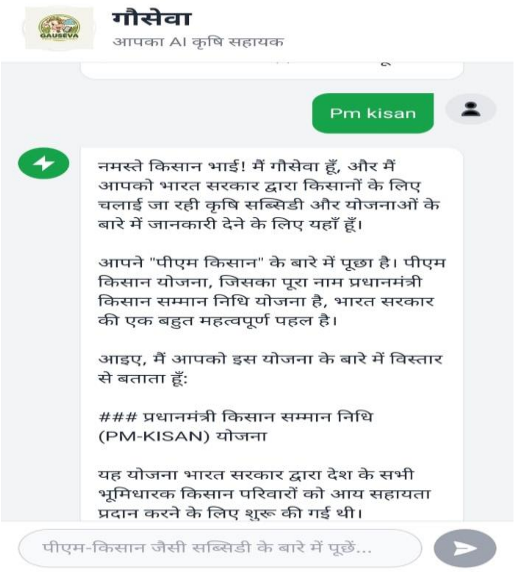

Figure 7. Response by chatbot in Hindi

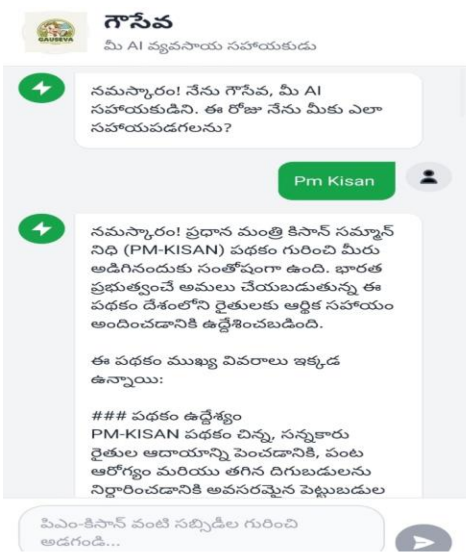

Figure 8. Response by chatbot in Telugu

Figure 9. Response by chatbot in Tamil

The usability testing confirmed the app interface was intuitive for non-technical users, and performance testing noted acceptable response times for both SMS alerts and chatbot queries.

VI. Conclusion and Future Directions

This paper has presented the design, implementation, and validation of GauSeva, a hybrid IOT and AI system for rural cattle management. The project successfully demonstrates the integration of an Arduino-based GPS/GSM tracking unit with a multilingual AI chatbot. The system's primary contribution is its dual-mode functionality, which provides critical, offline location alerts via SMS while simultaneously offering sophisticated, online AI-driven assistance in multiple regional languages. This approach directly addresses the key challenges of poor internet connectivity and language barriers, providing a solution that is low-cost, scalable, and highly accessible to rural farmers.

Future enhancements for the GauSeva platform are clear. The hardware unit can be expanded by integrating advanced health sensors to monitor parameters like body temperature and heart rate, enabling early disease detection. On the software side, true geofencing capabilities can be implemented to send automated alerts when cattle stray from a predefined area. Further enhancements could include cloud-based data analytics to provide farmers with long-term insights into herd movement, solar charging to improve battery Slife, and voice-based alerts to improve accessibility. By building on this scalable foundation, GauSeva can further evolve into a comprehensive digital solution for modern, sustainable agriculture.

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