International Journal of Scientific Research in Engineering and Management (IJSREM)
Special Edition - Volume 09 NCFT -2025 SJIF Rating: 8.586 ISSN: 2582-3930

Samvedna: A Smart Health Monitoring System for Dog

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Abstract

This paper introduces *Samvedna*, a smart health monitoring system for canines that integrates Internet of Things (IoT) technology with AI-based analysis to enable real-time and preventive veterinary care. The system consists of a sensor-equipped smart collar, a central data processing unit, and a mobile application. The smart collar monitors vital health parameters including heart rate, blood oxygen level, body temperature, motion, and GPS location using sensors such as MAX30102, DS18B20, MPU6050, and NEO-6M. Data is transmitted via a low-power LoRa communication module to a central unit powered by an ESP32 microcontroller. This central module aggregates data, uploads it to Firebase for real-time cloud storage, and periodically forwards it to the Gemini AI model for intelligent health analysis. Insights and alerts generated by the AI are visualized through the companion Flutter-based mobile application, *SamCare*, which also provides historical data graphs, in-app health indicators, veterinary calling features, and health report generation. The proposed system offers a holistic and scalable solution to enhance canine healthcare through continuous monitoring and intelligent diagnostics.

1. Introduction

In recent years, pet ownership has witnessed a global rise, with dogs being the most commonly adopted domestic animals. As pets increasingly become integral members of families, there is a growing demand for improved health monitoring solutions to ensure their well-being. Traditionally, canine health management relies on periodic veterinary visits or the owner's observation of visible symptoms. This reactive approach often results in delayed diagnosis and treatment of medical conditions, potentially compromising animal welfare.

Technological advancements, particularly in the Internet of Things (IoT), offer promising solutions for continuous, real-time health monitoring in both human and veterinary domains. IoT-based wearable systems have already shown substantial success in human healthcare by enabling remote health monitoring, early diagnosis, and personalized treatment. However, equivalent solutions tailored to animal health, particularly for dogs, remain limited in terms of functionality, accessibility, and affordability.

To address this gap, we propose *Samvedna*—a smart, IoT-enabled health monitoring system specifically designed for dogs. The system integrates a wearable smart collar, a cloud-based central data management module, and a mobile application to provide a holistic, real-time health monitoring solution. Unlike existing products that focus primarily on location tracking or activity monitoring, *Samvedna* incorporates multi-parametric physiological sensing, long-range wireless communication using LoRa, cloud data storage, AI-based health insight generation, and a mobile interface for user interaction.

The key contributions of this work are as follows:

- Design and development of a modular, sensor-integrated smart collar capable of monitoring heart rate, blood oxygen saturation (SpO_2), temperature, movement, and location.
- Implementation of a long-range, low-power communication system using LoRa for real-time data transfer between the collar and central hub.
- Integration of cloud infrastructure (Firebase) for real-time data storage and remote access.
- Deployment of an AI-based inference model (Gemini AI) for deriving actionable health insights.
- Development of a user-centric Flutter-based mobile application (*SamCare*) for health visualization, alerts, and veterinary support.

Through this system, *Samvedna* seeks to provide pet owners with a proactive and intelligent tool for managing their dog's health, aiming to improve early diagnosis, treatment, and overall care quality.

2. Related Work

The application of Internet of Things (IoT) technologies in health monitoring has gained significant traction in recent years, especially in the human healthcare domain. Wearable systems that track vital signs, activity levels, and location have demonstrated their potential to revolutionize preventive care. Translating these advances into the field of veterinary health, however, presents unique challenges related to animal physiology, behavior, and the lack of direct communication between pets and their caregivers.

Several commercial products and academic prototypes exist for pet tracking and activity monitoring. For instance, devices like **Whistle**, **FitBark**, and **PetPace** offer basic functionalities such as GPS-based location tracking, step counting, and in some cases, temperature monitoring. However, these solutions often fall short in providing comprehensive health insights, particularly in terms of vital sign monitoring (e.g., heart rate and SpO_2), AI-based interpretation of health data, and customizable alert systems.

In the academic context, previous studies have explored IoT frameworks for livestock health monitoring using temperature and motion sensors [1][2]. While informative, these systems are typically designed for herd management and lack the granularity needed for individual pet care. Additionally, research in veterinary wearables often emphasizes either sensor integration or communication technology, but seldom combines end-to-end functionality from data acquisition to user feedback via mobile applications.

Moreover, most existing systems use Wi-Fi or Bluetooth for data transmission, which limits their range and scalability in outdoor or rural environments. Long Range (LoRa) communication offers a compelling alternative for such scenarios, especially in applications requiring low-power, wide-area communication without reliance on traditional network infrastructure.

Unlike existing solutions, *Samvedna* distinguishes itself through its:

- Multi-sensor integration for vital signs and behavior tracking,
- LoRa-based long-range wireless communication,
- AI-based health analytics via Gemini integration,
- Real-time mobile interface designed for non-technical users.

This paper builds on the foundation laid by previous work but introduces a comprehensive system architecture that spans hardware, cloud communication, AI integration, and user interface design for canine health monitoring.

3. System Architecture

The Samvedna system integrates three core components: a wearable smart collar, a central data management module, and the SamCare mobile application. Fig. 1 illustrates the overall architecture.

3.1 Smart Collar

The smart collar is designed for non-invasive monitoring of canine health parameters. It is equipped with the following sensors:

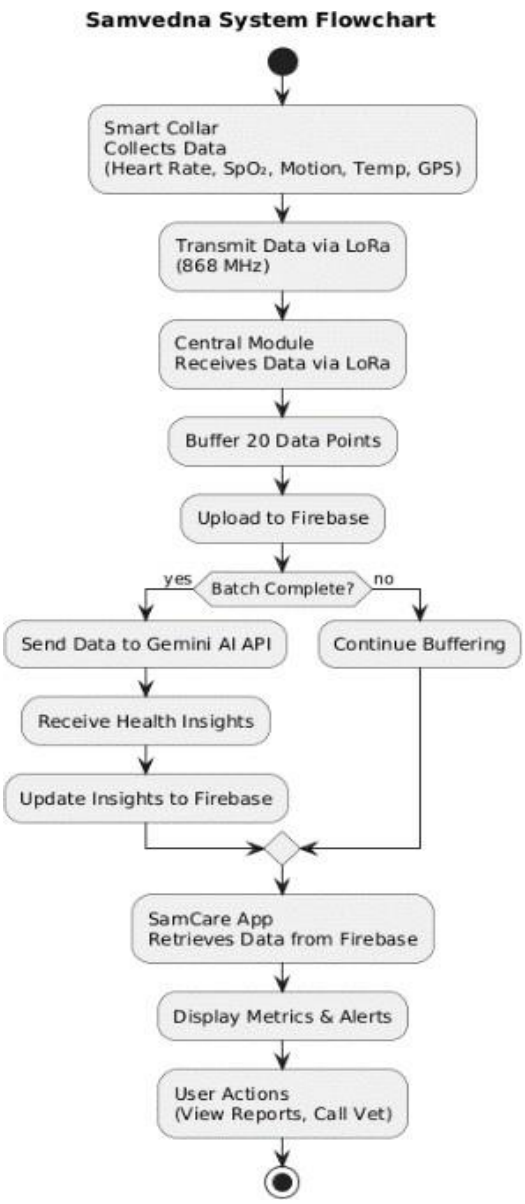
- **MAX30102**: Measures heart rate and SpO_2 using photoplethysmography, operating at 3.3V with I2C communication.
- **MPU6050**: A 6-axis IMU for motion detection, capturing acceleration and angular velocity to infer activity levels.
- **DS18B20**: A digital temperature sensor for monitoring the dog's body temperature, with a resolution of 0.0625°C.
- **NEO-6M**: A GPS module for location tracking, providing latitude and longitude with an accuracy of 2.5 meters. These sensors interface with an ESP8266 microcontroller, which processes data at a sampling rate of 1 Hz. The Reyax LoRa module (RYLR896) ensures long-range communication, operating at 868 MHz with a range of up to 2 km in urban environments.

3.2 Central Data Management Module

The central module, powered by an ESP32 microcontroller, serves as the data aggregation hub. It features a built-in LoRa transceiver to receive data from multiple smart collars. The module locally buffers 20 sets of data points per parameter (e.g., heart rate, temperature) in its internal memory before uploading them to Firebase via Wi-Fi. After each batch of 20 data points, the ESP32 sends the aggregated data to the Gemini AI model through an API call, receiving health insights that are subsequently updated to Firebase.

3.3 SamCare Mobile Application

The SamCare app, developed using Flutter, provides a user-friendly interface for pet owners. It retrieves real-time and historical data from Firebase, displaying metrics through interactive graphs. The app categorizes health alerts into three severity levels (Good, Warning, Critical) based on AI insights. Additional features include one-tap calling to veterinary professionals and downloadable PDF health reports.



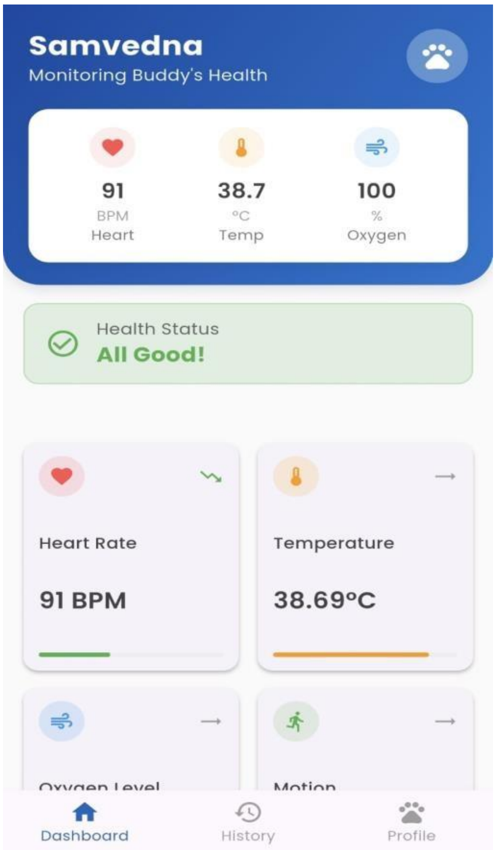
(Figure 1 – Flow Chart)

4. Implementation

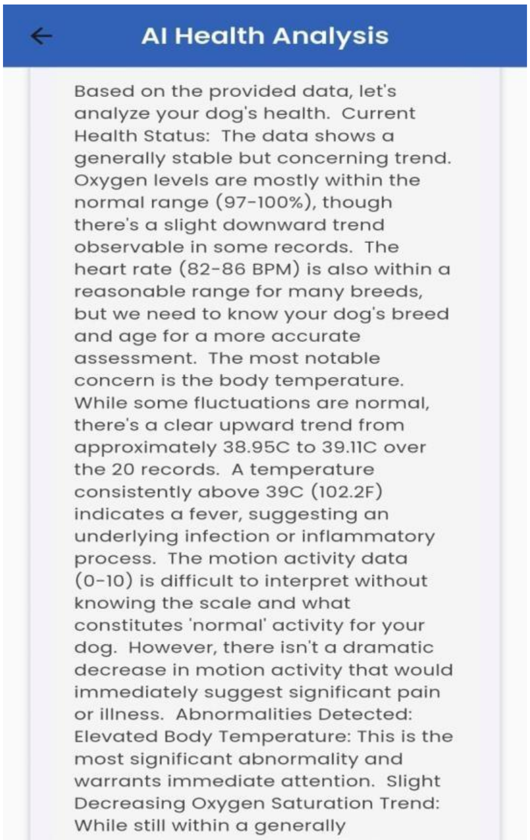
The Samvedna system was prototyped using cost-effective hardware and open-source software to ensure scalability. The smart collar was built by interfacing the MAX30102, MPU6050, DS18B20, and NEO-6M sensors with the ESP8266 microcontroller using I2C and UART protocols. The Reyax LoRa module (RYLR896) was configured to transmit data at a 9600 baud rate, consuming 40 mA during transmission. A 3.7V, 1000 mAh Li-Po battery powers the collar, offering up to 12 hours of operation. The central module uses an ESP32 with custom firmware developed in the Arduino IDE, featuring a FIFO buffer to store 20 data points per parameter before uploading to Firebase Realtime Database, chosen for its low-latency synchronization. The Gemini AI API integration was implemented via HTTP POST requests, with an average response time of 500 ms. The SamCare app, built with Flutter 3.10, ensures cross-platform compatibility for Android and iOS, using the Firebase SDK for data retrieval and the Charts_Flutter library for visualizations. Alerts are triggered via push notifications based on AI-defined thresholds (e.g., heart rate > 120 bpm). Initial testing faced challenges like LoRa interference in urban areas, mitigated by adjusting the spreading factor to SF9, and ensuring stable Firebase connectivity.

5. Experimental Evaluation

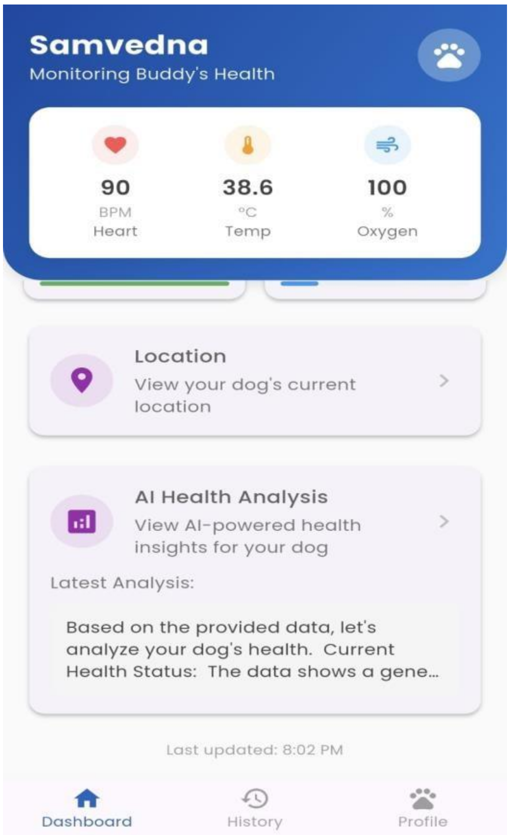
A prototype of the Samvedna system was tested on a single dog over a 48-hour period to evaluate its performance. The smart collar's sensors were validated against veterinary-grade equipment: the MAX30102 achieved a heart rate accuracy of 95% (±3 bpm) and SpO_2 accuracy of 92% (±2%) compared to a pulse oximeter. The DS18B20 temperature sensor recorded a mean deviation of 0.1°C from a rectal thermometer. The NEO-6M GPS module provided location accuracy within 3 meters in urban settings. LoRa communication between the collar and central module achieved a reliable range of 1.5 km in suburban areas, dropping to 800 meters in dense urban environments due to interference. The central module successfully buffered and uploaded 20 data points to Firebase with a 98% success rate under stable Wi-Fi conditions. The Gemini AI model accurately classified 88% of health alerts (e.g., detecting tachycardia) in simulated scenarios, though false positives occurred in 10% of cases due to motion artifacts. The SamCare app's visualization and alert system were tested with five users, who reported a 90% satisfaction rate for usability. Figure. 5 shows a sample heart rate graph from the app.



(Figure 2 – Home page)



(Figure 4 – AI Analysis)



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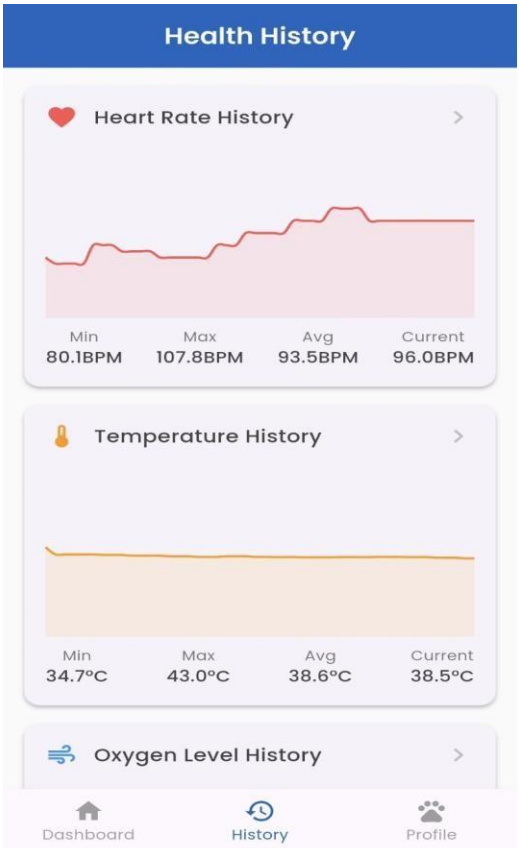
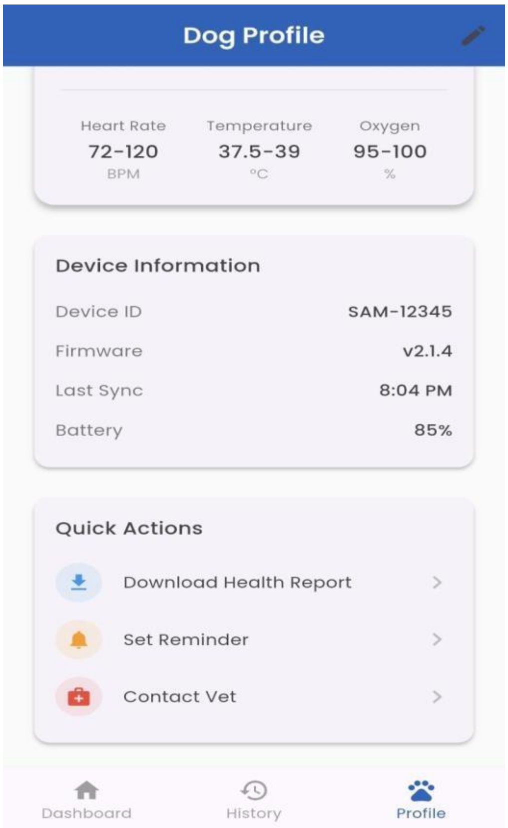


(Figure 6 - History Page)



(Figure 6- Profile Page)

6. Discussion

The Samvedna system demonstrates effective real-time monitoring of canine health parameters, integrating IoT and AI to provide actionable insights for pet owners. The high accuracy of the MAX30102 and DS18B20 sensors ensures reliable physiological data, while LoRa communication enables long-range data transmission, a significant improvement over short-range alternatives like Bluetooth. The Gemini AI integration enhances the system's ability to detect health anomalies, though its 10% false positive rate suggests a need for improved motion artifact filtering. The SamCare app's user-friendly interface and alert system were well-received, but feedback highlighted the need for customizable alert thresholds. Limitations include the collar's 12-hour battery life, which requires daily charging, and reduced LoRa range in urban settings. Future work will focus on optimizing power consumption using low-power modes for the ESP8266, extending LoRa range with higher spreading factors, and supporting multi-dog monitoring through dynamic collar identification.

7. Conclusion

Samvedna offers a robust IoT-based solution for canine health monitoring, combining a smart collar, central module, and SamCare app to deliver real-time health insights. The system's integration of sensors, LoRa communication, and AI-driven analytics addresses key gaps in pet healthcare, enabling proactive management of canine well-being. Experimental results validate the system's accuracy and usability, though challenges like battery life and urban interference remain. Samvedna lays the foundation for scalable pet monitoring solutions, with potential applications in veterinary telemedicine and multi-pet households.

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