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Monitoring of Patient Health Using IoT and Machine Learning Based on Vital Signs

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ABSTRACT

The integration of Internet of Things (IoT) and Machine Learning (ML) offers a transformative approach to patient health monitoring, enhancing the efficiency and accuracy of healthcare systems. This research presents a comprehensive framework for real-time monitoring of vital signs such as heart rate, blood pressure, temperature, and oxygen saturation. IoT-enabled wearable devices continuously collect patient data and transmit it to a centralized system for processing. Machine Learning algorithms analyze the data to detect patterns, predict health risks, and provide early warnings of potential medical conditions. In this paper, a microcontroller acts as a mode for communication purpose. This can be used as a primary monitoring system that traces patient vital signs using sensors and intimates about patient health to their family members and concerned doctors in nearby hospitals in case of any immediate need via internet. The system leverages advanced predictive models to identify anomalies and trends, facilitating timely interventions and personalized healthcare. This approach reduces the burden on healthcare facilities, enables remote patient monitoring, and improves patient outcomes by providing continuous, data-driven insights. Additionally, the proposed solution addresses data privacy and security concerns, ensuring the integrity and confidentiality of sensitive health information. By combining IoT technology with ML-driven analytics, this framework offers a scalable and efficient tool for modern healthcare, promoting proactive patient care and reducing hospital readmissions.

Keyword: Embedded System, Internet of Things, Patient Health Care System, Microcontroller Unit.

I. Introduction

It's not possible every time particularly in critical situations to communicate with the doctor in hospital or the guardian during instances such as increase in heart rate, respiratory level, when a child or adult is suffering with high fever, people living in hill stations or outskirts of the city or during emergency while driving time. This system

helps in sending the patient health vital signs to the doctor in the nearby hospital via SMS through internet. Using the IoT cloud, captured data of the several parameters measured are transmitted to the collaborating hospital. Therefore, doctor can attend the patient remotely and can give the preliminary medication before the patient is rushed to the hospital. Patient health monitoring using IoT involves leveraging interconnected devices and sensors to collect, transmit, and analyze vital health data in real-time. The wearable sensors and devices are utilized that patients can wear IoT-enabled devices (e.g., smartwatches, ECG monitors) and measure vital signs such as heart rate, blood pressure, temperature, oxygen saturation (SpO2), and glucose levels.

These sensors continuously collect health data and convert it into digital signals. The information is then sent wirelessly via Wi-Fi, Bluetooth, or cellular networks to centralized systems or cloud platforms. The collected data is securely transmitted to a cloud-based server, where it is stored and can be accessed remotely by healthcare providers. Advanced encryption ensures the data's privacy and integrity. Machine Learning (ML) algorithms process and analyze the data to detect anomalies, identify patterns, and predict potential health issues. For example, a sudden drop in oxygen levels could trigger an alert for immediate intervention. If any irregularities are detected, the system can send instant alerts to healthcare providers or family members. This allows timely medical responses and prevents complications. Doctors and caregivers can monitor patient data remotely through web portals or mobile apps. This is particularly useful for chronic disease management, post-surgical care, or elderly patients living independently. Patients can also access their own health data, enabling them to actively manage their health and make informed decisions about lifestyle changes or treatments. IoT systems can integrate with EHRs to provide a comprehensive health profile, allowing for better diagnosis and personalized care. There are several key benefits of the patient health monitoring such as identifies health issues, continuous monitoring of high-risk patients, reduce cost, enhanced patient outcomes, and ensure timely prevention.

Traditional methods for patient health monitoring rely on periodic, in-person assessments and manual data collection, often requiring patients to visit healthcare facilities. In-clinic check-ups are required to monitor the patient health regularly. Vital signs such as blood pressure, heart rate, temperature, and weight are measured manually using standard medical instruments like sphygmomanometers, thermometers, and stethoscopes. Some laboratory tests are conducted by analysis of samples (such as blood, urine, etc.) to monitor various health parameters, such as cholesterol levels, blood glucose, and kidney or liver function. However, this monitoring is limited to the hospital environment and often involves bulky equipment. Patients manually track symptoms or vital signs (e.g., using home blood pressure cuffs or glucose meters) and report their findings during doctor visits. This method depends heavily on patient compliance and accuracy. Techniques such as X-rays, MRIs, and CT scans are used periodically to assess internal health conditions. These methods provide snapshots rather than continuous data. Health information is traditionally recorded on paper charts, which can be prone to errors, loss, and difficulty in sharing between different healthcare providers. For monitoring heart activity, patients might wear portable ECG devices (Holter monitors) for a set period (24-48 hours), capturing data that is later analyzed by doctors. Although, these methods are beneficials for the serious diseases. However, there are some limitations with the traditional methods such as intermittent data collection, limited accessibility, delayed response, manual errors, and resource-intensive. Therefore, IoT-based health monitoring offers continuous, real-time data collection and remote access, addressing many of these limitations and enabling proactive, personalized care. The contribution of the current article is as follows:

- To design and develop patient health vitals monitoring system that can be used to capture and transmit the data via internet from the patient in emergency to the corresponding doctor and alert the caretaker.
- To develop an emergency alert system using sensors such as heartrate sensor, respiratory sensor, thermal sensor and indicate the change in patient vital sign parameters.

II. Literature Survey

With existing systems, patient must be hospitalised to get regular periodic monitoring. Once discharged, monitoring cannot be possible. It is not possible to have the monitoring system at home. Also, existing systems are capable of measuring patient health parameters and transmit them using Zig Bee or Bluetooth protocol & etc., These protocols can be used to send data only for short-ranges. Doctor cannot always access patient data. Remote monitoring of patient health through internet using E-Health sensor shield interface kit by Ananda Mohan Ghosh et al. [1] cannot transmit any alert message. Remote Health Monitoring System Using IoT and Cloud Computing developed a real-time monitoring framework using wearable sensors and cloud integration. Data transmission via MQTT allowed remote access, reducing hospital visits. However, it lacked advanced predictive analytics, focusing only on data visualization. IoT-based smart healthcare monitoring system implemented sensors to track heart rate, temperature, and SpO2. Data was processed with microcontrollers and alerted abnormal values. While effective in continuous monitoring, it didn't integrate with Electronic Health Records (EHR) or provide decision support. Predictive analysis of patient health using machine learning and IoT applied decision trees and SVM algorithms to IoT data, enhancing cardiac anomaly detection. Despite accuracy improvements, the system faced high computational costs, limiting real-time performance. Wireless body area networks (WBANs) for healthcare monitoring proposed a Zigbee-based short-range wireless system for tracking physiological signals. It demonstrated effective data transmission but lacked cloud integration and had limited range and scalability. Security and privacy framework for IoT-Based Health Monitoring Systems designed robust encryption protocols for protecting IoT health data, improving security and privacy. However, the computational overhead needed optimization for real-time applications. An IoT-based system for early detection of hypertension used blood pressure sensors with cloud storage to monitor hypertension trends. It successfully identified risk factors early but did not include predictive modeling capabilities. AI-powered IoT framework for patient monitoring integrated deep learning models to predict health deterioration using IoT data. While accuracy was high, the system required large datasets, limiting real-time adaptability. Remote elderly monitoring system using IoT sensors focused on fall detection and health alerts for seniors. Effective in detecting emergencies, it lacked advanced health trend analysis. IoT-based wearable ECG monitoring system implemented an IoT-based ECG device for real-time cardiac monitoring. It improved detection but had issues with signal noise and battery life. IoT and big data analytics for healthcare combined IoT sensor data with big data techniques for trend analysis and prediction. While scalable, it required significant computational resources and lacked real-time anomaly detection.

Also, Healthcare system for patient monitoring controlled by Raspberry Pi Unit, R Kumar et al. [2] includes observation of patient vital parameters through sensors which can be displayed using putty software cannot provide alarm alert to doctors and family members. Monitoring patient health status using IoT & RFID tags, Sarfraz Fayaz Khan [3] does not include responsive measures related to patient health condition. Monitoring of patient's health situation by transmitting needy data and alert message to doctors & family members, Freddy Jimenez et al. [4] did not include control of any appliance. Smart hospital monitoring system to observe patient's health status using spark kit unit,

S. Siva [5] et al. involves collection of patient vital signs and sending of alert message if the observed readings raise above a preset threshold level.

III. Proposed Model

The proposed design will support and monitor patient health parameters while in hospital and after getting discharged. The system main objective is to send the data using webpage to continuously monitor the patient health through internet. This system will continuously collect and record vital body measurements such as temperature, respiratory level, heartbeat rate and compares them with preset threshold levels. If the measured values exceed the predefined limits, it will immediately send alert message to doctor.

- Remote Monitoring: Wirelessly driven IoT, brings health care management near to patients instead of the patient to health care. Data of measured parameters are gathered, recorded, and sent secured using IoT-based sensor devices. This data is sent to doctors for proper diagnosis of medical issue.
- Realtime Monitoring When Patient in Observation: IoT driven monitoring sensor devices collects information and uses the cloud-based IoT system to manage the stored data.
- Preventive HealthCare Management: IoT based healthcare management system uses sensor recorded data, that helps in early detection of status of the patient during emergencies and it also alerts family members.

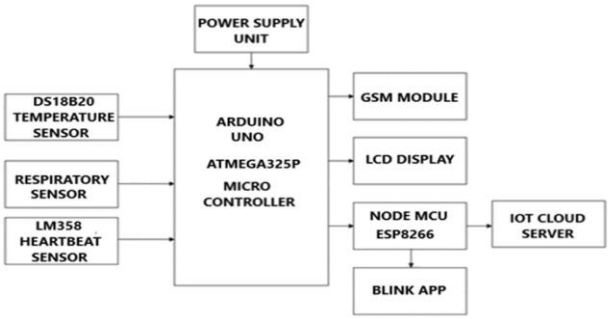
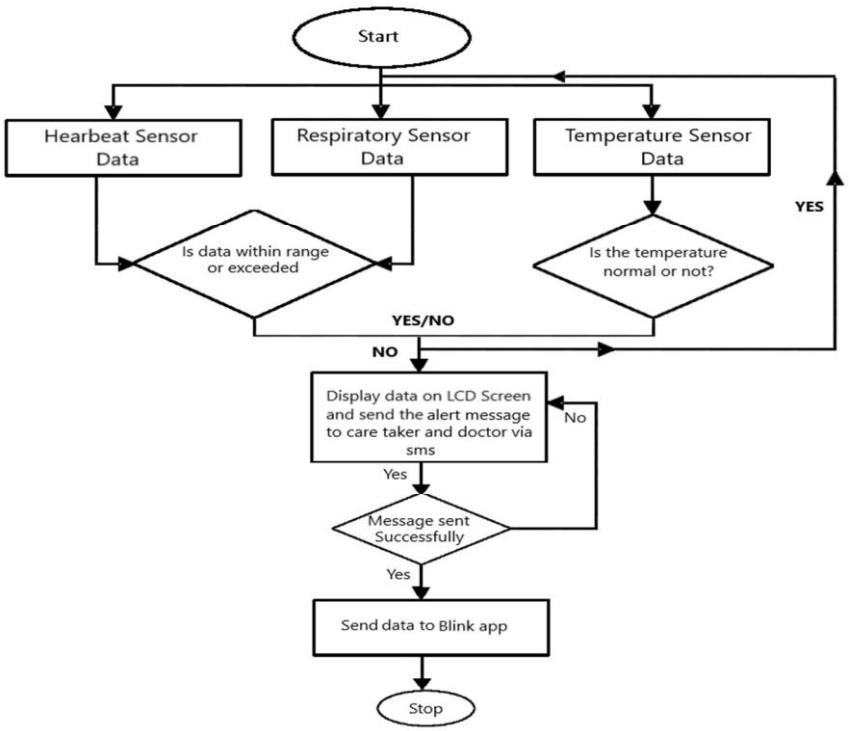


Figure 1. Arduino chip diagram



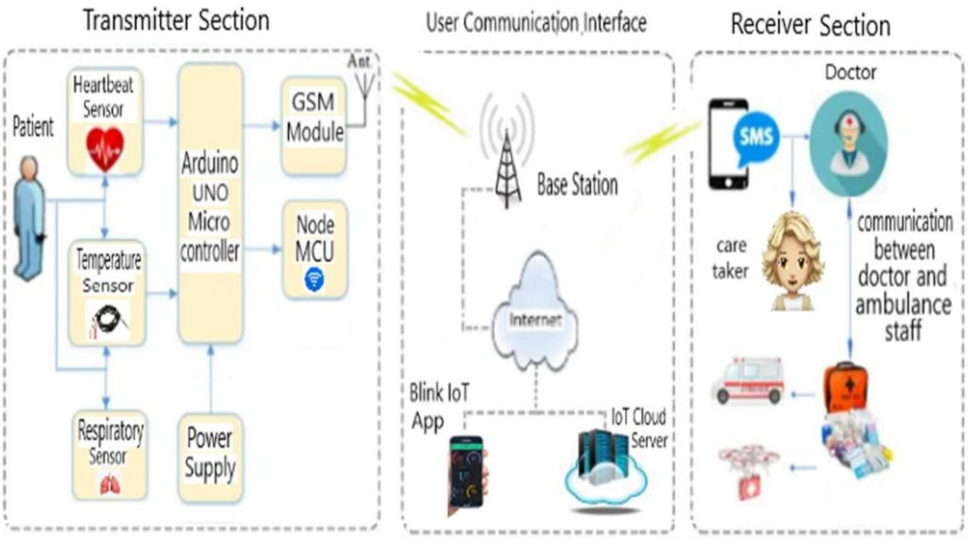
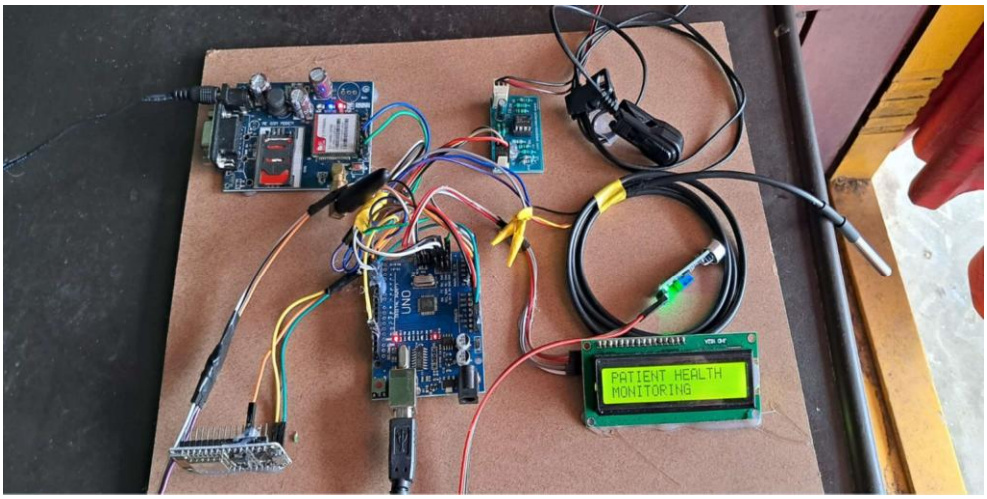


Figure. 3 Transmission and Communication

The proposed system uses microcontroller to send data. It uses IoT to provide patient data to doctor and/or caretaker. Patient health information is saved and available in cloud database. So, doctor will be able to access easily information related to patient's health at all times of course from any location using Blink App. For patients, an LCD is connected to microcontroller to see in live their health parameter status. In emergency cases, it will automatically send alert message to doctor as well as patient relative through SMS.

IV. Experimental Setup and Results

- HARDWARE REQUIRED
  - Arduino Uno Micro-controller
  - LCD Monitor
  - I2C Module
  - Dallas Temperature Sensor (DS18B20)
  - Respiratory Sensor
  - LM358 Heart Beat Sensor
  - GSM Module
  - NodeMCU – (ESP32 Micro-Controller)
- SOFTWARE REQUIRED
  - Arduino IDE



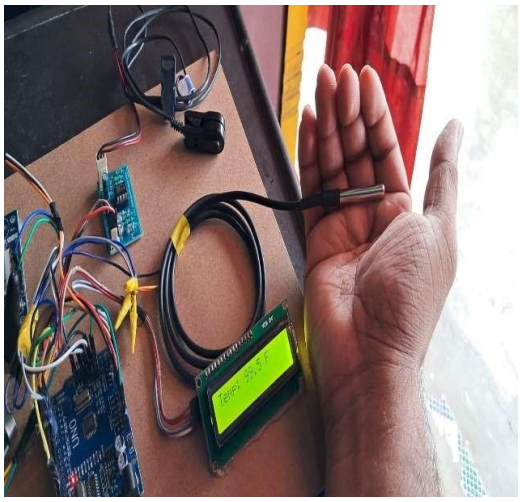


Figure 5. Increased temperature displayed on LCD

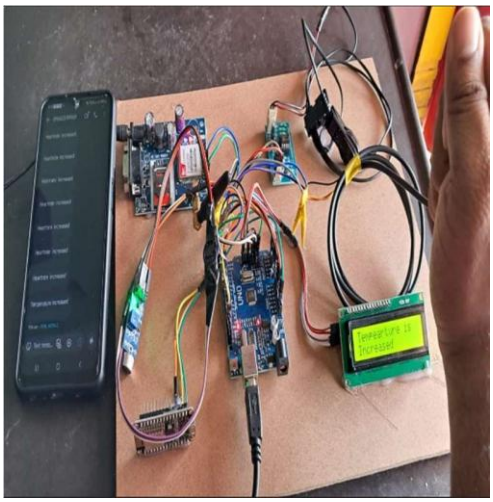
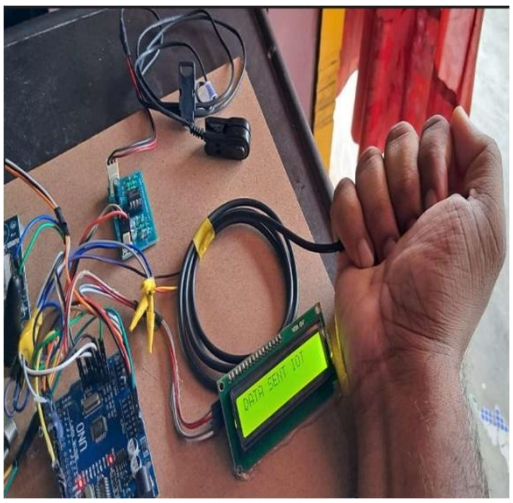


Figure 6. SMS alert message sent to mobile



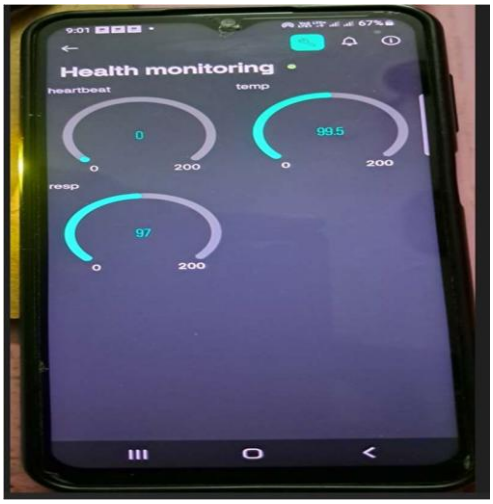


Figure 7. Increased temperature data sent to Blink App using IoT cloud server

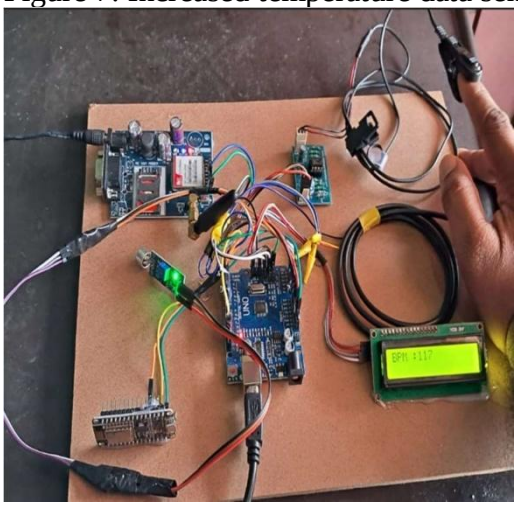


Figure 8. Increased Heartbeat rate displayed on LCD

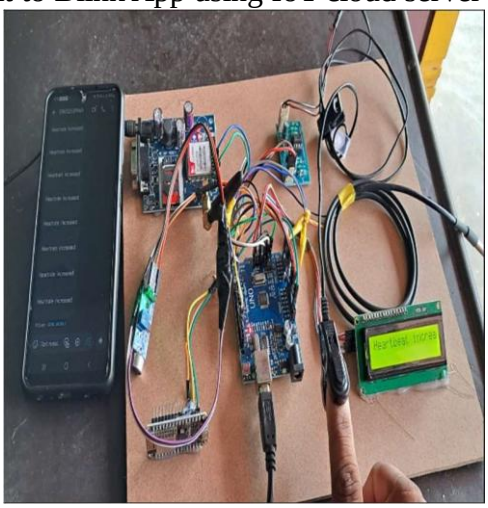


Figure 9. SMS alert message sent to mobile

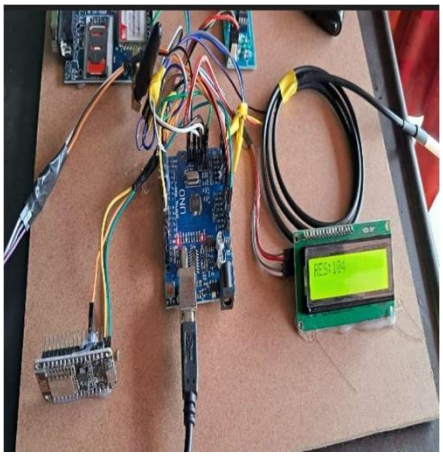


Figure 10. Increased respiratory level displayed on LCD

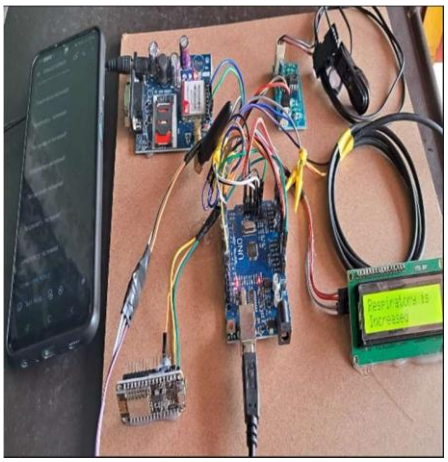


Figure 11. SMS alert message sent mobile

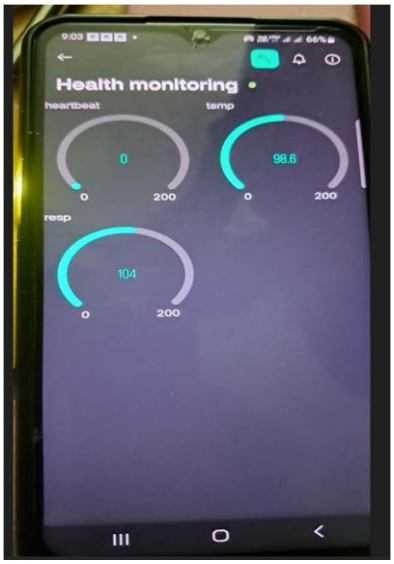


Figure 12. Increased Respiratory Level sent to Blink App using Iot Cloud Server

v. CONCLUSION

By considering huge practical significance of IoT, a lower in cost and simple real time, health monitoring system especially for patients with risk of cardiac attack, other unexpected events and medical emergency cases, is proposed with this paper. ATMega328P is used in this system as it has multi-tasking ability with lower power consumption. Furthermore, this system can even be used in ambulance units and be installed with ease. Large data acquired is stored in database. Moreso, this is valuable data for immediate monitoring of the patient in need. Totally with this system, doctor's daily workload is reduced, accurate results and efficient patient monitoring are possible. While using software embedded C during simulation, few problems are encountered. Other applications such as ECG Monitoring can also be included in the system. High accurate sensors can also be preferred if cost is not a constraint.

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