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IOT-Enabled Smart Collar for Pet Animals

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Abstract: Pet health is a serious consideration for modern pet owners, particularly because pet owners have steadily moved to using more smart monitoring systems. Traditional pet-tracking solutions were typically isolated by health monitoring and location monitoring systems not interfaced together in a one small monitoring system. This project addresses these concerns by proposing a wearable device with a mobile application that will monitor a dog's vital parameters and location in real-time. The results are based on the use of a wearable system using a ESP32 microcontroller to interface with a NEO-6M GPS module to collect and report the location along with a LM35 temperature sensor to gather the dog's body temperature and a pulse oximeter sensor that will collect SpO2 and heart-rate data. The ESP32 will use its built-in Wi-Fi capabilities to transmit that data to Firebase to allow a seamless connection to the Android application. The Android application will communicate with Firebase to retrieve location and health metrics and display on the application. The application will allow members to customize geofencing parameters and track location so that if a dog moves away from the designated plus or minus geofencing boundaries alerts are sent to its' users. The wearable uses a small, efficient, and effective monitoring system that will allow users to monitor their pet in real-time and improve pet care and owner awareness.

Keywords: *Pet Monitoring, Wearable Device, Real-Time Tracking, ESP32 Microcontroller, Geofencing, Health Sensors, Android Application, Firebase Communication*

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I. INTRODUCTION

The Internet of Things (IoT) has become ubiquitous across a variety of disciplines, including the world of pets, where remote health and safety monitoring are increasing in importance. This project proposes an intelligent, smart monitoring system for pets by combining a wearable device with a mobile application, which tracks location and vital health measurements. The system consists of a wearable vest, containing sensors and microcontroller, and an Android application that allows the pet owner to monitor their dog's condition. The vest itself uses an ESP32 microcontroller with Wi-Fi capabilities, a NEO-6M GPS module, LM35 temperature sensor, and a pulse oximeter, in order to gather relevant information. Once the data is gathered, it is transferred securely to Firebase using a dedicated API. After this retrieval of data is transferred to the Android application, the Android app displays the data in real-time, and allows the user to set dynamic geofencing limits. If the dog exits the specified boundary, the user is instantly alerted on the accompanying Android application. The proposed system utilizes real-time data collection, wireless communication, and mobile access to provide an accessible and effective smart pet monitoring.

II. RELATED WORKS

As pet-centric IoT applications have emerged, various researchers have investigated wearable technology and mobile devices to track pet health, safety, and location in real time. The goal is to improve pet welfare whilst being considerate of device power consumption, development costs, and datacosts.

Joshua William D. Cervania et al. [1] designed a wearable vest for typically companion dogs, along with an associated Android application, which included a GPS, GSM, Bluetooth, and health sensors, which were connected through a NodeMCU. The device supported real-time tracking of location, temperature, and pulse, and included a locking alarm and geofencing alerts. The system provided reliable data transfer, and reasonable accuracy for health metrics. The study found IoT supported pet care. Maximilian Haverkämper [2] presented a Smart Dog Collar which introduced an ideal level of comfort versus functionality or data collection. The collar utilized GPS, IMU, and temperature sensors for location, heart rate, and environmental monitoring. The product was evaluated on a number of iterations and different breeds of dog, and found that while there was good success with comfort levels, heart rate readings could be impacted because of thick fur. The study identified some opportunities to improve sensor accuracy. Jayesh Sharma [3] created an Arduino Uno, SIM800A and NEO 6M based vehicle tracking system which

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utilizes GPS and GSM technologies. The design methods shown in the original research paper are relevant to GPS data acquisition and cloud transmission through cloud services (Amazon Cloud & MySQL), and therefore these design methods can be modified for applications with pet tracking characteristics. Mayank Kumar Jarwal et al. [4] present a low-cost location tracker with forwarding emergency alerts functionality. Location data was collected and stored in a secure data base as well as providing a mobile app to collect securely, that allows to give an update or alerts based geofences which will increase safety with real time updates. IJSREM Journal [5], the use of Firebase's real-time data synchronization capability to develop a mobile application was investigated and demonstrated the abilities of updating or modifying data, and resolving synchronization conflicts when using Firebase's real-time data updates. The results presented demonstrates the usefulness of firebase for systems that require communication and procedures with pet tracking characteristics with real-time capabilities. Chunnu Khawas and P. Shah [6] conducted an investigation into using Firebase for building Android apps that contain unstructured data, and provided valuable knowledge on the advantages of using firebase, methods for integrating firebase into existing systems, and how multimedia data can be processed through Firebase, available knowledge that you can use when developing an application for a competent pet-care application. Contardi et al. [7] developed a medical device prototype using a photometric biosensor with the ESP32 to monitor real-time oxygen and heart rates. The ESP32 was a great tool for using low-cost electronics very similar to a wear pet health system that requires real-time physiological measurement.

Considered collectively, these works show the growing need for lightweight, real-time, and reliable IoT systems to improve pet care through wearable tech and cloud-integrated mobile platforms.

III. PROPOSED METHODOLOGY

In the research that was presented in this study, the researchers utilized the descriptive research method for data collection and results. Descriptive research is defined as describing the characteristics of the subject and/or phenomenon being studied and therefore focuses on the "what" as opposed to the "why", which is the research topic. There are three methods of descriptive research used to collect this information: case study, survey, and observational method. For this project, which focuses on monitoring the location and health of dogs, we used two of the descriptive research methods: observation method and case study. In using the observational method, the researchers engaged in the analysis of the dog's behavior and its health conditions. This was done by taking note of the dog's naturalistic behavior; meaning that the dog's activity was observed as it happened in a natural context, without interference from the researchers. In addition, the researchers conducted laboratory observations; which were to observe whether the device continued to operate during the dog's activities, and to see how it rated for endurance, whether it stayed attached to the dog. In using the case study method the researchers observed and documented what occurs in the behavior of the dog while using the wearable device, and the dog's health conditions over time. The research used the case study method to build a history of the dog's health and location data; monitoring changes as observed by the researchers they were able to cover all aspects of monitoring the dog's vital signs and movement patterns.

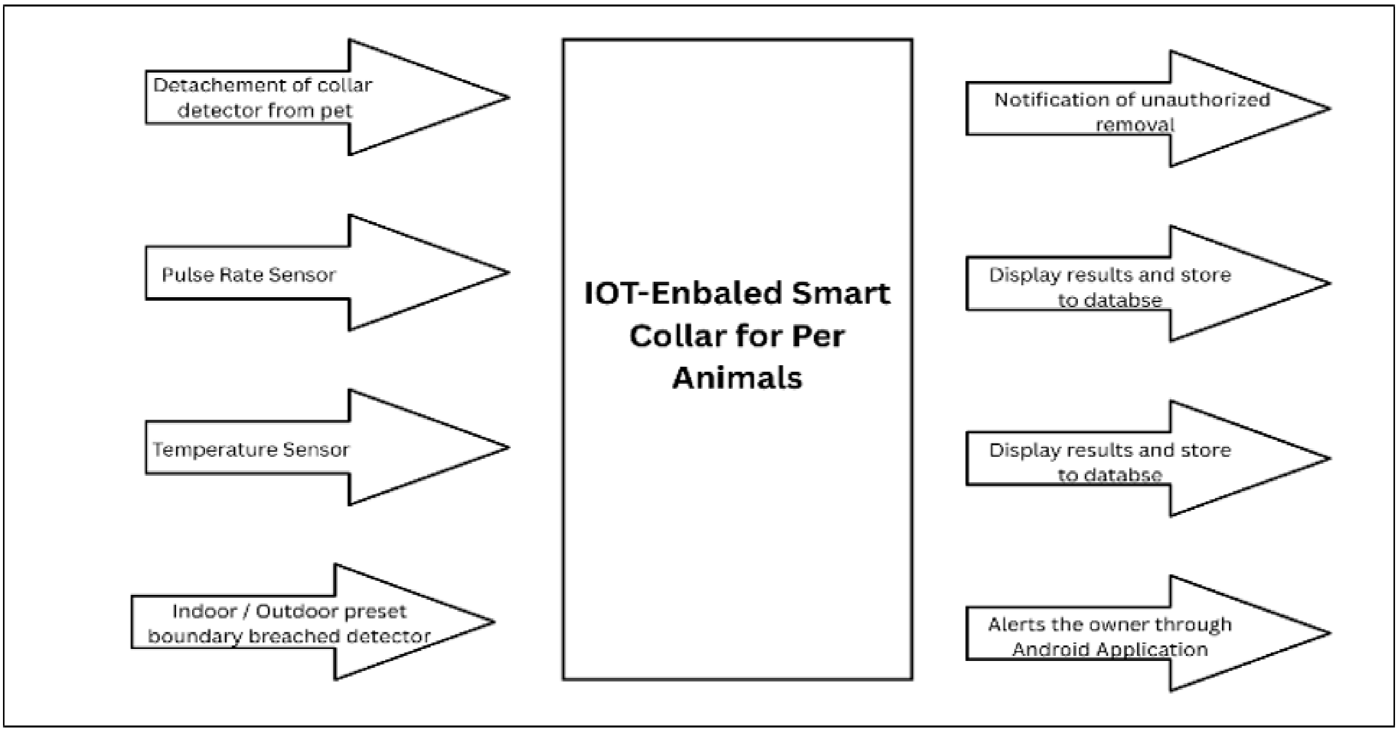

Fig 1 Level 0 Diagram of IOT-Enabled Smart Collar for Pet Animals

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Fig. 1 illustrates the level 0 diagram of the "IOT-Enabled Smart Collar for Pet Animals". It shows that the prototype relies on five inputs. It needs to process the inputs which are the detachment of dog vest, reading of the three sensors and the breach of the set boundary using geofencing. But the owner needs to use the application to measure the dog's health condition, the dog collar will notify the owner if the dog have exceeds the boundaries of geofence, and it will trigger an another alarm and will send the last location of the dog's whereabouts on the application if somebody had detached the dog's collar.

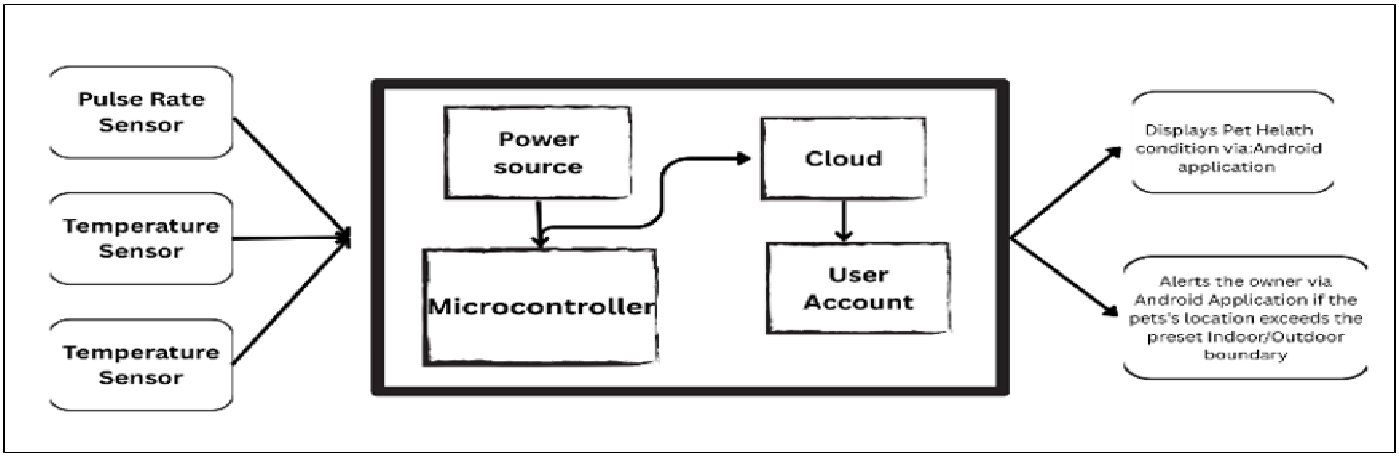

Fig 2 Level 4 Diagram of IOT-Enabled Smart Collar for Pet Animals

Fig. 2 Illustrates the Level 4 Block Diagram of IOT_Enabled smart collar for Pet Animals. The inputs are Geofence boundary breached Detector, Temperature Sensor and Pulse Rate Sensor. The outputs of the prototype are the following: 1.) It will help the owner to monitor pet health through mobile application. 2.) It will alert the owner through mobile application if the dog breached the geofence boundary. The GPS module is the one that is responsible for getting the GPS coordinates.

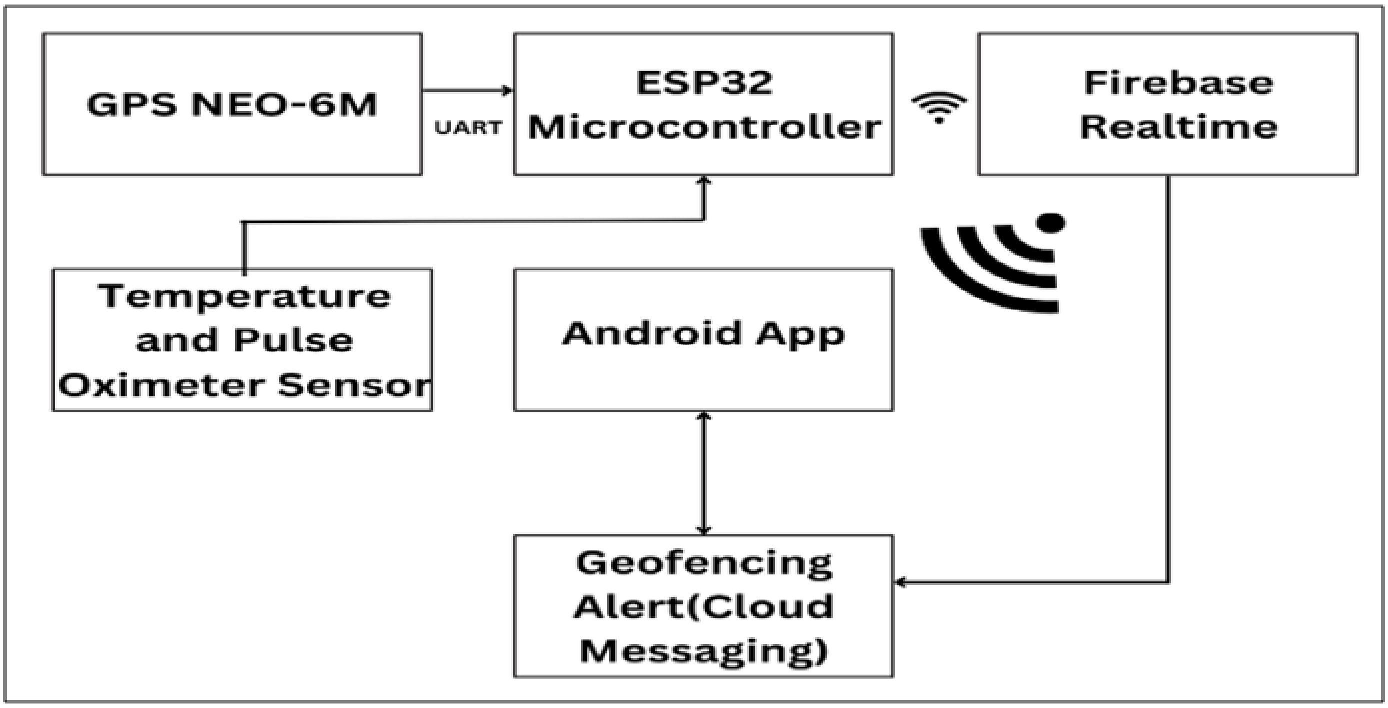

Fig 3 System Architecture Diagram

Fig 3 shows a health and location monitoring system. The ESP32 microcontroller serves as the main unit. It connects to the GPS NEO-6M module through the UART to obtain the real-time location data. The ESP32 also collects health-related data from the temperature and pulse oximeter sensor. It transmits all collected data via wireless connection to the Firebase Realtime Database. An Android application connects to this database and shows the user all the live data. Additionally, the Android application features a geofencing function that sends notifications using cloud messaging if the user moves outside of the established area. Overall, it allows continuous health and location monitoring and alerts on the integrated mobile platform.

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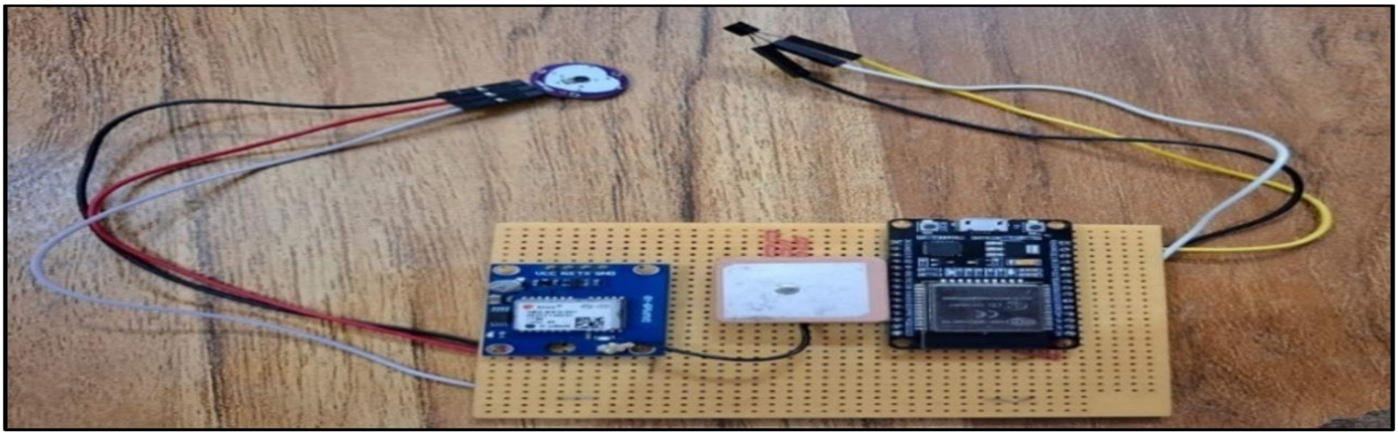

Fig 4 Hardware Setup

The hardware system of the IoT-enabled smart collar for pet animals is shown in Figure 4 with a GPS module, a pulse oximeter sensor, a temperature sensor, and an ESP32 microcontroller module with integrated Wi-Fi to transmit information in real time. All electronic components will be mounted onto a perforated board to create stable connections and facilitate easy integration, permitting continuous tracking of a pet's location and health parameters.

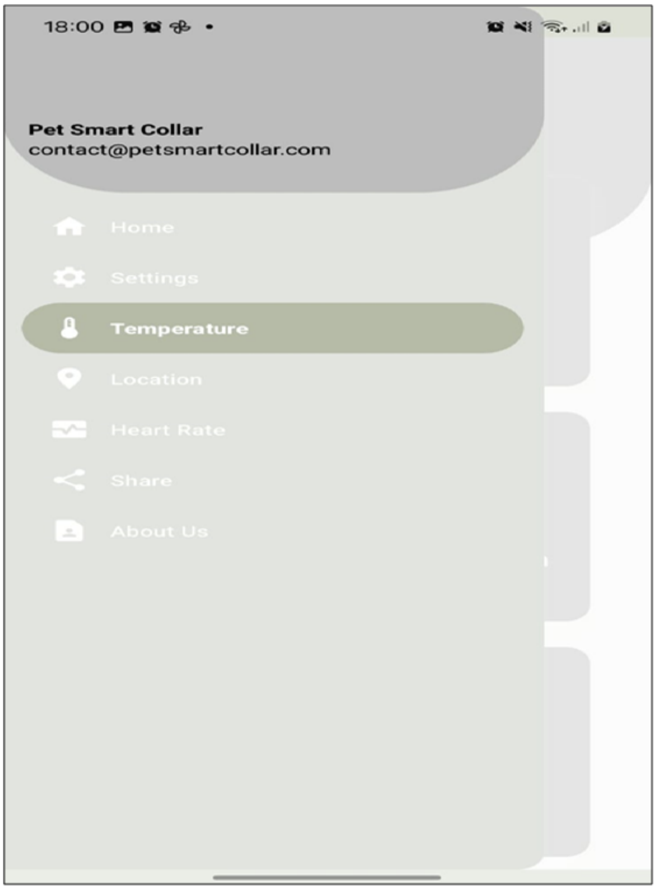

Fig 5 App Interface

Fig 5 shows the dashboard of the mobile application. The app provides the main dashboard of our mobile application, with options for users to view the pet's location, temperature current location, and pulse rate data. Users can click on these three options to receive the information they seek.

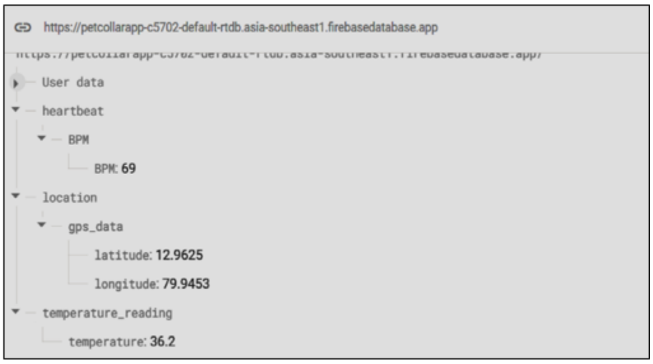

Fig 6 Firebase Realtime Database

Fig 6 presents a view of the Firebase Realtime Database, where the ESP32 microcontroller ultimately stores pet sensor data in JSON format. Pet data includes heartbeat (in BPM), body temperature, and GPS data (latitude and longitude). The ESP32 organizes the pet sensor data and is periodically sent wirelessly to Firebase. With real time data made available to the Android app, the pet's health and location can be monitored.

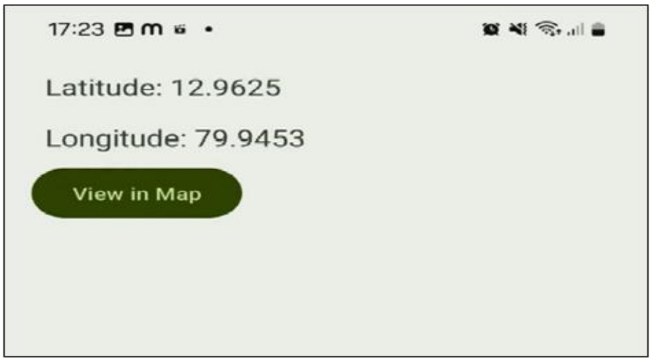

Fig 7 Display Location Coordinates

Fig 7 depicts the user interface of the Android application showing the real-time GPS locations of the pet showing the latitude and longitude values obtained from the Firebase Realtime Database. it shows that the system has a button that says "View on Map" which enables users to view their pet’s current location on a map. Moreover, this application's button improves accessibility and provides real-time monitoring.

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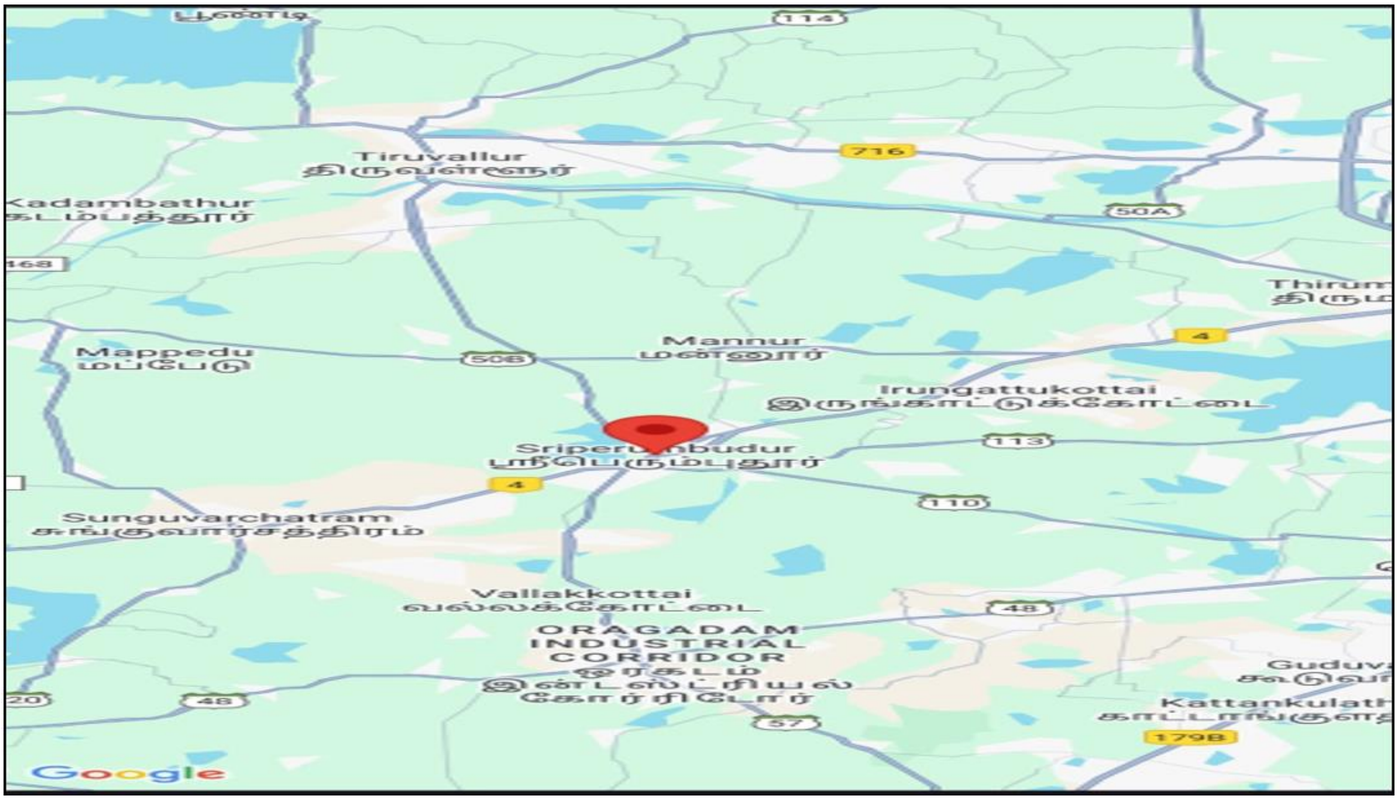

Fig 8 Location Mapping

Fig 8 displays the location of the pet on Google Maps, pinpointed based on the latitude and longitude coordinates retrieved from the Firebase Realtime Database. As shown, the pet is located in Sriperumbudur, Tamil Nadu. This map integration helps users visualize the exact geographical position of the pet, enhancing the real-time tracking feature and ensuring the pet's safety through precise location monitoring.

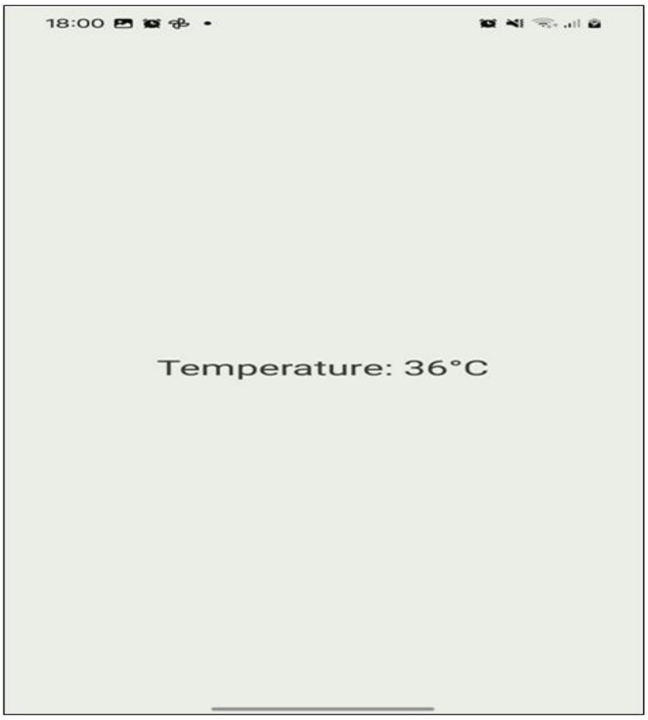

Fig 9 Display of Temperature Data

Fig 9 shows the temperature reading displayed on the mobile application,. This temperature data is likely gathered through a LM35 sensor connected to the pet's collar or tracking device and transmitted in real-time via a cloud database. Monitoring the pet's surrounding temperature ensures that the pet is not exposed to extreme environmental conditions, thereby supporting its health and safety

Fig 10 Display of Heart Beat

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Fig 10 displays the heart rate reading of the pet, Monitoring the heart rate helps in tracking the pet's physical health and detecting any abnormalities at an early stage, ensuring timely veterinary care if required.

IV. SUMMARY OF FINDINGS

➢ *This Study Summarizes the following findings:*

- The acceptance test of IOT-Enabled smart collar for pet Animals showed that once the device is attached to the dog, it is able to reliably collect and record health data including pulse, respiratory rate, and temperature using the sensors included in the device.
- The acceptance test of the GPS module indicated that the device was able to successfully track the real-time location of the dog, and that the device was able to generate a location alert if the dog moved out of a defined safe zone.
- The acceptance test of the Wi-Fi connectivity showed that health and location data could be sent to the Android application over the network, which allows for the owner to see the status of their dog in real time.
- The acceptance test of the Android application showed that the owner is able to monitor the dog's health and location, view the data in daily, weekly and monthly format, and toggle between indoor and outdoor monitoring mode, to allow for better tracking and analysis.

V. CONCLUSION

➢ *This Study Concludes the following:*

- To achieve accurate location tracking using the GPS module, the placement of the device on the vest was carefully considered for optimal outdoor signal performance. The system uses Wi-Fi connectivity to transmit the location data to the owner's application, ensuring reliable communication within the expected range.
- To verify the accuracy of the dog's vital signs, we compared the recorded values (pulse, respiratory rate, and temperature) with actual reference values and calculated the percent error. Correctly placed sensors on the dog's body were crucial to get a valid reading.
- For the Android application to accurately monitor the dog's health and location, it was critical all components (sensors, GPS, Wi-Fi) were correct and working together.

RECOMMENDATIONS

➢ *This Study Recommends the following:*

- To improve the accuracy of getting the exact location of the dog using the GPS module for outdoor mode, the placement of the module in the dog's vest needs to be optimized for better signal reception.
- To improve the accuracy of the dog's vital signs, future researchers should test the device multiple times to achieve consistent and reliable readings for respiratory rate, temperature, and pulse rate.
- To improve the vest design, future researchers should make the vest adjustable to fit different dog sizes and breeds comfortably.
- To enhance the operating time of the devices embedded in the vest, future researchers should use a battery with higher capacity to allow longer continuous use.
- To improve the embedded circuit, future researchers should consider using smaller, lightweight modules and components to reduce the overall weight of the vest for better comfort.

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