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CANINE COMPANION: Ensuring your Pet's Safety and Health using IoT & ML

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Abstract: With the surge in global pet ownership, the demand for intelligent and responsive pet care systems has intensified. Conventional monitoring approaches, such as infrequent vet visits and isolated GPS collars, often fall short in providing proactive and comprehensive health insights. This research introduces an economical, IoT-driven pet wellness system integrating ESP32 microcontroller, biometric sensors, geolocation tracking, and machine learning intelligence. By continuously monitoring physiological parameters—heart rate, body temperature, and blood oxygen saturation—and pairing this with GPS tracking, the system ensures holistic care. Cloud-based data visualization through ThingSpeak and predictive analysis via supervised ML algorithms provide actionable insights. Alerts are transmitted to pet owners in real-time using Telegram integration, thereby enhancing emergency responsiveness. This study emphasizes the system's design, deployment, and operational viability for responsible and effective animal care.

Keywords: Pet care technology, wearable IoT, machine learning, real-time monitoring, GPS tracking, ESP32, animal welfare, data analytics

I. INTRODUCTION

In recent years, the integration of smart technologies into domestic life has transformed various sectors, including pet care. Traditional health monitoring systems for pets largely depend on physical examinations during scheduled vet visits, which may not suffice for early diagnosis or emergency response. Moreover, behavioral changes or signs of distress may go unnoticed between visits. To address this, the Canine Companion platform presents a technology-driven solution for real-time monitoring and predictive wellness management in pets. Based on the ESP32 microcontroller and an array of non-invasive sensors, the system offers continuous tracking of vital signs and geolocation. Additionally, cloud analytics and machine learning enhance the decision-making capability of pet owners. Besides private use, the system holds potential for use in veterinary practices, boarding centers, and animal shelters where monitoring multiple pets efficiently is critical. It could also extend to livestock management in agricultural settings, reinforcing its versatility and scalability.

A. Challenges of Traditional Pet Health Monitoring

Traditional systems for monitoring pet health papers rely primarily on veterinary examinations or basic portable devices. These approaches provide snapshots that will help your pet's health, but in many cases it is not sufficient to recognize the disease. Pets, especially dogs and cats, may not show obvious symptoms until the health problems persist quite a bit. Without continuous monitoring, subtle changes in important parameters such as heart rate, oxygen saturation (SPO2), or body temperature remain unaware. Diagnosis and treatment could be delayed. These devices typically do not have the ability to pursue several health parameters or integrate predictive analytics to expect potential risks. Furthermore, in many cases, GPS persecution is not included. This is essential to ensure your pet's security in real time. In emergencies, delays can have serious consequences for identifying and responding to health abnormalities.

B. Proposed IoT-Based Canine Companion System

The Canine Companion system leverages IoT, cloud computing, and machine learning to provide real-time health monitoring and location tracking for pets. By continuously collecting and analyzing vital parameters, the system enables early disease detection and timely intervention. Key features include:

- Real-time health monitoring using MAX30100
- (heart rate, SpO_2) and temperature sensors.
- GPS tracking for pet safety with geofencing alerts.
- Cloud storage (ThingSpeak) for secure data logging and historical analysis.

- Machine learning for predictive health analytics.
- Telegram alerts for abnormal health conditions.

This system bridges the gap between traditional pet care and modern technology, offering a proactive approach to pet health management.

II. SYSTEM ARCHITECTURE AND COMPONENTS

A. Research Question

How can an IoT-based system integrating real-time health monitoring, GPS tracking, and machine learning improve pet health outcomes and owner convenience compared to traditional methods?

The Canine Companion system is built on the following components:

Hardware Layer:

- ESP32 Microcontroller: Coordinates data acquisition, processing, and wireless communication.
- MAX30100 Sensor: Measures pulse rate and blood oxygen saturation.
- DS18B20 Digital Thermometer: Tracks temperature variations.

Figure 1: Overview of an ESP32 Board

Figure 2: Pulse rate sensor

Figure 3: Temperature sensor

- Neo-6M GPS Module: Detects and logs the pet's geographic coordinates.
- Power Supply and Optional Display: Ensures portability and allows local monitoring.
- Accelerometer and Gyroscope (Optional): Future expansion for behavior analysis.
- Software Stack:
- Arduino IDE: Programming environment for ESP32 firmware.
- ThingSpeak API: Cloud platform for storing and visualizing telemetry data.
- Python Flask: Backend for real-time data interface and user dashboard.
- Scikit-learn: ML library used for health status classification.
- Telegram Bot API: Facilitates real-time alert delivery to user devices.
- Folium: Used to render dynamic maps for location tracking and geofencing.

Data Transmission:

Sensor data is sent to ThingSpeak cloud via Wi-Fi using MQTT/REST APIs.

- Machine Learning Model:
- Random Forest Classifier: Trained on historical health data to predict health status (Normal, At-Risk, Ill).
- Data Preprocessing: Includes normalization, missing value handling, and feature engineering.

User Interface:

- Flask Web Application: Displays real-time and historical health data, GPS location, and predictive alerts.
- Folium Integration: Maps pet location and nearby veterinary clinics.
- Alert System: Telegram notifications for abnormal health readings or geofence breaches.

Relevant Terminology

- IoT (Internet of Things): Network of interconnected devices for data collection and communication.
- ThingSpeak is an online platform where the data from IoT devices can be stored and studied.
- Random Forest Classifier: A supervised algorithm used for classifying data into distinct groups.
- Geofencing: Virtual boundaries triggering alerts when crossed.

III. SYSTEM FUNCTIONALITY

A. Health Monitoring via IoT

Sensor readings are periodically captured and transmitted over Wi-Fi to ThingSpeak. The ESP32 also locally filters and preprocesses the data to reduce noise and network load. Components are chosen for low power consumption and durability, supporting both indoor and outdoor deployments.

Figure 4: LCD displaying Real-time sensor data.

B. GPS Surveillance and Geofencing

The GPS module provides real-time location updates. Users can define geofences within the dashboard, triggering alerts if the pet moves outside safe zones. These geofences can be static or dynamic based on time of day or owner activity patterns.

Figure 5: Map showing the pet's location.

C. Predictive Health Analytics

Using collected data, the system trains a Random Forest model to classify health conditions. ML integration helps identify early deviations in vital signs, offering better response time compared to static threshold systems. Future versions will explore ensemble and deep learning models for improved accuracy.

Figure 6: Model prediction

D. Web-Based Dashboard

A Flask-powered interface enables users to visualize real-time stats and trends, check maps via Folium integration, and receive health reports. It also allows customization of alert thresholds and geofence boundaries. Historical data visualization helps track long-term health trends.

Figure 7: Flask web dashboard.

E. Automated Alerts and Notifications

Anomalies in biometric readings or unauthorized location movement automatically trigger messages via Telegram, improving situational awareness and enabling immediate action. Alerts are prioritized based on severity using a predefined ruleset and ML-driven risk scores.

Figure 8: Telegram alert message.

F. Behavioral Monitoring (Upcoming)

The future version will integrate motion-based analytics via accelerometers and gyroscopes to track abnormal movement patterns indicative of injury, anxiety, or seizures. These insights will be displayed via heat maps and motion graphs on the dashboard, enhancing early behavioral diagnostics.

IV. SYSTEM IMPLEMENTATION AND VALIDATION

A. Sensor Calibration

Sensor modules were calibrated and benchmarked against commercial-grade equipment, including certified thermometers and pulse oximeters. Calibration routines were executed regularly to maintain accuracy.

Transmission Efficiency

Test runs showed consistent data transfer with latency below 2 seconds. The ThingSpeak dashboard displayed real-time updates reliably under normal home internet conditions. Data loss mitigation strategies were implemented via local caching.

C. ML Model Evaluation

- Accuracy: 94%
- Precision: 91%
- Recall: 95%
- F1 Score: 93%

The model was trained using an 80/20 data split and validated through repeated simulations under varying conditions. Feature importance analysis confirmed temperature and heart rate as the top predictors.

D. Alert System Testing

The alerting framework was tested with induced faults and location deviations, showing an average alert time of 2.8 seconds. System robustness was confirmed under stress tests involving multiple concurrent events.

Deployment Trials

Pilot testing in a small pet care facility demonstrated the system's scalability for multiple concurrent users. The dashboard performance remained stable, and user feedback indicated improved confidence in pet health oversight.

V. SYSTEM PERFORMANCE ANALYSIS

- Sensor Accuracy: Above 98% for temperature and pulse metrics.
- Location Precision: ±3 meters verified via map overlays.
- Classification Performance: 94% accuracy in real-time use cases.
- Alert Latency: < 3 seconds across multiple trials.
- Offline data caching was implemented to ensure resilience during temporary internet outages, preserving health logs and GPS data until reconnection.
- Battery Life: Approximately 8-10 hours in continuous monitoring mode; extendable with power optimization.
- User Interface Responsiveness: Dashboard response time under 1 second for basic queries.

VI. INDUSTRY IMPACT AND SCALABILITY POTENTIAL

The application of IoT and AI to pet care is part of a broader shift toward smart living and connected health ecosystems. As more households adopt pets, the commercial demand for advanced care technologies continues to grow. The Canine Companion system aligns with market trends such as wearable health tech, predictive veterinary care, and telehealth for animals.

A. Commercial Viability

This solution can be adapted into a product line including smart collars, harnesses, or modular clip-ons. Partnerships with veterinary chains or pet insurance providers could drive rapid adoption, especially when bundled with wellness plans. Subscription-based models could offer additional revenue streams.

B. Expansion Opportunities

- Pet Tech Startups: Can use the platform as a base for app-driven ecosystems.
- Veterinary Clinics: May integrate it for remote patient monitoring.
- Public Health Research: Aggregated data (anonymized) could aid in studying zoonotic disease trends.
- Pet Boarding Facilities: Can enhance service quality through automated tracking.

C.Sustainability and Cost Efficiency

The hardware is designed to be low-power and cost-effective, using widely available modules. Cloud costs are minimal due to ThingSpeak's free and scalable model, making it accessible in resource-constrained settings as well.

Figure 9: ThingSpeak dashboard showing health data graphs.

D. Integration with Emerging Technologies

The platform can extend into areas like:

- Edge AI for on-device inference
- 5G modules for low-latency telemetry
- Voice-enabled pet interfaces
- Integration with home automation systems
- Facial recognition for pet identification

VII. RESULTS

During testing, the Canine Companion system exhibited impressive performance across various parameters. The sensor accuracy was notably high, with heart rate readings achieving 98.5% accuracy, SpO_2 measurements at 97.8%, and temperature detection at 99.1%. The GPS module provided a precision of ±3 meters. In terms of machine learning performance, the system achieved a prediction accuracy of 93.6%, with a precision of 0.89 and recall of 0.91. Real-world usability was also commendable—Telegram alerts were delivered within 5 seconds of detecting abnormal health readings, and the web dashboard updated health data in under 2 seconds. Additionally, offline GPS tracking ensured uninterrupted location monitoring. User feedback was overwhelmingly positive, with pet owners appreciating the system's user-friendly interface and the timely, proactive notifications it provided.

Figure 10: Final summary dashboard showing overall system performance.

VIII. CONCLUSION AND FUTURE ENHANCEMENTS

The Canine Companion system successfully integrates IoT, machine learning, and cloud computing to transform pet health monitoring. It provides real-time updates, predicts potential health issues, and enables precise location tracking, thereby enhancing pet safety and giving owners greater peace of mind. Looking ahead, several enhancements are envisioned to further improve the system's capabilities. These include incorporating advanced sensors to monitor respiratory rate and activity levels, developing a dedicated mobile application for iOS and Android platforms to improve accessibility, utilizing blockchain technology for secure health data storage, and enabling support for multiple pets to cater to households with more than one animal.

Future enhancements for the system include the integration of facial recognition or RFID tagging to enable accurate identity verification of pets. To ensure data integrity and enhance security, blockchain-based secure logging will be implemented. The development of mobile applications and multilingual interfaces is also planned to improve accessibility and user experience. Advanced analytics leveraging accelerometer and gyroscope data will be introduced for comprehensive behavioural monitoring. Additionally, the system will be adapted for use in livestock management, offering valuable applications in the veterinary and agri-tech sectors. There are also plans to expand its capabilities to support emergency services by integrating with local animal rescue operations.

IX. SECURITY, PRIVACY, AND ETHICAL CONSIDERATIONS

A. Data Encryption and Security Measures

All data exchanges are encrypted via HTTPS, with upcoming support for TLS at the device level. Future plans include secure token-based access and periodic credential rotation.

B. Ethical Handling of Data

User permission is mandated before initiating data collection. Informed consent ensures that the use of biometric and GPS data adheres to ethical standards. Usage beyond real-time monitoring (e.g., for research) requires anonymization and explicit opt-in.

C. Compliance with Data Laws

The system aligns with global and regional standards like GDPR and India's Personal Data Protection Bill. Data residency and portability features are being considered for international deployment.

D. Risk Mitigation Strategies

Routine security audits, OTA updates with integrity verification, and encrypted storage formats help minimize risks and maintain trust. By prioritizing transparency, user autonomy, and responsible data stewardship, the Canine Companion system promotes ethical innovation in pet technology.

REFERENCES

1. A. Sharma, R. Patel, and S. Gupta, "Smart Pet Health Monitoring Using IoT," Int. J. of Embedded Sys., vol. 18, pp. 23-28, 2021.
2. J. Lee, D. Kim, and H. Park, "ML for Disease Prediction in Pets," IEEE Access, vol. 10, pp. 23456–23470, 2022.
3. M. Johnson, R. Thomas, and L. Walker, "Remote Veterinary Health Monitoring via IoT," J. Vet. Tech., vol. 9, pp. 67–75, 2019.
4. S. Banerjee, V. Ramesh, and T. Singh, "AI-Powered Wearables for Pet Care," ACM HealthTech, pp. 45-52, 2023.
5. https://thingspeak.com
6. https://flask.palletsprojects.com
7. M. Young, The Technical Writer's Handbook, University Science, 1989.
8. D. P. Kingma and M. Welling, "Auto-encoding variational Bayes," arXiv preprint arXiv:1312.6114, 2013.
9. K. Das, M. Bose, and P. Sinha, "GPS-based Pet Tracking System," Int. J. Smart Tech., vol. 12, pp. 99–105, 2020.