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Original Article

RESEARCH AND TRACKING OF STRAY DOGS USING IOT AND RFID TECHNOLOGY

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ABSTRACT

Stray dog overpopulation has become an increasingly urgent concern, especially in densely populated urban centers as well as in less regulated rural areas. If left unchecked, the proliferation of stray dog populations can result in a whole range of problems, from dog bite cases to the spread of zoonotic diseases like rabies, and even damage to local ecosystems, apart from concerns about animal cruelty and neglect. While many government and non-government organizations are working tirelessly to address these problems through sterilization, vaccination, and rescue efforts, their efforts are often piecemeal and reactive. One of the key areas where there is a clear gap is the lack of a technology-driven platform that allows for real-time reporting, tracking, and monitoring of stray dog populations. This lack of a structured approach results in wasteful efforts and missed opportunities for intervention. It is in this context that the current project seeks to address the need for a comprehensive and technology-driven solution that leverages a web-based interface, real-time GPS tracking, and RFID-based identification to better manage stray dog populations. With this approach, it becomes possible not only to address citizen reports more effectively but also to tap into a rich source of data that can be used for planning interventions that are preventive and welfare-oriented.

Keywords: IoT-Based Monitoring, RFID, GPS Tracking, Real-Time Reporting, Urban Stray Management

INTRODUCTION

Stray dogs are likely to suffer from adverse conditions including hunger, injuries, bad weather conditions, infections, and these conditions not only affect the dogs, but also present a serious risk to public health and safety. Their presence can result in traffic accidents, the spread of zoonotic diseases like rabies, at the same time violent reactions brought on by hunger or fear in town and cities. If these issues do not get solved, they might become a significant the public's worry that calls for cooperation between the public and government officials. mainly to the lack of a digital platform, traditional methods like a manual reporting, physical capture, and offline adoption campaigns are typically inefficient, unpredictable and difficult to scale. Essential information like the location, health, or rescue status of the dogs is not normally available and retrievable, which affects decision-making and further actions.

The goal of this research project is to offer an effective and technologically advanced solution to these problems. A digital platform designed with the Django web framework and integrated with RFID and GPS technology will be used to classify the pulse rate using the Random Forest machine learning algorithm. This digital platform will help effective and scalable management of stray dogs monitoring. And these allowing users to report dog sightings, indicate interest in adoption, and help with tracking the location and identity of dogs using sensor-based systems. These Additionally help with, the digital platform allows administrators to monitor

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trends such as stray dog hotspots, locations that are frequently reported, and the history of animals that have been tagged. Such real-time data analysis can greatly improve rescue efforts, streamline immunization and sterilization programs.

Real time data monitoring is like this can enhance rescue missions, findings sterilization and vaccination programs, and help in animal welfare plans. Also, the system is built to send alerts for critical situations involving dogs that are hurt or unresponsive, guaranteeing that rescue teams respond quickly. By disseminating information about adoption events, vaccinations, and responsible pet ownership practices, it raises public awareness. The platform supports transparent operations and active citizen participation through mobile accessibility and secure data management. In order to achieve humane, effective, and sustainable stray dog manage in urban areas, this project imagines a cooperative and include ecosystem where communities, NGOs, veterinary professionals, and local authorities empowered by smart technologies collaborate.

REVIEW OF RELATED LITERATURE

Jena et al. (2025) Free-roaming dogs are a better preventing rabies strategy, based on an analysis of the terminology, and it's used for unrestricted dogs. The research claims that the frequent use of derogatory language leads to harmful actions like removing instead of sensitive management. The authors pointed out that the best ways to control dog populations and the spread of rabies are mass vaccination (70% coverage) and sterilization. Thus, speaking with understanding can increase public awareness and support long-term efforts to prevent rabies. Jena et al. (2025).

Hussain et al. (2022) developed a wearable device system to observe the health of COVID-19 patients using physiological data. The system collected data such a body temperature, pulse rate, blood pressure, and oxygen levels for real-time monitoring. A Random Forest classifier used to analyze the sensor data in order to find the level of infection or goodness of the patients. The 99.26% accuracy of the proposed model indicate the value of AI-based wearable monitoring for remote healthcare management Hussain et al. (2022).

Peng He (2023) highlights the most major compromises within sampling extent, duration, and rate and offers a thorough guide for designing GPS studies of animal social behavior. The article points out, how important this design factors are to data quality and behavioral conclusion accuracy Peng He (2023).

Emanuel Pereira (2023) mixed patent analysis from 2009 to 2023 with scientific literature to perform a comprehensive analysis of the use of RFID technology in animal tracking. The article points out the use of passive UHF RFID tags for animals tracking as the main application because of their affordability. The application of RFID technology in conjunction with other technologies such as GPS and cameras is also highlighted for enhancing tracking systems Emanuel Pereira (2023).

Dickson Tayebwa (2022) examined into the effects of rabid dog attacks on Central Ugandan peoples. According to the study, two rabid roaming dogs attacked 18 domestic animals and 29 people, with children making up the majority of the victims. There are gaps in knowledge and access to healthcare, as evidenced by the fact that many victims first sought treatment from traditional healers rather than medical facilities. In order to lower the number of rabies cases, the authors stressed the importance of better healthcare access, public education, and roaming dog control Dickson Tayebwa (2022).

Fatma Nur Yasar (2021) concentrate on an IoT-based feeding system to give a remedy for malnutrition in stray animals through systematic and reliable food distribution. The proposed system integrates weight sensors, Arduino controllers, and LPWAN (LoRa) technology for real-time monitoring of food stocks and data transfer. A friendly interface using Blynk allows volunteers and managers to track feeding points and advantages for stray animals. A pilot implementation in Kadıköy (119 private vets), Istanbul, confirms the practicability of the system with cost evaluation and scalability Fatma Nur Yasar (2021).

Alfin Fernandha Pratama (2021) Though existing studies are based on scheduled feeding and monitoring, they do not have a specific system for outdoor stray cat care. Studies involving image recognition or PIR sensors concentrate on detection rather than real-time health and feeding monitoring. Most studies reviewed disregard the combination of feeding, watering, and real time outdoor monitoring. This study bridges the gap by proposing an IoT-capable system with image processing, smartphone operation, and real-time stray cat condition monitoring Alfin Fernandha Pratama (2021).

Todorov and Stoinov (2020) developed an IoT-based farm management system to automate animal monitoring, reducing human involvement and increasing productivity. The system uses the ESP8266 Wi-Fi module for wireless data transfer and an expert system for analysing animal health factors like milk quality and somatic cell count. To provide secure data transfer, the system applies MD5 and SHA1 hashing for authentication and integrity checks. A high-level protocol on HTTP is designed to overcome the limitations of resource-constrained devices Todorov and Stoinov (2020).

PROPOSED METHOD

The system worked on ESP32-based device with RFID, GPS, and a pulse sensor to identify, locate, and monitor stray dogs. User via reports is managed by admin, enabling quick rescue, health condition, and adoption Figure 1. And the hardware part of the system includes ESP32 microcontroller, RFID Reader (MFRC522), RFID tags (attached to dogs), Pulse sensor (measure pulse rate) and Wi-Fi module (data transmission).

The software system used Django web application, database for storing dog records. This system's user-friendly and designed web interface for reporting and adoption greatly improves community involvement in the welfare of stray dogs. By providing important details like their name, mobile number, the location of the incident, the time, and the reason, citizens can easily report dogs that are hurt, lost, or dead. This makes it possible for the relevant authorities to react to the incident quickly and give priority to those who require immediate attention. A report about a dead dog beneath a parked car on campus, for example, show how accurate user input is crucial for efficient case verification and response. Additionally, the system allows adoption requests, which offer user details and dog profiles, encouraging a clear and well-organized procedure for shelters. The system allows adoption requests, user information and dog profiles, in general, the system promotes accountability, timeliness, and public and animal welfare authorities' collaboration. And then used to classify the Random Forest algorithm to find pulse rate values into different health conditions. The dataset contains pulse values and activity status, which are used as input features. The model is trained using labelled data and then used to predict the health condition of dogs.

The health conditions are categorized in Normal, Low Abnormal, High Abnormal, Very High Abnormal, No Pulse. The proposed Internet of Things system was successfully developed and implemented using a combination of RFID, GPS, and physiological data sensing technologies to classify pulse readings and track and monitor stray dogs.

The Report Form module allows citizens to take an active role in the rescue of stray dogs in distress. The module has a friendly interface where users can report, provide the location, and point it out on the map. There is also a description box where the user can enter information regarding the status or actions of the dog. To help in easier identification, the user can enter pictures of the dog and the surrounding area, such as landmarks and shops. These help the rescue teams in finding and understanding the situation. The form utilizes all of the data including location, images, and descriptions is saved in the backend for later processing. this form providing their name, mobile number, and adoption reason, anyone can apply for the adoption of a stray dog using the Adoption Form module. This helps organizations in understanding the applicant's goals. For safe data processing, the form uses secure server side techniques like CSRF.

This information is store and working by the admin based action, such as interviews and home visits. This module helps in proper and efficient pet adoption.

Figure 1

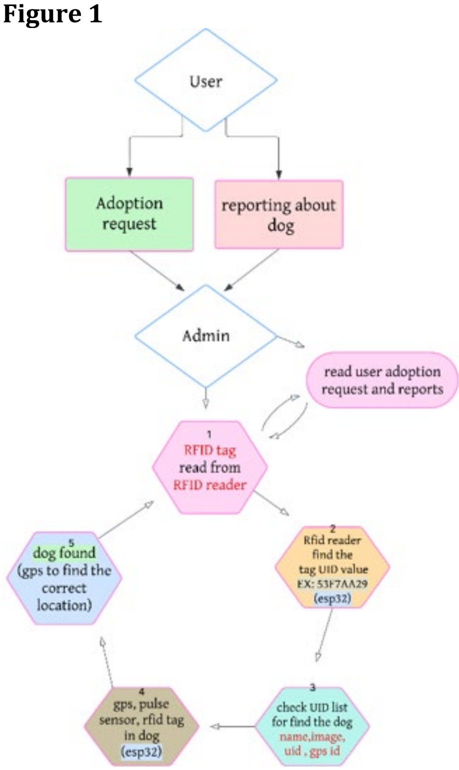

Figure 1 Framework for Stray Dogs Management

The admin interface is a significant component of the system and is utilized for the management and processing of user-submitted data from both the Report Form and Adoption Form modules. Through the Report Form, citizens are able to take an active role in the rescue of stray dogs by submitting information such as the location of the dog, which is shown through an interactive map, information about the dog's condition, and images of the dog and the surrounding landmarks. These submissions are safely stored in the backend and are accessible by the admin for further review and action. The Adoption Form module is utilized for the collection of necessary information such as the name, contact details, and reason for adoption, which enables the admin to make a determination of eligibility for pet adoption. All submissions are safely processed through server-side security and are accessible for further action or follow-through, such as rescue operations or adoption interviews.

The first process of the rescue and identification system begins when the RFID reader scans the RFID tag on the stray dog. The RFID tag contains a Unique Identifier (UID) that represents the digital identity of the dog. The RFID reader is wireless, allowing it to scan the tag without direct contact. This provides a non-invasive and efficient way of identifying dogs in the field. As the dog draws near, the RFID reader scans the tag and transmits the UID to the ESP32 microcontroller connected to the reader. This process is usually practiced in rescue zones, shelters, or when visiting the field. Every dog has a specific identification in the rescue, medical, and adoption process to the use of RFID technology. This communication device, the ESP32 microcontroller uses Wi-Fi to send the UID to the server. This technology provides an automated procedure that removes the capacity for human error in the identification process. The information flow from the devices to the admin panel and start at this point. To guarantee long term performance, the RFID tag is attached to a collar. It only takes a few seconds. to scan. This makes it perfect for manage and large scale of stray dogs. As soon as the RFID tag is scanned, admin are immediately informed.

The reader reads the UID and transmits the data to the ESP32 module after the RFID tag successfully scanned. The dog database is uniquely identified by its UID based verified, this is a hexadecimal value like 53F7AA29. The UID provides the main focus for gathering all data connected to a specific dog. The ESP32 uses a secure HTTP or MQTT connection to send the UID to the admin backend. immediate updates on the admin panel are made possible by this real-time process. the UID helps the system identify multiple dogs and prevents confusion. This correct UID is only transmitted, and so there is no possibility of data mismatch or duplication.

This UID is connected to various pieces of information to get a dog details such as health information, GPS coordinates, gender details, and dog images. Once the UID is received, the backend starts a process to acquire the related information. The integrated process helps the rescue to be accurate and fast. The data transaction is made a secure, server protection and encryption techniques. The UID is a key it is used to unlocks the whole dog profile on the admin panel. Admins do not have to remember any information—everything is automatically extracted using the UID.

Once the UID is extract from ESP32, and then the admin panel automatically search and verify the dog database for a corresponding entry. Every UID is linked to the whole dog profile, which includes the dog's name, dog image, UID number, GPS tracking number, and dog gender and breed. The database it's a always updated as dogs are identified and registered. Once a corresponding entry is extracted, all the information is displayed on the admin panel in a friendly interface. The image is a visual representation of the dog's identity, which is very important for distinguishing similar dogs Figure 2. The GPS ID helps the system to identify the current position of the dog in the next step. The retrieval of information in real time ensures efficient processing and avoids time wastage in the verification of information by hand. If the UID is not traced in any record, the system traces it for analysis or registration.

Figure 2

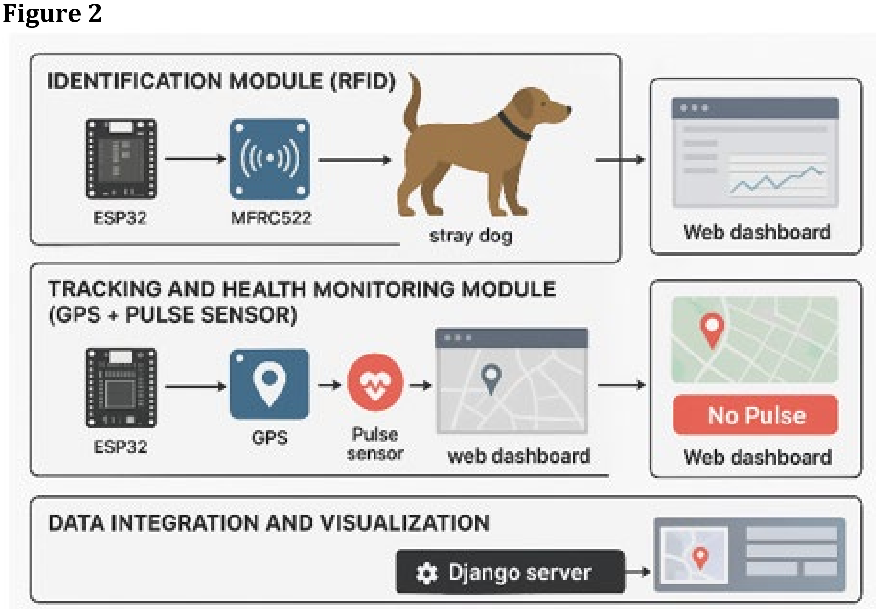

Figure 2 Visual Representation of Stray Dogs Management

The admin has the provision to manually update or verify the information if needed. This is an important step in ensuring that the RFID tag is linked to a known dog and avoids any mistake in rescue or adoption. This information is secure from unauthorized access using an authentication method. The admin can also track the previous offer and rescue history of the dog related information available. This centralized information is a process to make the system reliable and responsible. The system also allows the export of reports and creation of a digital record for the rescued dogs. This is an very important feature for connecting and authenticating the information related to the dog before initiating the rescue operation.

Once the dog's UID and GPS ID have been verified, the next step of the process is to identify the location of the dog using GPS coordinates. The GPS feature of the system is integrated into the dog's wearable device or gadget, which continuously sends the location information of the dog to the backend system. The location information is updated in real-time interactive map for the admins on the dashboard. The admins can also track the exact location where the dog is at any given point in time, which helps in facilitating quicker rescue operations. If the dog is in motion, the admins can track the live location information reflected as an interactive map. the GPS system tracks the vital signs of the dog using an pulse sensor attached to the dog.

The sensor is always on to predict the heartbeat of the dog and is transmitting this information along with the GPS. If the heartbeat is detected as irregular or absent, a health alert will automatically be sent to the admin dashboard. This will not only help in locating the dog but will also inform us about the health status of the dog even before we reach the destination. This is a smarter system due to the integration of GPS, RFID, and heartbeat sensors. These alerts will be visible on the dashboard, and this information will immediately be sent to the rescue team. These points on the map will show images uploaded by the user in the past and will also show landmarks for better understanding.

The admin will also be able to view the timestamp for GPS and pulse information for verification. Once the location of the dog is established and scanned, the admin will be able to update this status as "Dog Rescued." This is important for completing the entire process. Finally, the combination of GPS tracking and pulse detection to makes the rescue process, more efficient and effective for dogs.

ANALYSIS AND INTERPRETATION OF DATA

The two major components of the hardware design included an RFID scanner for identification purposes and a GPS module and pulse sensor for location and health-related purposes. The ESP32 microcontrollers, which acted as the primary data acquisition and communication tool, were connected to both modules. The collected data was then sent in real-time to a web dashboard and REST API developed using Django because of the ESP32's in-built Wi-Fi capabilities. In the RFID system shown in Figure 3, the ESP32 was connected to the MFRC522 RFID reader module using jumper wires on a breadboard.

Figure 3

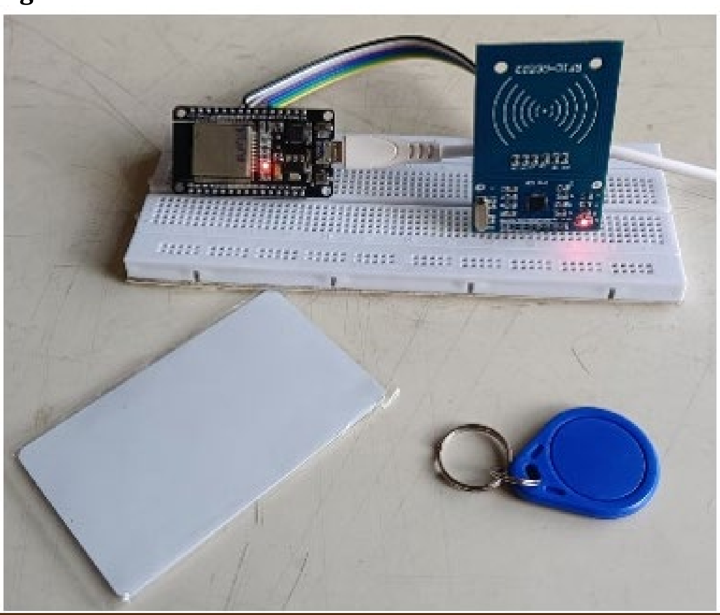

Figure 3 RFID Setup Using the ESP32 and MFRC522 Module

The second one major component of the system was allocate for location monitoring. The GPS and pulse sensor are connected to another ESP32 board in Figure 5. While the pulse sensor measured the heart rate of the dogs, the GPS module continuously transmitted location information (latitude and longitude) values.

Figure 4

Figure 4 GPS and Pulse Sensor Module Connected to ESP32 (kit)

The proposed system utilizes a solar-assisted lithium-ion energy management architecture that would sustain a stable autonomous power supply to power up the ESP32 microcontroller. The architecture is suitable for low-power IoT applications that operate outdoors.

Figure 5

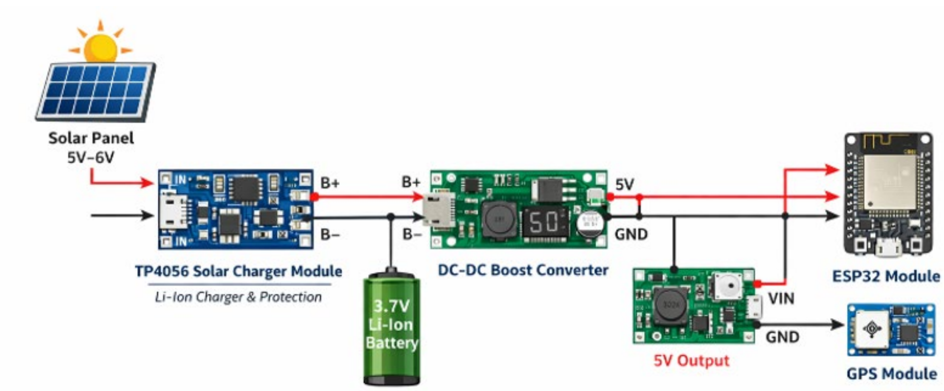

Figure 5 RFID Setup using the ESP32 and MFRC522 Module

A photovoltaic module rated for 5 to 6 volts is the prime energy harvesting device. The output of the PV is fed into the input terminals of the TP4056 lithium-ion charging controller. The TP4056 controller regulates the charging of the lithium-ion battery through a constant current and constant voltage charging technique. This provides the added advantage of protecting the battery from overcharge and over-discharge situations.

The energy storage is provided by a single-cell 3.7V Li-ion battery connected between the terminals (B+ and B-) of the charging module. The use of a battery is crucial in ensuring continuous operation of the IoT node irrespective of inadequate solar irradiance, e.g., under nighttime. This is essential to sustain operation in realistic outdoor conditions.

In order to match the regulated supply requirement for the load, the battery voltage is converted to a higher voltage using a DC-to-DC boost converter. This converter boosts the variable battery voltage from 3.0 to 4.2 V to a regulated 5-V supply. This regulated voltage supply is connected to the VIN pin of the ESP32 module and the VCC input of the GPS module to ensure their operation in spite of the variable battery voltage.

The collected dataset consists of pulse rate values and activity levels of dogs. The data was reprocessed and divided into training and testing sets to evaluate the performance of the machine learning model. The Random Forest classifier was trained using the dataset and tested using unseen data. Performance evaluation metrics such as accuracy, precision, recall, and F1-score were used to measure the effectiveness of the model. From the classification results, it was observed that the model performed well in identifying the different health conditions. Most of the classes such as Normal, Low Abnormal, and High Abnormal achieved high accuracy scores.

Overall, the integration of solar energy harvesting, protected lithium-ion storage, and high efficiency DC-DC conversion enables a self-sustaining power solution for IoT products, which can be implemented for long-term maintenance-free operation. Such a system architecture enhances both system reliability and autonomy, with reliable operation throughout a range of environmental conditions.

RESEARCH FINDINGS

First, simulate practical applications, in which each stray dog would be tagged with a collar containing the tag, the system was tested using multiple RFID tags. The UID was immediately readable and sent to the server upon bringing the tag close to the reader. All the scans were successfully recorded with a timestamp on the Django web page Figure 6, proving the efficiency of the system in identifying different animal species. This makes the human identification process unnecessary and gives a practical solution to automatically registering dogs at feeding points, shelters, or vaccination centre.

Figure 6

RFID Scan Records

(New scans data show on top)

UID	Date & Time (IST)
F95DAF06	23-02-2026 12:49:05
81718A18	23-02-2026 12:46:47
53F7AA29	23-02-2026 12:44:42
5FE098A7	23-02-2026 12:44:29
E48ABDDC	23-02-2026 12:43:47
F95DAF06	23-02-2026 12:43:38
81718A18	23-02-2026 12:43:26
E48ABDDC	23-02-2026 12:42:25
F95DAF06	23-02-2026 12:42:17
81718A18	23-02-2026 12:42:10
E48ABDDC	23-02-2026 12:41:46
53F7AA29	23-02-2026 12:41:38
F95DAF06	23-02-2026 12:41:23
81718A18	23-02-2026 12:41:19

Figure 6 Django Web Page Logging RFID Scans with Timestamp

Second, this data was transmitted in real-time and grouped based on different pulse conditions, such as normal, low, high, and no pulse, as depicted in Figure 7's Django dashboard. The health condition of the dog was mainly dependent on this categorization. The indicated "No Pulse" warning, displayed in red colour indication, would need the immediate attention of a rescue team and indicate some serious problems like injury, device removal, or died.

The users track the location of the dog exactly using Google Map to generate the "View Map" links available in the dashboard, it's helped to reduce the response time.

Figure 7

Figure 7 Django Dashboard Showing Real-Time GPS and Pulse Monitoring and Dog Activity

Furthermore, the system was also test for its robustness with the presence of noise, latency, and high frequency of updates. It was observed that the system displayed different "High Pulse" readings, for example, 222 and 229 BPM, which might be an indication of stress or hyperactivity of the dog. Dog pulse low or zero readings can be useful in determining if the dog is unconscious, sleeping, or not responding at all. The system moves from passive monitoring to active monitoring with the interpretation of dog behaviour. this type of method greatly improves dog identification, veterinary services and ground-level animal rescues. Moreover, the accuracy of the API endpoint and the robustness of the backend database are ensured by the consistency of the log entries of the RFID and GPS data over different periods of time, even after multiple sessions. The data can be used for long-term observation of dog behaviour, migration, and health patterns, apart from real-time monitoring. The two-module system ensures that the RFID scan log function remains active even if one of the systems fails for some time (for example, loss of GPS signal in a covered region).

Third, the developed system is able to effectively integrate IoT hardware components with a machine learning model in order to automatically predict the health condition monitoring of stray dogs based on pulse value. Once real-time pulse data is obtained from the ESP32 module using the pulse sensor connected to it, the developed Random Forest model is able to predict the health condition category based on this input data.

For instance, the data set used for training this model consists of various pulse rate data with five classes: high-abnormal, low-abnormal, no pulse, normal, and very high-abnormal. Once this data is loaded and reprocessed, the random forest classifier is used for testing.

RESULT FINDINGS

The dataset was successfully loaded, As well as model has successfully trained without any problems, indicating that the data set is appropriate for building a trustworthy model. Following evaluation, the model's accuracy is 0.9876, or roughly 98.7%. This demonstrates how well the model is classifying various medical conditions based on the input.

Table 1

Table 1 Classification Reports

Class	Precision	Recall	F1-Score	Support
High-abnormal	1	1	1	6
Low-abnormal	1	1	1	16
No Pulse	0	0	0	1
Normal	0.96	1	0.98	27
Very High-abnormal	1	1	1	31

The classification model's performance evaluation using precision, recall, F1-score, and support values for each health status class is displayed in Table 1. The classification model performs remarkably well on the majority of classes, as the table demonstrates. The Low-abnormal, High-abnormal, and Extremely Precision, recall, and F1-score all receive perfect scores of 1.00 for high-abnormal classes. With zero misclassification errors on these three classes, these values indicate that the classification model operates consistently. Additionally, the Normal class achieves near-perfect precision, recall, and F1-scores (0.96, 1.00, and 0.98, respectively). These values indicate that the model is still dependable even though there is little misclassification.

The classification model was unable to correctly classify the No Pulse class because its precision, recall, and F1-score are all equal to 0.00. The classification model had trouble learning patterns for this class, as indicated by the low support value of 1. The table demonstrates that while the classification model performs poorly on underrepresented classes, it is generally very effective in all classes.

It is evident from the model's performance that it classifies the dogs' health conditions with a high degree of accuracy. The model's overall accuracy of 0.99 indicates that it is a very good predictor. The high weighted average values of precision, recall, and F1-score—0.98, 0.99, and 0.98, respectively—show that all the classes, including High-abnormal, Low-abnormal, Very High-abnormal, and Normal, were classified with extremely high precision, recall, and F1-score. However, because there was very little data in the No Pulse class, the model performed poorly in terms of precision, recall, and F1-score, as shown by the macro average values of 0.80.

Finally, the ml model that had been trained was successfully stored for future forecasts and integrated into the monitoring system.

The experimental findings demonstrate how well the Random Forest classifier predicts dogs' health based on pulse rate data. The model's high degree of accuracy—roughly 98.7%—demonstrates that the suggested system can categorize pulse rate data into the appropriate health conditions. However, because there are fewer samples in the dataset, "No Pulse" data has demonstrated lower accuracy.

The foundation for creating intelligent systems for handling stray dogs in practical settings is greatly aided by this system prototype. Both rural and urban areas can benefit greatly from the numerous systems that have been put in place by different urban and rural organizations. Health sensors, roaming GPS collars, and RFID checkpoints at food stations allow for real-time monitoring of hundreds of stray dogs. Machine learning algorithms that forecast anomalous patterns in location and health-related indication can also be added to this system. In overall, this system has proven successful in combining inexpensive hardware with a powerful software tool for real-time animal health, location, and identification monitoring. The dynamic visualization of this data on a web-based interface has made this system not only very helpful but also very accessible for field workers, veterinary doctors, and rescue organization managers. This study has validated the potential of the IoT and RFID technology as a crucial tool for the management and welfare of stray animal populations and immediate actions when required.

CONCLUSION

The developed web application is a one-stop, structured platform for the welfare of stray dogs, promoting active community engagement and effective administrative management. The application enables users to report cases of injured, lost, or deceased dogs by providing critical information like location, time, reporter information, and images, which helps in taking immediate action from the concerned authorities. Besides reporting, the application has an adoption request feature, promoting responsible pet ownership by giving rescued dogs a permanent and loving home. The application has a centralized dashboard for administrators, which helps in real-time monitoring and management of reported cases and adoption requests, improving administrative transparency and decision-making.

The application has features such as geolocation tagging, timestamped entries, and image uploads, ensuring that critical information is collected accurately and helping in prioritizing cases based on urgency. Moreover, alert systems can alert concerned teams in case of emergencies, which helps in taking immediate action when lives are at stake. This initiative closes the communication gap between the community and rescue teams, thus raising the bar for the welfare of stray animals and community engagement. The adoption of digital technology in this field not only simplifies processes but also helps to create a culture of compassion and civic responsibility for stray animals.

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