e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 10, October 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.521

© 2024 IJMRSET | Volume 7, Issue 10, October 2024| DOI: 10.15680/IJMRSET.2024.0710034

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

RSSI Based Indoor Localization for Tracking and Health Monitoring

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ABSTRACT: Accurate localization and health monitoring play critical roles in various applications, including soldier tracking, healthcare, and emergency response. However, traditional GPS systems often fail to provide precise positioning indoors due to signal obstructions and interference. This paper presents an RSSI (Received Signal Strength Indicator)-based indoor localization system as an effective alternative to GPS for real-time tracking. By leveraging the signal strength of Wi-Fi or Bluetooth Low Energy (BLE) beacons, the system determines the location of individuals with improved accuracy. In addition to location tracking, the proposed system integrates a heartbeat sensor to monitor the user's vital health metrics in real-time. This combination enhances situational awareness by transmitting both positional and health data to a centralized monitoring station via GSM. The system provides dual benefits—ensuring the safety of individuals through precise indoor tracking and promoting proactive health monitoring through continuous heart rate analysis. Our experimental results demonstrate the system's reliability in challenging indoor environments, making it suitable for military, healthcare and emergency applications.

KEYWORDS- RSSI(Received Signal Strength Indicator), Heart beat sensor, Health monitoring, Indoor localization tracking.

I. INTRODUCTION

In today's rapidly evolving technological landscape, accurate indoor localization and health monitoring have become paramount across various fields, including military operations, healthcare services, and emergency response systems. While Global Positioning System (GPS) technology has revolutionized outdoor navigation, its efficacy diminishes significantly in indoor environments due to signal interference from walls, furniture, and other obstacles. This limitation necessitates the exploration of alternative localization methods that can operate effectively indoors.

One promising approach is the use of Received Signal Strength Indicator (RSSI) technology, which utilizes the signal strength of Wi-Fi or Bluetooth Low Energy (BLE) beacons to estimate the position of individuals within a defined space. By deploying a network of beacons, the RSSI-based localization system can provide real-time tracking capabilities, allowing for enhanced situational awareness in critical applications.

Simultaneously, monitoring the health of individuals in these environments is increasingly important. Heart rate is a vital sign that can provide significant insights into a person's well-being, particularly in high-stress situations like military missions or medical emergencies. Integrating a heartbeat sensor into the localization system allows for the continuous collection of health metrics alongside positional data.

This paper presents a novel RSSI-based indoor localization system that incorporates heartbeat sensor integration, aiming to enhance both individual safety and health monitoring. By transmitting real-time data to a centralized monitoring station via GSM, this system not only ensures precise tracking of individuals but also fosters proactive health management.

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II. OVERVIEW

This project aims to develop an innovative indoor localization system that combines Received Signal Strength Indicator (RSSI) technology with heartbeat monitoring to enhance safety and health management in critical environments. Recognizing the limitations of GPS indoors, the system utilizes a network of Wi-Fi or Bluetooth Low Energy (BLE) beacons to accurately estimate the position of individuals in real time. Additionally, integrating a heartbeat sensor allows for continuous monitoring of vital signs, providing crucial insights into individuals' well-being during high-stress situations.

Data, including both localization and health metrics, is transmitted to a centralized monitoring station via GSM, enabling timely responses in critical scenarios. This dual-focus approach is particularly beneficial for military operations, emergency response, and healthcare settings, ultimately improving situational awareness and fostering proactive health management. By addressing significant challenges in indoor navigation and health monitoring, this project seeks to create a comprehensive solution that enhances safety and efficiency in high-stakes environments.

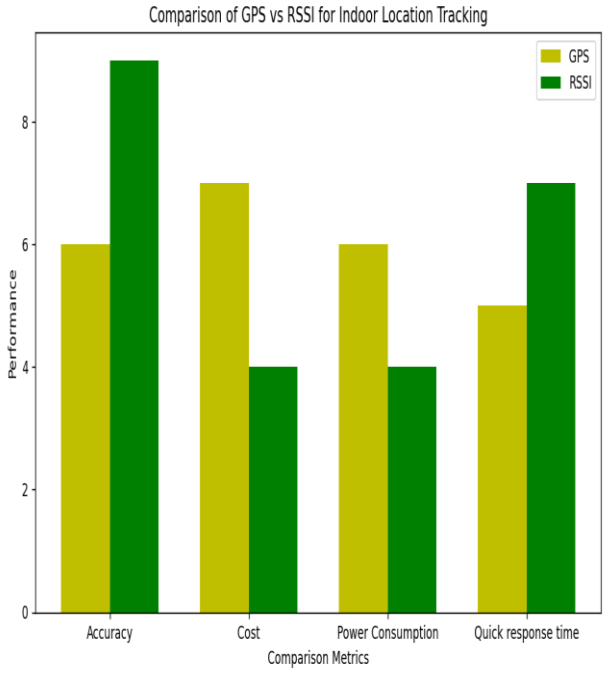

Fig 1: Comparison between RSSI and GPS

III. HARDWARE COMPONENT

1. Microcintroller-It process data from sensors and controlling communications. It collects heartbeat data, measures RSSI values, and sends the processed information to a central server or display unit.
2. Wireless module communication-It enable real-time data transmission and localization by measuring signal strength (RSSI) to estimate the user's position. These modules ensure seamless communication between sensors, microcontrollers, and external servers or databases.
3. Heartbeat sensor-It monitors heart rate by detecting blood flow changes through optical sensing. They provide continuous health metrics, which the microcontroller processes and sends for real-time monitoring and alerts.
4. Access Points-Wi-Fi routers can provide RSSI data for devices connected to them.

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IV. SOFTWARE SPECIFICATION

1. IDE-Arduino IDE for programming Arduino-based boards.
2. C/C++ for programming microcontrollers (Arduino, ESP32).

V. EXISTING SYSTEM

Current indoor localization systems primarily rely on technologies such as GPS, RFID, and Bluetooth, each of which has significant limitations. GPS, while effective outdoors, struggles in indoor environments due to signal obstructions from walls and ceilings, leading to unreliable positioning. Additionally, GPS devices consume substantial battery power, making them impractical for continuous monitoring, especially in critical applications like healthcare and military operations.

RFID systems, although useful, operate over short ranges and require a dense network of tags and readers, resulting in high implementation costs and complex infrastructure. They also necessitate a direct line of sight for optimal performance, which can be challenging in many indoor settings. Bluetooth-based localization suffers from variable signal strength and limited range, often leading to inconsistent location estimates and increased battery drain on connected device. Traditional health monitoring systems generally lack integrated location tracking capabilities, making it difficult to correlate health data with an individual's whereabouts. Many of these systems operate independently, requiring manual input and monitoring, which can delay critical responses.

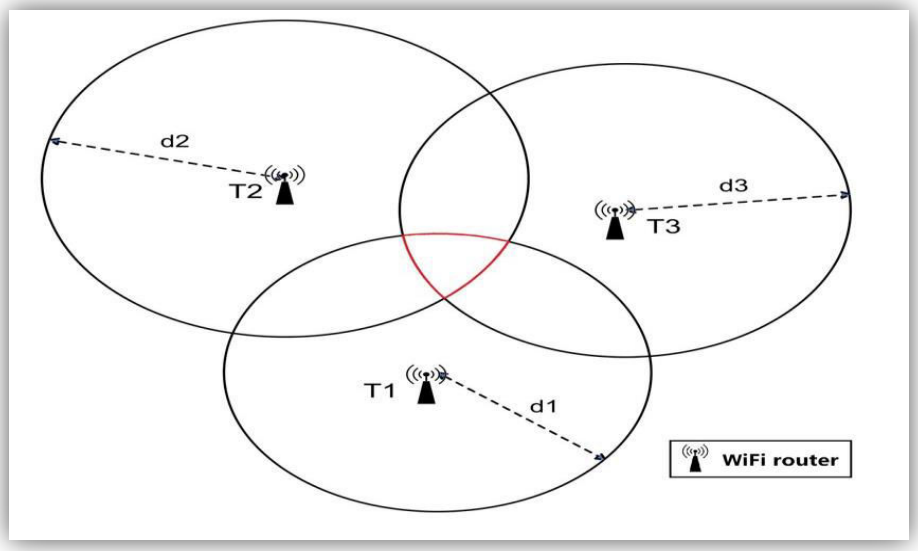

Fig 2: Proposed Solution

These drawbacks highlight the need for a more comprehensive solution that combines accurate indoor localization with real-time health monitoring, addressing the limitations of existing systems and improving safety and care in various applications.

VI. PROPOSED SYSTEM

A. Abbreviations and Acronyms
1. RSSI- Received Signal Strength Indicator
2. GPS- Global Positioning System
3. ESP32- Espressif32

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B. Objective

- Use RSSI signals from Wi-Fi or BLE beacons to accurately locate individuals indoors with trilateration.
- Continuously track heart rate using a heartbeat sensor for health monitoring.
- Transmit location and health data in real-time and trigger alerts for quick response during emergencies.

C. Methodology

RSSI-based indoor localization uses signal strength from multiple Wi-Fi or BLE beacons to estimate a person's position using the trilateration technique. Trilateration determines the location by calculating distances from three or more known reference points (beacons) based on RSSI values and solving equations to find the individual's coordinates.

Each beacon forms a circle with a radius equal to the calculated distance, a and the intersection of these circles gives the estimated position. A microcontroller (ESP32/Arduino) collects RSSI data, processes heartbeat sensor readings, and performs trilateration for real-time tracking. BLE beacons or Wi-Fi access points serve as reference points for RSSI measurements.

The heartbeat sensor (MAX30102/Pulse Sensor) continuously monitors the individual's health by detecting heart rate. Once the location and health data are computed, they are transmitted to a server or displayed on a mobile application for real-time monitoring. In scenarios where abnormal heart rates are detected—such as in emergencies or health crises—alerts are generated, including the user's location, to

Facilitate immediate response and assistance. This system is useful in healthcare, military operations, and emergency response, providing both positional awareness and health monitoring. This integrated solution ensures safety, operational efficiency, and better monitoring in indoor environments. Ultimately, this sophisticated combination of RSSI-based trilateration for localization and heartbeat monitoring creates a comprehensive solution that enhances safety, operational efficiency, and real-time situational awareness in indoor environments.

VII. IMPLEMENTATION OF PROJECT

In today's technological landscape, indoor localization and health monitoring have become critical across sectors like military operations, healthcare, and emergency response.

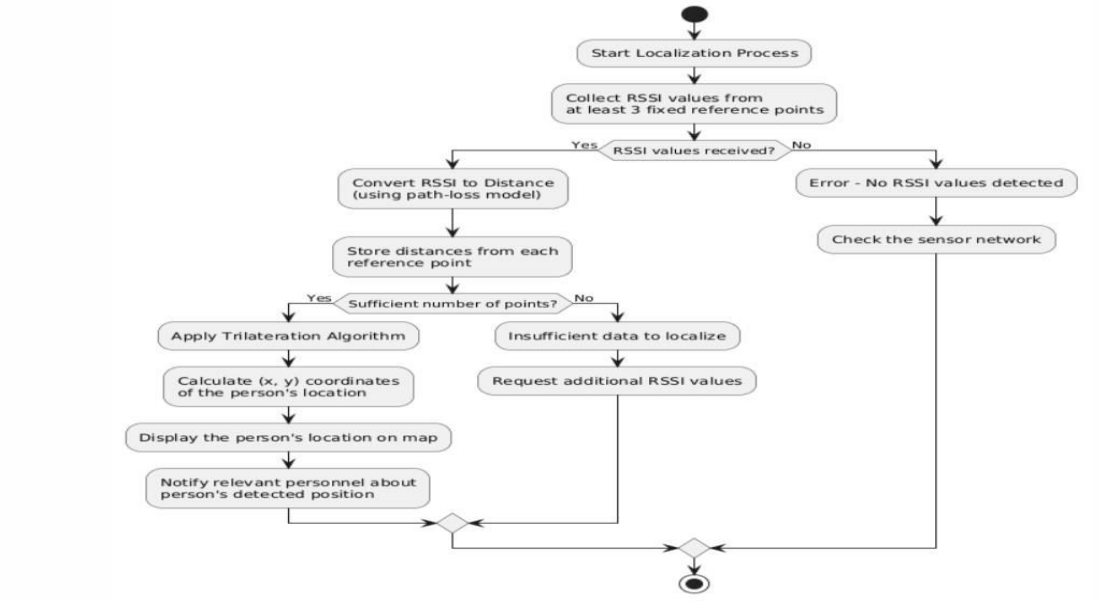

Fig 3: Flow chart for proposed solution

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While Global Positioning System (GPS) technology excels outdoors, it is unreliable indoors due to interference from walls and other obstacles. This limitation necessitates alternative localization methods, such as using Received Signal Strength Indicator (RSSI) technology, which leverages signal strength from Wi-Fi or Bluetooth Low Energy (BLE) beacons to estimate the position of individuals within a space.

This paper proposes a novel RSSI-based indoor localization system that integrates a heartbeat sensor, allowing real-time tracking and health monitoring. BLE beacons are deployed throughout the area, emitting signals detected by a receiver carried by the user. Using RSSI data, the system estimates the user's location via trilateration techniques. Trilateration involves calculating distances from at least three known reference points (the beacons) based on the RSSI values. By determining the distance from each beacon, the system formulates a set of equations representing circles around each beacon. The intersection of these circles provides the estimated coordinates of the user, allowing for precise location tracking**.** Additionally, a heartbeat sensor continuously monitors the individual's heart rate, particularly useful in high-stress environments like medical emergencies or military missions.

A microcontroller processes both localization and heart rate data, transmitting them via a GSM module to a centralized monitoring system. This setup enables real-time monitoring of both position and health metrics on a dashboard, enhancing situational awareness and safety. Challenges include the accuracy of RSSI values due to interference, battery efficiency, and ensuring secure transmission of sensitive health data. This system offers a promising approach to integrating indoor localization and health monitoring, with potential applications in healthcare, military operations, and emergency management.

VIII. ADVANTAGES

- Enhanced indoor localization utilizes RSSI technology to provide accurate position tracking in environments where GPS is ineffective due to interference.
- Continuous monitoring of heart rate allows for immediate assessment of an individual's health status, particularly in critical situations.
- The integration of localization and health data facilitates a comprehensive understanding of an individual's well-being and safety.
- Centralized monitoring systems enhance situational awareness for healthcare providers, military personnel, and emergency responders.
- The system can be easily scaled by adding more BLE beacons to cover larger indoor areas, improving accuracy and coverage.
- BLE technology is energy-efficient, enabling longer battery life for portable devices without compromising performance.
- BLE beacons can be installed in various indoor settings, such as hospitals, military bases, or emergency response areas, adapting to different needs.
- Real-time alerts generated by the system can significantly reduce response times in emergencies, potentially saving lives.
- The system is suitable for various applications, including healthcare, military operations, and emergency management, making it a versatile solution for multiple sectors.

IX. FUTURE WORKS

- Use machine learning to create algorithms that enhance distance estimation and improve localization accuracy in changing indoor environments.
- Add more sensors, like accelerometers and gyroscopes, to provide better context and strengthen the reliability of both localization and health monitoring.
- Implement stronger encryption methods and secure communication protocols to protect sensitive health and location data, ensuring user privacy.
- Develop easy-to-use interfaces for mobile apps and dashboards to enable real-time visualization of location and health metrics, simplifying monitoring and alerting for users.

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