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Real-Time Patient Monitoring Using IOT and Ai For Chronic Disease Management (LIFEPULSE)

Mrs.P.Prema[1], Vinodhini.M[2], V.Nanthitha[3], Kaviya.S[4],Jeyasooriya.Y[5]
[1,2] *Assistant Professor Computer Science and Engineering,*
[3,4,5] *UG graduates Computer Science and Engineering*
**SreeSakthi Engineering College, Coimbatore*

ABSTRACT
Chronic diseases such as diabetes, hypertension, and cardiovascular conditions require continuous monitoring to prevent severe health complications. This paper presents an innovative real-time patient monitoring system integrating the Internet of Things (IoT), Artificial Intelligence (AI), Neural Networks, Blockchain, and Thermoelectric Generators (TEG). The system consists of a wearable band/watch that collects real-time health data, including blood sugar levels, hypertension, oxygen levels, and ECG readings. The data is transmitted to the cloud every five minutes and securely stored using blockchain technology. AI and neural network models analyze the historical patient data to predict potential health deterioration. Alerts are generated in a three-stage escalation process: first to the patient, then caregivers, and finally emergency medical teams if necessary. Additionally, the band includes a "Call" button for immediate assistance and voice assistance for visually impaired users. The device is powered by a thermoelectric generator based on the Seebeck effect, with a lithium-ion battery as an alternative power source. This paper discusses the system architecture, implementation, and potential impact on healthcare.
KEYWORDS:*chronic, hypertension, cardiovascular, artificial intelligence, neural networks, blockchain, thermoelectric, band/watch, alert, seebeck effect, lithium-ion battery..*

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I. INTRODUCTION

The growing prevalence of chronic diseases necessitates real-time health monitoring solutions that provide timely interventions. Traditional monitoring methods are inefficient due to periodic checkups, which may fail to detect sudden health deteriorations. Our proposed system aims to bridge this gap by leveraging IoT and AI to continuously track vital health parameters and predict potential risks.

1.2. Yealy evolution in this topic:

Below is a year-by-year overview highlighting key innovations

- 2013-Empatica Founded
- 2014-Embrace Wearable Development
- 2016-FDA Approval of MiniMed 670G
- 2018-FDA Clearance for Embrace

Advancements in Noninvasive Glucose Monitoring:

- 2019-Launch of KardiaMobile 6L
- 2022-Empatica's Health Monitoring Platform Clearance
- 2023-FDA Approval of iLet Bionic Pancreas:
- 2024-Growth in IoT-Enabled Patient Monitoring
- 2025-Emergence of Advanced Health Monitoring Devices ,Integration of Networked Medical Devices

II.LITERATURESURVEY

Several research studies and existing solutions have contributed to the development of real-time patient monitoring systems. The following are key studies that highlight advancements in this domain:

- IoT-Based Health Monitoring: Studies have demonstrated that IoT-enabled devices can efficiently collect and transmit patient health data in real-time, reducing the need for manual intervention.
- AI and Neural Networks for Predictive Analysis: Research has shown that AI-driven models, particularly deep learning techniques like LSTMs and RNNs, improve the accuracy of health predictions by analyzing patient data trends.
- Blockchain for Secure Medical Records: Various studies emphasize the benefits of blockchain in ensuring tamper-proof and decentralized health data storage, enhancing security and patient privacy.
- Wearable Devices in Healthcare: Modern wearable technologies, such as smartwatches and fitness bands, have been extensively explored for their ability to provide continuous health monitoring and emergency alerts.
- Energy Harvesting for Wearables: Research on thermoelectric generators has proven their potential to provide sustainable power for wearable devices by harnessing body heat, reducing dependency on conventional batteries.

The proposed system builds on these advancements to provide an integrated and efficient real-time monitoring solution for chronic disease management.

III. SYSTEM ARCHITECTURE

3.1 Wearable Device

The core of the system is a smart wearable device designed as a band or watch, incorporating multiple sensors to measure:

- Blood Sugar Levels: Measured using a continuous glucose monitoring (CGM) sensor.
- Hypertension (Blood Pressure): Monitored using a non-invasive blood pressure sensor.
- Oxygen Saturation (SpO2): Detected using a pulse oximeter.
- Electrocardiogram (ECG): Recorded using an ECG sensor.

The collected data is transmitted to a cloud-based database every five minutes for storage and analysis.
Device used for monitoring is

- Sphygmomanometer (blood pressure)
- Glucometer (blood glucose)
- Pulseoximeter (SpO_2)
- Spirometer (lung function)
- Transoesophageal Doppler (cardiac output via esophageal ultrasound)

We have embedded this all devices into a single micro chip and we have installed into the watch .

3.2 Blockchain for Secure Data Storage

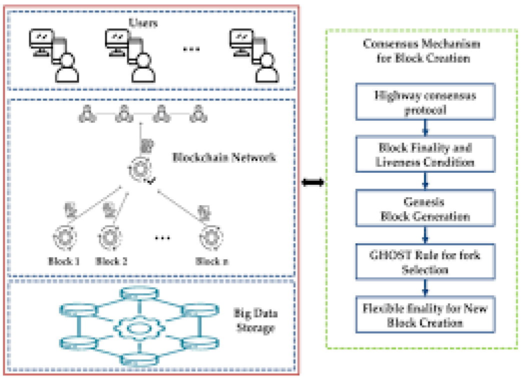
Blockchain technology is employed to securely store and manage patient health data. It ensures:

- Data Integrity: Blockchain prevents unauthorized alterations, ensuring that medical records remain tamper-proof.
- Decentralization: Patient data is distributed across a secure, decentralized ledger, reducing the risk of a single point of failure.
- Privacy and Security: Through cryptographic encryption, blockchain ensures that only authorized personnel can access patient records.
- Transparency and Auditability: All modifications and access to patient data are logged, providing an immutable history of medical data changes.

By integrating blockchain technology, our system enhances data security, ensures trust among stakeholders, and eliminates the risks associated with centralized data storage.

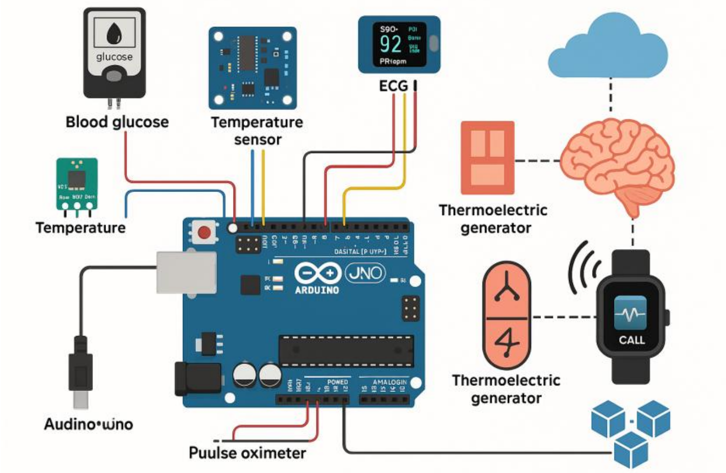
3.3 AI and Neural Network Analysis

Using AI and neural networks, the system analyzes historical health data to detect deviations from normal health trends. The AI model predicts potential health risks and triggers alerts when anomalies are detected.



Input Data:
The system continuously collects real-time data from the wearable device. This data serves as input for the machine learning models. The main inputs include:

- Blood Sugar Levels (mg/dL)
- Blood Pressure (Systolic and Diastolic in mmHg)
- Oxygen Saturation (SpO2) (%)
- ECG Data (waveform values and heart rate)
- Patient Historical Data (from blockchain database)
- Environmental Data (ambient temperature, activity level)
- Patient Metadata (age, gender, pre-existing conditions, medication adherence)



These parameters are preprocessed and transformed into structured datasets for training and inference.
Deep learningModels Used:

1. Decision Tree Algorithm

A Decision Tree is a simple yet powerful supervised learning algorithm used in this project for rule-based classification and interpretability of patient health conditions.

- Application in the System:
    - Classifies patient health status as *Normal*, *Warning*, or *Critical* based on thresholds in the input features.
    - Helps in early-stage alerts by evaluating individual parameters (e.g., if SpO2 < 90% and heart rate > 120 bpm → Warning).
    - Provides transparent decision paths to explain why a certain health alert is triggered.

2. Random Forest Algorithm

Random Forest is an ensemble method that builds multiple decision trees and aggregates their outputs to improve accuracy and avoid overfitting.

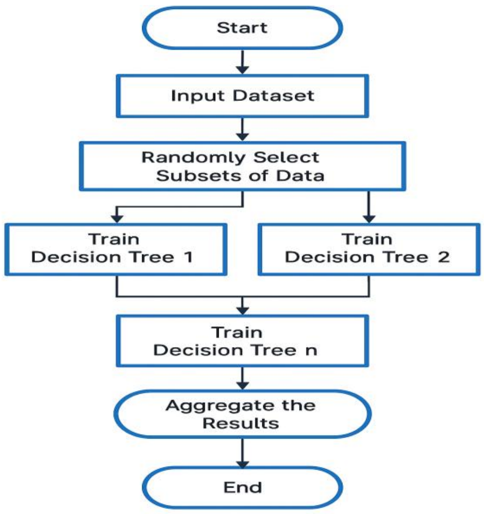
- Application in the System:
    - Used for predictive analytics to forecast potential health deterioration.
    - Aggregates predictions from multiple decision trees to classify the likelihood of events such as a hypertensive crisis or arrhythmia.

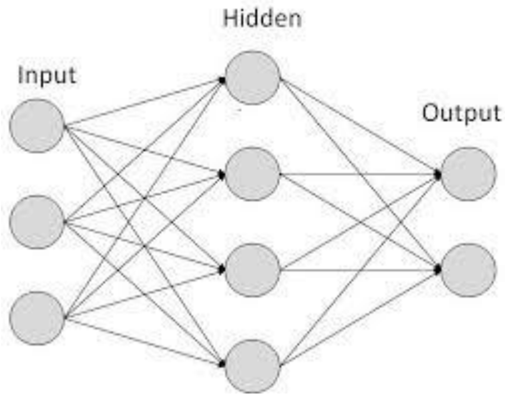
- Analyzes complex interactions among multiple health parameters and historical data

Example:
Let’s say the system receives this input:

- Blood Sugar: 190 mg/dL
- Blood Pressure: 150/100 mmHg
- SpO2: 88%
- Heart Rate: 130 bpm

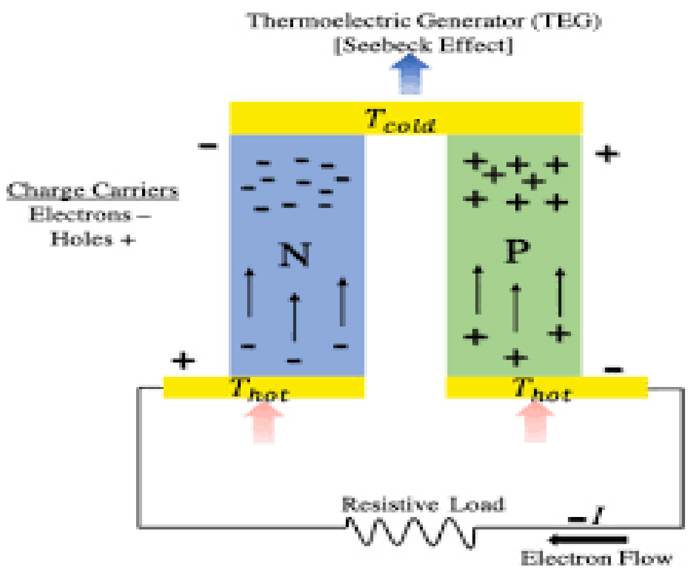
Decision Tree: Based on predefined thresholds, this might classify the situation as *Warning* or *Critical*.
Random Forest: Considering this data in context with previous history and multiple tree-based evaluations, it might predict a 78% probability of an acute cardiovascular event in the next hour, triggering the alert mechanism





3.4 Thermoelectric Generator

The wearable device utilizes a thermoelectric generator (TEG) based on the Seebeck effect to generate energy from the body’s natural heat. This allows continuous power generation without the need for frequent recharging. The TEG consists of thermocouples that convert temperature differences into electrical energy, ensuring sustainable and reliable power for the wearable device. In cases where the thermoelectric generator is insufficient, a lithium-ion battery is used as an alternative power source to maintain uninterrupted functionality.



IV .METHODOLOGY

The methodology for implementing the real-time patient monitoring system is as follows:

4.1 Data Collection

- Sensors embedded in the wearable device collect real-time health parameters every five minutes.
- Data includes blood sugar levels, blood pressure, oxygen saturation, and ECG readings.

4.2 Data Transmission and Storage

- The collected data is transmitted wirelessly to a cloud-based storage system.
- Blockchain technology ensures data security and integrity by maintaining a decentralized ledger.

4.3 AI-Based Analysis and Prediction

- AI algorithms analyze historical and real-time patient data to detect health trends and anomalies.
- Neural networks, specifically Recurrent Neural Networks (RNN) or Long Short-Term Memory (LSTM), are employed for predictive analysis.
- AI provides real-time insights and generates alerts if a patient's health deteriorates.

4.4 Feature Extraction

To improve the accuracy of AI-based predictions, the system extracts key features from the collected data:

- Blood Sugar Levels: Average glucose levels, trend over time, sudden spikes or drops.
- Hypertension (Blood Pressure): Systolic and diastolic pressure variations, hypertension risk patterns.
- Oxygen Saturation (SpO2): Oxygen level trends, abnormal desaturation events.
- ECG Readings: Heart rate variability, arrhythmia detection, waveform analysis.
- Patient History: Long-term trends, medication adherence, previous alerts, and responses.
- Environmental Factors: Temperature, humidity, and activity level correlations with vital signs.

These extracted features are fed into neural networks to enhance prediction accuracy and anomaly detection.

4.5 Alert Mechanism Implementation

- The system follows a three-tier escalation mechanism:
  - Stage 1: The patient receives a notification if abnormal health readings are detected.
  - Stage 2: Caregivers are alerted if the patient's condition does not improve.
  - Stage 3: Emergency medical teams are notified if further deterioration is observed

V. BENEFITS OF THE PROPOSED SYSTEM

- Continuous Monitoring: Real-time tracking of vital parameters ensures early detection of health deterioration.
- AI-Based Prediction: Advanced AI and neural networks provide accurate predictions, reducing emergency occurrences.
- Secure Data Storage: Blockchain technology ensures data integrity and security.
- Energy-Efficient Power Source: Thermoelectric generators provide sustainable power, reducing dependency on battery replacements.
- Emergency Assistance Feature: A "Call" button ensures immediate help when needed.

VI. Conclusion

This real-time patient monitoring system offers an advanced solution for chronic disease management by integrating IoT, AI, and blockchain. The use of a thermoelectric generator ensures long-term usability without frequent recharging. Future work includes refining AI models for better predictive accuracy and enhancing wearable ergonomics.

References

[1]. A. Smith et al., "IoT in Healthcare: Applications and Challenges," IEEE Transactions on Biomedical Engineering, 2021.
[2]. B. Jones, "Blockchain for Secure Medical Records," Journal of Medical Informatics, 2022.
[3]. C. Lee et al., "Neural Networks for Predicting Chronic Disease Outcomes," AI in Medicine, 2023.
[4]. "Internet of Things in Healthcare: Theory and Practice" – Adam Bohr, KavehMemarzadeh
[5]. "Internet of Things for Healthcare Technologies" – PoonamPhogat, Dac-Nhuong Le, Prasant Kumar Pattnaik, Raghvendra Kumar
[6]. Dhanvijay, M. M., &Patil, S. C. (2019). "Internet of Things: A survey of enabling technologies in healthcare and its applications." Computer Networks, 153, 113-131.
[7]. Islam, S. M. R., Kwak, D., Kabir, M. H., Hossain, M., &Kwak, K. S. (2015). "The internet of things for health care: A comprehensive survey." IEEE Access, 3, 678-708.
[8]. Patel, K. K., Patel, S. M. (2016). "Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges." International Journal of Engineering Science and Computing, 6(5), 6122-6131.
[9]. World Health Organization (WHO) – Reports on digital health and IoT applications in healthcare. https://www.who.int
[10]. IEEE Xplore – Research papers on IoT in healthcare. https://ieeexplore.ieee.org
[11]. Springer Link – Journals and books on IoT applications in medicine.https://link.springer.com
[12]. D. Kumar et al., "Real-Time Health Monitoring Using Wearable Sensors and Cloud Computing," International Journal of Medical Informatics, 2020.
[13]. E. Zhang and M. Patel, "AI-Based Predictive Systems for Chronic Disease Management," Healthcare Technology Letters, 2021.
[14]. F. Ahmad et al., "Thermoelectric Generators for Energy Harvesting in Wearable Devices," IEEE Sensors Journal, 2022.
[15]. G. Nguyen and T. Do, "Application of Blockchain in Securing IoT Medical Data," Sensors, vol. 21, no. 5, 2021.
[16]. H. Chen et al., "Wearable Technologies for Remote Health Monitoring in Chronic Illness," Journal of Biomedical Science and Engineering, 2020.
[17]. I. Singh and R. Verma, "Deep Learning in Healthcare: A Review of Recent Advances," Computers in Biology and Medicine, vol. 136, 2021.
[18]. J. Li et al., "Smart Healthcare System Based on IoT and Cloud Computing," Future Generation Computer Systems, 2021.