

Development of a Smart Wearable Harness for Dogs: An Integrated System for Real-Time Health Monitoring, GPS Tracking, and Behavioral Analysis

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Abstract—the development of a smart dog harness equipped with multi-modal sensing capabilities to enhance pet health monitoring and safety. The proposed system integrates heart rate monitoring, GPS-based real-time location tracking, motion detection, and voice frequency analysis to offer a comprehensive solution for monitoring the well-being and behaviour of dogs. Leveraging low-power Internet of Things (IoT) technologies, the harness is designed to be lightweight, durable, and comfortable, ensuring minimal intrusion while maximizing functionality. The system aims to assist pet owners in early detection of health issues, prevent loss through location awareness, and support behavioural research by capturing vocal and movement patterns. The smart harness represents a step toward advanced pet care through wearable technology.

Index Terms—Smart harness, pet health monitoring, voice frequency analysis, wearable devices, motion pattern recognition

I. INTRODUCTION

This study presents the development of an integrated smart harness system for dogs, designed to address these needs through multi-modal sensing and real-time analytics. The proposed harness incorporates heart rate monitoring to provide continuous physiological insights, GPS-based real-time location tracking to enhance safety and prevent loss, and motion pattern analysis to detect irregularities in physical activity levels. Furthermore, the system includes voice frequency analysis to identify and interpret behavioral cues, offering a novel approach to understanding canine emotional states. By combining these

functionalities, the smart harness delivers a unified platform for comprehensive health monitoring and behavioral assessment, contributing to improved well-being and safety in companion animals.

To better understand the potential demand for dog wearable devices, a user survey was conducted. The results showed that only 13% of respondents currently use any kind of wearable technology for their pets, highlighting a significant opportunity to introduce new solutions in this space. Interestingly, when asked about their interest in a device that could monitor health and track location, 57% stated they would definitely use it, and another 26% were likely to use it, reflecting strong user interest.

Participants expressed the most interest in tracking features such as GPS/location (47 responses), heart rate (42), and body temperature (40). When it came to pricing preferences, the majority (59%) indicated they would prefer devices priced below ₹5,000, pointing to the need for budget-friendly innovations. These findings provide valuable insights into user preferences and reinforce the necessity for an affordable, multi-functional smart collar that focuses on health monitoring and safety

II. MATERIALS AND METHODS

A. *Components*: The smart harness system integrates multiple components designed to monitor a dog's health and behavior in real time. A heart rate sensor, built into the harness, uses a non-invasive optical method to track the dog's pulse, providing continuous cardiovascular monitoring. To ensure

accurate location tracking, a GPS module is included, which enables real-time positioning and geofencing capabilities. Motion detection sensors are embedded to monitor physical activity, recognize unusual movements, and observe rest or sleep cycles. Additionally, a voice frequency detector analyzes vocalizations such as barking or stress-related sounds to help assess the dog's emotional state. The data from all sensors is managed by a microcontroller that processes the inputs and communicates with a connected mobile or cloud-based application. Powering the entire system is a battery unit optimized for long usage with minimal recharging, ensuring the device remains reliable and efficient.

- B. *Communication Protocol:* The smart harness utilizes a dual communication strategy to balance local accessibility and remote monitoring. For nearby interactions, the system employs short-range wireless technologies such as Bluetooth Low Energy (BLE) or Wi-Fi, allowing pet owners to access real-time data via a mobile application. For continuous remote monitoring and cloud synchronization, the harness is equipped with cellular connectivity (e.g., LTE-M or NB-IoT), which transmits data directly to the cloud infrastructure, ensuring that health and behavior updates are available regardless of distance..
- C. *Cloud Integration:* Sensor data collected by the harness is securely transmitted to a cloud-based platform using lightweight IoT communication protocols. The cloud system handles real-time analytics, stores historical records, and offers remote accessibility for users and veterinary professionals. This architecture enables comprehensive tracking of the pet's health and activity trends over time, providing actionable insights anytime, from anywhere

Design Considerations: Comfort and Ergonomics: The harness is engineered with lightweight, breathable materials that ensure prolonged comfort for the dog during daily use. Adjustable straps are incorporated to provide a secure yet flexible fit, accommodating a wide range of dog sizes and breeds without compromising mobility.

Durability: To withstand diverse environmental conditions, the harness is constructed using waterproof

and abrasion-resistant fabrics. This robust design ensures reliable performance in both indoor and outdoor settings, including exposure to rain, dirt, and physical activity.

Power Optimization: The system integrates energy-efficient hardware components along with intelligent power management strategies to minimize energy consumption. These optimizations enable longer operational periods between charges, thereby enhancing user convenience and maintaining continuous monitoring functionality.

III. DEVELOPMENT

A. *Hardware Design:*

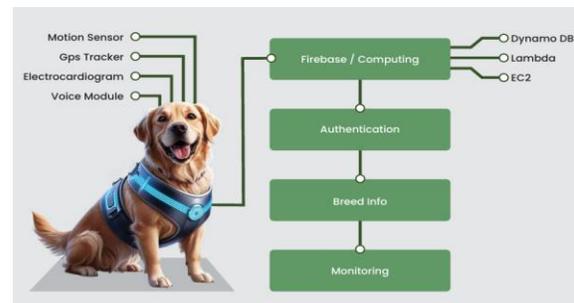
The heart rate sensor, motion detection system, and GPS tracker are integrated into a compact and lightweight design, ensuring minimal discomfort for the dog. Components are housed in a weather-resistant enclosure.

B. *Software Development:*

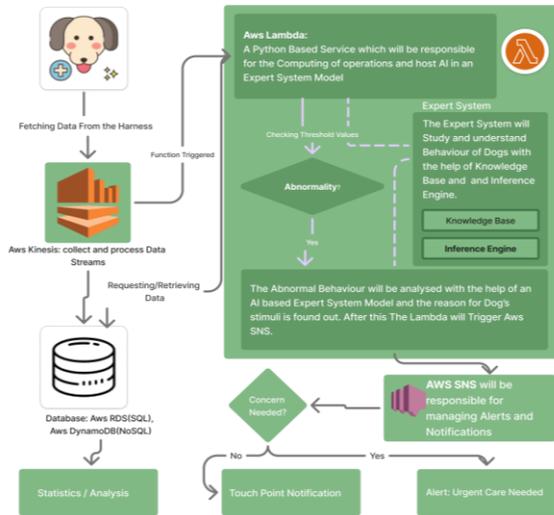
The system processes and transmits real-time data to a cloud platform, where it is analyzed and presented via a user-friendly mobile application. The software features alerts for abnormal heart rates, unusual motion, or specific vocal patterns.

C. *Application and Use Cases:*

1. **Pet Health Monitoring:** Tracks heart rate and activity levels, enabling early detection of potential health issues.
2. **Safety and Security:** Real-time GPS tracking helps locate lost pets or monitor dogs in open areas.
3. **Behavioral Insights:** Analyzing voice frequencies provides cues about stress, aggression, or other behavioral states.
4. **Training Assistance:** Motion and vocal data help trainers evaluate and adjust training methods.



1. High level Architecture



2. Low level architecture

IV. CHALLENGES AND FUTURE DIRECTION:

A. Challenges:

One of the key challenges in developing a wearable health monitoring system for animals is ensuring accurate heart rate detection across varying activity levels and different fur types, which can affect sensor performance. Additionally, optimizing the system for low power consumption is essential to extend battery life, especially for long-term use without frequent recharging. Another important consideration is enabling real-time data processing while maintaining the device's portability and comfort. Balancing computational efficiency with lightweight, unobtrusive design is critical to ensure the harness remains practical for everyday use without causing discomfort or restricting movement.

B. Future Directions: To enhance the overall performance and usability of the system, future development will focus on incorporating ultra-low-power components along with optimized sleep cycles to significantly extend battery life without adding bulk or increasing the device's weight. Integrating AI-driven analytics will enable the system to move beyond basic monitoring by employing predictive algorithms that can detect potential health issues or behavioural anomalies before they escalate. Additionally, designing the system with scalability in mind will allow for adaptation

across different animal species, each with unique physiological and behavioural characteristics, thereby expanding its utility in both domestic and agricultural settings.

V. RESEARCH GAP AND FUTURE FOCUS

Future advancements in wearable pet health monitoring should prioritize the development of multimodal sensing systems. Current devices often rely on single-sensor configurations, which limits the breadth of health metrics that can be captured. Integrating various physiological and behavioral sensors would enable more holistic monitoring. Additionally, predictive analytics and preventive care remain underutilized due to the lack of systems capable of learning from historical data. By incorporating machine learning models, it becomes possible to identify health anomalies early and provide tailored warnings specific to individual animals. Another critical area is the long-term reliability of collected data. Devices frequently experience data degradation over time or under diverse environmental conditions. To mitigate this, future designs must employ advanced signal processing techniques and sustainable power solutions. Ensuring robust data privacy and security is equally vital, as pet health data lacks standardized protection protocols. The adoption of blockchain and end-to-end encryption can safeguard this sensitive information. Furthermore, although wearables gather physiological data, they often fail to connect this information with behavioral insights. The integration of artificial intelligence for interpreting behavioral trends alongside physiological changes can empower owners with more actionable feedback. Ergonomic design must also evolve to accommodate variations in species, breeds, and body sizes, calling for customized, hypoallergenic wearables. Another opportunity lies in enhancing compatibility between wearable devices and veterinary systems through standardized APIs and clinical decision-support features. Cost and accessibility remain barriers for many pet owners; future initiatives should focus on affordable production methods and flexible service models. Expanding research beyond canine subjects to include other species will also broaden the impact of wearable technology. Lastly, attention should be directed toward environmental sustainability by using

recyclable materials and designing modular, upgradable systems to minimize ecological footprints.

VI. CONCLUSION

The development of a smart harness system marks a significant advancement in the field of animal health monitoring and care. By integrating real-time tracking of vital health parameters, location data, activity recognition, and vocalization analysis, such a system provides a holistic view of an animal's physical and emotional state. This multifaceted approach not only enhances the safety and well-being of pets but also facilitates early detection of health anomalies, enabling timely intervention and reducing the risk of severe medical conditions.

In addition to supporting everyday pet care, the data collected through continuous monitoring can serve as a valuable resource for veterinarians and researchers. Insights derived from this information can contribute to behavioural studies, inform breed-specific care strategies, and support the development of predictive health models. The ability to detect subtle changes in behaviour or physiology opens up new possibilities in preventative care and personalized treatment plans.

Looking forward, future enhancements will focus on refining sensor accuracy, improving energy efficiency, and ensuring greater comfort and adaptability of the harness design. Incorporating advanced data analytics and machine learning could further improve the system's diagnostic capabilities. Moreover, the core technology has the potential to be adapted for broader use across different animal species, including livestock and service animals, where continuous monitoring could significantly improve health outcomes and productivity.

This research underscores the growing relevance of wearable technology in animal welfare, highlighting its potential to revolutionize traditional pet care and pave the way for more intelligent, data-driven solutions in veterinary health and animal behaviour science.

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