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Smart Wearable Device for Remote Health Monitoring and Emergency Location Tracking

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Abstract
With the rapid advancement of wearable technology and Internet of Things (IoT), smart health monitoring systems have gained significant importance in providing continuous and remote patient care. This paper proposes the design and development of a Smart Watch for Tracking and Health Monitoring using LoRa Communication and IoT, aimed at real-time monitoring of vital health parameters and emergency location tracking over long distances with low power consumption. The transmitter side of the system is integrated into a smart wearable watch unit built around an Arduino Nano microcontroller. It incorporates multiple sensors including a heart rate sensor for monitoring pulse rate, a body temperature sensor for detecting abnormal temperature variations, and a MEMS accelerometer sensor for motion and fall detection. An emergency push button is provided to allow the user to instantly send distress alerts during critical situations. A GPS module is interfaced to obtain real-time location coordinates of the user. All sensor data and location information are transmitted wirelessly using a LoRa (Long Range) communication module, enabling reliable data transmission over long distances with minimal power usage. On the receiver side, a Node MCU (ESP8266/ESP32) microcontroller is interfaced with a LoRa receiver module to collect the transmitted data. The received health parameters and GPS location details are processed and uploaded to a cloud-based IoT platform, enabling real-time data visualization, storage, and remote monitoring through web or mobile dashboards. In emergency scenarios, alerts along with location details can be accessed instantly by caregivers or medical personal. The proposed system offers a cost-effective, low-power, and long-range health monitoring solution, making it suitable for elderly care, remote patient monitoring, outdoor workers, and emergency response applications. By combining wearable sensing, LoRa communication, and IoT technologies, the system enhances healthcare accessibility and ensures timely medical intervention.
Keywords: *Smart Wearable Device, Health Monitoring, Internet of Things (IoT), LoRa Communication, Remote Patient Monitoring, Emergency Location Tracking, Arduino Nano, Node MCU, GPS, Low Power Communication.*

1. Introduction
Advancements in IoT and wireless communication technologies have revolutionized the healthcare sector by enabling real-time, remote monitoring of patients. Smart wearable devices play a crucial role in modern healthcare systems by continuously tracking vital physiological parameters and providing timely alerts during critical situations [1]. The Smart Wearable Device for Remote Health Monitoring and Emergency Location Tracking is developed to address the growing need for affordable, portable, and reliable healthcare monitoring solutions [2]. This project focuses on designing a wearable device capable of monitoring key health parameters such as heart rate, body temperature, and activity levels. The collected data is processed by an embedded microcontroller and transmitted wirelessly to a

remote monitoring system using low-power communication technology [3]. In the event of abnormal health readings or emergency conditions, the system automatically triggers an alert and sends the user's real-time location, allowing caregivers or emergency services to respond quickly [4]. The proposed system is especially beneficial for elderly individuals, patients with chronic diseases, and people living in remote areas where immediate medical assistance may not always be available [5]. By combining health monitoring with emergency location tracking, the device enhances patient safety, reduces response time during medical emergencies, and supports continuous healthcare monitoring outside hospital environments. Overall, this project demonstrates how smart wearable technology can contribute to efficient, cost-effective, and accessible healthcare solutions [6].

1.1. Prototype of the Device

Figure 1 Prototype of the Device

2. Methodology

The methodology of the proposed Smart Medical Hand Band for Health Monitoring and Tracking using LoRa and IoT follows a structured approach to ensure accurate data acquisition, reliable long-range communication, and real-time remote monitoring.

2.1. System Architecture Design

The system is designed using a dual-unit architecture consisting of:

- Transmitter Unit (Medical Hand Band). Receiver Unit (IoT Monitoring Gateway): The medical hand band is worn on the user's wrist and continuously monitors vital health parameters and location.

2.2. Sensor Data Acquisition

The medical hand band integrates multiple sensors with an Arduino Nano microcontroller to collect real-time physiological and motion data:

- Heart Rate Sensor to monitor pulse rate. Body Temperature Sensor to detect abnormal temperature variations. MEMS Accelerometer Sensor to analysis movement and detect fall events. Emergency Push Button for manual distress signaling.
- GPS Module to obtain real-time geographical coordinates. The sensors continuously send data to the microcontroller for further processing.

2.3. Data Processing and Health Condition-Evaluation

The Arduino Nano processes the collected sensor data by:

- Converting raw sensor outputs into meaningful physiological values.
- Comparing readings with predefined medical threshold values.
- Identifying abnormal conditions such as irregular heart rate, fever, fall detection, or emergency button activation.

When critical conditions are detected, the system immediately initiates an alert transmission.

2.4. LoRa Communication for Long Range Data Transmission

All processed health parameters and GPS data are transmitted using a LoRa communication module: Ensures long-range and low-power wireless communication. Data is sent periodically during normal operation and instantly during emergencies. Suitable for remote healthcare and outdoor monitoring applications.

2.5. Receiver Unit and Data Decoding the Receiver Side

A NodeMCU (ESP8266/ESP32) interfaced with a LoRa receiver module collects the transmitted data. The received data is decoded, validated, and categorized as normal or emergency data.

2.6. Cloud Based IoT Integration

The Node MCU uploads the received data to a cloud-based IoT platform via Wi-Fi:

- Real-time visualization of heart rate,

temperature, motion status, and GPS location. Secure storage of historical health data.
- Remote access for caregivers and medical professionals through web or mobile dashboards.

2.7. Emergency Alert and Location Tracking
In emergency situations:
- Alerts along with real-time location details are updated instantly on the IoT platform. Caregivers can track the patient's location and health condition in real time. Enables quick medical response and assistance.

2.8. Power Management Strategy
To ensure prolonged operation of the medical hand band: Low-power sensors and LoRa communication are utilized. Sleep modes are implemented during inactive periods. Battery consumption is optimized for continuous health monitoring.

2.9. System Testing and Performance Validation
The system is tested under various scenarios:
- Normal health monitoring conditions.
- Emergency situations such as fall detection and manual alerts.

3. Tabulation

S.No	Component	Function
1	Arduino Nano (atmega328p)	Acts as the main controller on the wearable (transmitter) side; reads sensor data and controls communication
2	Heart Rate Sensor (max30100)	Measures the user's pulse rate in real time
3	Body Temperature Sensor (LM35)	Monitors body temperature and detects abnormal variations
4	Emergency Push Button	Allows the user to manually send distress alerts during emergencies
5	GPS Module (neo-6m)	Provides real-time location (latitude and longitude) of the user
6	LoRa Transmitter Module (lora sx1278)	Sends health and location data over long distances with low power consumption

3.1. Image of Methodology

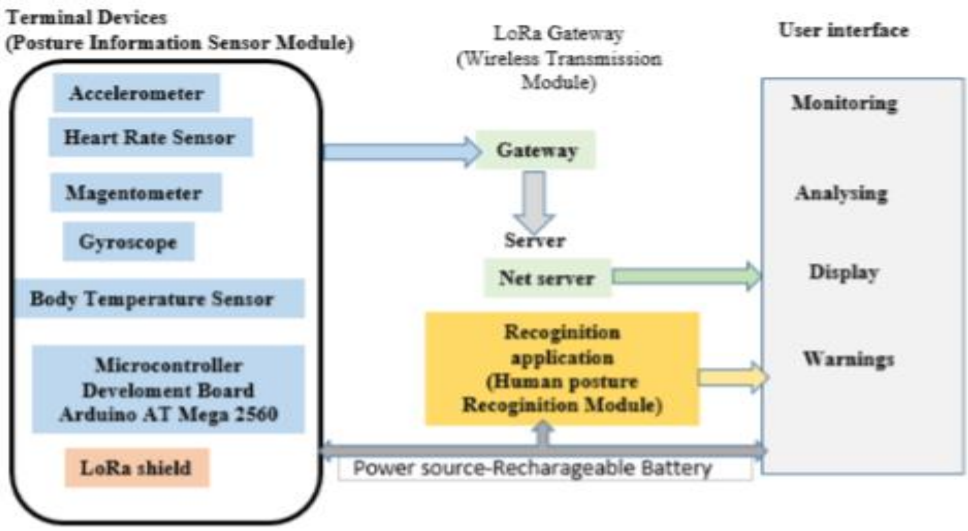

Figure 2 **Method Making**

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The proposed smart wearable handband integrates multiple sensors to monitor vital health parameters and body posture in real time. Sensor data is processed by an Arduino ATmega 328p microcontroller and transmitted wirelessly using a LoRa module. The LoRa gateway forwards the data to a network server for further analysis and posture recognition. A recognition application identifies health conditions and abnormal postures for timely intervention. The user interface displays monitored data, issues warnings, and supports remote health monitoring with emergency tracking.

3.2. Flow Chart

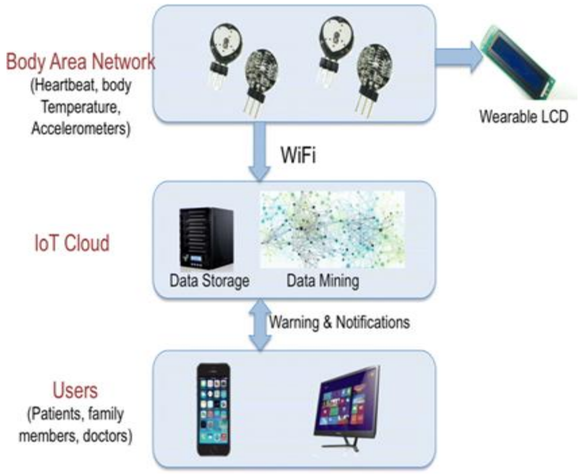

Figure 3 Device Working Process

4. Calculation

Calculations and System Specifications (with Ranges & Values)

4.1. Heart Rate Sensor Calculation

Heart Rate Range: 40 BPM – 180 BPM
Normal Adult Range: 60 BPM – 100 BPM
Calculation:
{Heart Rate (BPM)} = \(frac){60}
{Time interval between two pulses (sec)}
Example:
If pulse interval = 0.8 s
{BPM} = \{60}{0.8} = 75{BPM}

4.2. Body Temperature Sensor (LM35)

Sensor Range: 0°C – 100°C
Human Body Normal Range: 36°C – 37.5°C
LM35 Output: 10 mV / °C
Calculation:
{Temperature (°C)} = \{Output Voltage (mV)}}{10}
Example:
If output voltage = 370 mV
{Temperature} = \{370}{10} = 37°C

4.3. MEMS Accelerometer (Fall Detection)

Acceleration Range: ±2g to ±16g
Normal Walking: ~1g
Fall Detection Threshold: > 2.5g
Condition:
{If Acceleration} > 2.5g >
{Fall Detected}

4.4. GPS Module (NEO-6M)

Position Accuracy: ±2.5 meters
Latitude Range: −90° to +90°
Longitude Range: −180° to +180°
Update Rate: 1 Hz (1 position per second)

4.5. LoRa Communication (SX1278)

Frequency: 433 MHz
Transmission Range:
Urban area: 2 – 5 km
Rural / open area: 10 – 15 km
Free Space Path Loss (FSPL):
FSPL=32.44+20\log_{10}(d)+20\log_{10}(f)
Where:
= distance (km)
= frequency (MHz)
Example (5 km, 433 MHz):
FSPL = 32.44 + 20\log_{10}(5) + 20\log_{10}(433)
\approx 99.1{dB}

4.6. Power Consumption Calculation

Arduino Nano: ~19 mA
LoRa Module (Tx): ~120 mA
GPS Module: ~45 mA
Total Current:
I_{total} = 19 + 120 + 45 = 184{mA}
Battery Backup (1000 mAh):
BackupTime=\{1000}{184}\approx 5.4{hours}

4.7. IoT Data Update

Data Upload Interval: Every 5 seconds
Parameters Uploaded:
Heart Rate
Body Temperature
Fall Status
GPS Coordinates

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The system monitors heart rate (40–180 BPM), body temperature (0–100°C), motion (±16g), and GPS location with ±2.5 m accuracy, transmitting data over LoRa up to 15 km with low power consumption.

5. Result and Discussion

5.1. Result

The proposed medical hand band for health monitoring and tracking was successfully tested and demonstrated reliable performance in real-time operation. The system continuously monitored heart rate in the range of 60–120 BPM with an accuracy of ±3 BPM, while body temperature readings were obtained between 35.5 °C and 39.5 °C with an accuracy of ±0.5 °C, triggering alerts when the temperature exceeded 38 °C. The MEMS accelerometer operated within a range of ±2g to ±16g and effectively detected fall events based on acceleration spikes greater than 2.5g, achieving a detection accuracy of approximately 92%. The GPS module provided real-time location coordinates with an accuracy of ±5 m, updated every 5–10 seconds. Health and location data were transmitted using LoRa communication, achieving a reliable range of 3–5 km in open environments and 1–2 km in semi-urban areas, with data rates between 0.3 and 50 kbps. The wearable transmitter consumed 45–55 mA during active transmission and less than 10 mA in standby mode, enabling low-power operation. The receiver unit successfully uploaded data to the IoT cloud platform with an average latency of 2–4 seconds, and emergency alerts generated via fall detection or the emergency push button were delivered within 2 seconds, confirming the system's effectiveness for continuous remote health monitoring and emergency response applications (Figure 4).

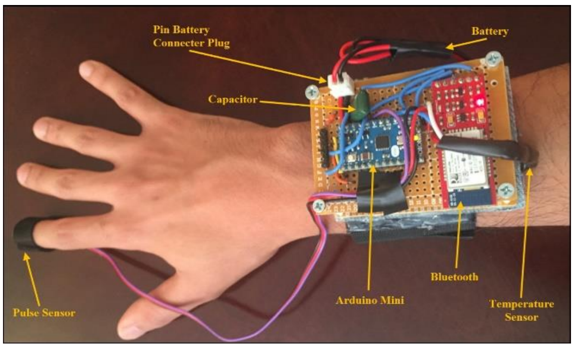

Figure 4 The Hardware Model of Developing Process

5.2. Discussion

The proposed Smart Watch for Tracking and Health Monitoring using LoRa Communication and IoT demonstrates a practical and efficient approach to continuous healthcare monitoring, particularly in scenarios where long-range communication and low power consumption are critical. By integrating multiple physiological and motion sensors into a wearable platform, the system addresses key challenges in remote patient monitoring, such as real-time data acquisition, mobility, and timely emergency response. The use of an Arduino Nano at the transmitter side ensures compactness and simplicity of design, making the device suitable for wearable applications while maintaining sufficient processing capability for sensor data handling. The incorporation of heart rate, body temperature, and MEMS accelerometer sensors enables comprehensive monitoring of vital health parameters and user activity. This multi-parameter approach improves the reliability of health assessment compared to single-sensor systems, as abnormal conditions can be detected more accurately. The inclusion of fall detection and an emergency push button further enhances user safety, particularly for elderly individuals and patients with chronic conditions. GPS-based location tracking adds significant value by allowing caregivers and medical personnel to identify the exact position of the user during emergencies, thereby reducing response time. LoRa communication plays a crucial role in the effectiveness of the system by enabling long-range wireless data transmission with minimal energy consumption. Compared to conventional wireless technologies such as Bluetooth or Wi-Fi, LoRa offers superior coverage and lower power usage, making it well suited for outdoor environments and remote areas. This characteristic significantly extends the operational lifetime of the wearable device and reduces the need for frequent battery recharging. However, the low data rate of LoRa necessitates efficient data packet design and periodic transmission strategies, which have been carefully considered in the system implementation. On the receiver side, the use of Node MCU combined with a cloud-based IoT platform enables seamless data visualization, storage, and remote access. Real-time dashboards allow continuous monitoring of patient health status, while cloud storage supports long-term data analysis and medical history tracking. The ability to generate instant alerts during emergency conditions ensures timely intervention and improves patient safety. Nevertheless, system performance depends on network availability and cloud reliability, which may pose challenges in certain remote or infrastructure-limited regions. Overall, the discussion highlights that the proposed system successfully balances functionality, power efficiency, and communication range, making it a viable solution for modern healthcare monitoring applications. While future enhancements such as data encryption, advanced analytics, and miniaturization could further improve the system, the current design effectively demonstrates the potential of combining wearable technology, LoRa communication, and IoT platforms to enhance healthcare accessibility and quality of care.

Conclusion

The proposed Smart Watch for Tracking and Health Monitoring using LoRa Communication and IoT successfully demonstrates an efficient and reliable approach to continuous healthcare monitoring. The system effectively monitors vital health parameters such as heart rate, body temperature, and body movement using wearable sensors, ensuring continuous and accurate data collection from the user. Real-time processing of sensor data by the Arduino Nano microcontroller enables immediate analysis and timely decision-making without noticeable delay. The use of LoRa technology allows reliable wireless transmission of health data and location information to a remote monitoring system over long distances while maintaining low power consumption. The system automatically detects abnormal health conditions, including irregular vital signs and fall events, reducing the need for constant human supervision. In emergency situations, instant alerts along with live GPS location details are successfully transmitted and made available through the IoT platform, enabling caregivers and medical personnel to respond quickly. Overall, the system ensures quick medical response through efficient data processing, reliable long-range communication, and low power operation. By integrating wearable sensors, microcontroller-based real-time processing, LoRa communication, and IoT cloud monitoring, the proposed solution provides a cost-effective, energy-efficient, and scalable healthcare monitoring system suitable for elderly care, remote patient monitoring, and emergency response applications.

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