IoT - ENABLED SMART MEDICAL ALERTING SYSTEM

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Abstract.

An IoT-enabled Smart Medical Alerting System fills the gap in real-time patient monitoring that usually comes into focus during the time of pandemics like Coronavirus disease. The emphasis of this research is in making an inexpensive and easy-to-implement procedure for the continuous monitoring of important health parameters such as oxygen saturation, heartrate and temperature of the body. The immediate alerts to healthcare providers if there is any strange reading helps in immediate intervention, therefore improving the outcome. It places a due emphasis on affordability and easy serviceability in resource-limited settings. From the results, it has been observed that during implementation of the system proposed provides a substantial improvement in Blood Pressure, Temperature and SpO2 measurement.

Keywords. Internet of Things, Patient Monitoring, Real-Time Alerts, Healthcare, Affordability, Accessibility, Resource constrained settings.

1. INTRODUCTION

Global healthcare systems are usually embroiled in experiences that keep the monitoring of the patients' needs continuous. Current patient monitoring systems available are then too high in cost, fairly complex, and very resource-heavy, rendering them impractical for rural and low-income areas. The study will create and formalize an affordable patient monitoring system using IoT technology with integrated alerting methods. Section II briefly describes some technologies associated with IoT-based health monitoring systems. Section III provides an explanation of the proposed architecture and components of the system. Section IV outlines the results and findings from the implementation process, and Section V concludes the study with observations on the way forward.

2. LITERATURE REVIEW

The first generator is proposed by Uddin, Alam and Banu that is titled "Internet of Effects- Grounded Real-time Case Monitoring System" which is capable of monitoring patient (e.g. vital sign) by means of computing and detection technologies. The collection of physiological data about the patient, including blood pressure, temperature and heart rate is performed using sensors on the body. This information that is extracted is sent to a single based platform with support for real-time monitoring for medical practitioners. This study studies the methods of transmission of the information, the communication procedures, and the inclusion of devices and software to enable monitoring of patients remotely by their healthcare specialists.

The IoT-based Patient Health Monitoring System introduced by Krishnan et al. (2018) addresses health emergencies that arise unpredictably, especially where elderly patients are concerned. Use of temperature and heart rate monitoring sensors interfaced with the Arduino Uno microcontroller; the system transmits data via Wi-Fi to a web server for real-time monitoring and alerts for critical health changes.

Hanumanthakari et al. (2022) proposed an IoT-enabled patient monitoring system in short-term healthcare services stressing scalability and adaptability of IoT technology in various health care applications. They suggest a cloud architecture that supports remote monitoring and centralized patient data storage for an accessible and secure protocol. Besides, mutually known alert measures are those that aim to alert caregivers under critical conditions, hence speeding up emergency response.

3. PROPOSED SYSTEM

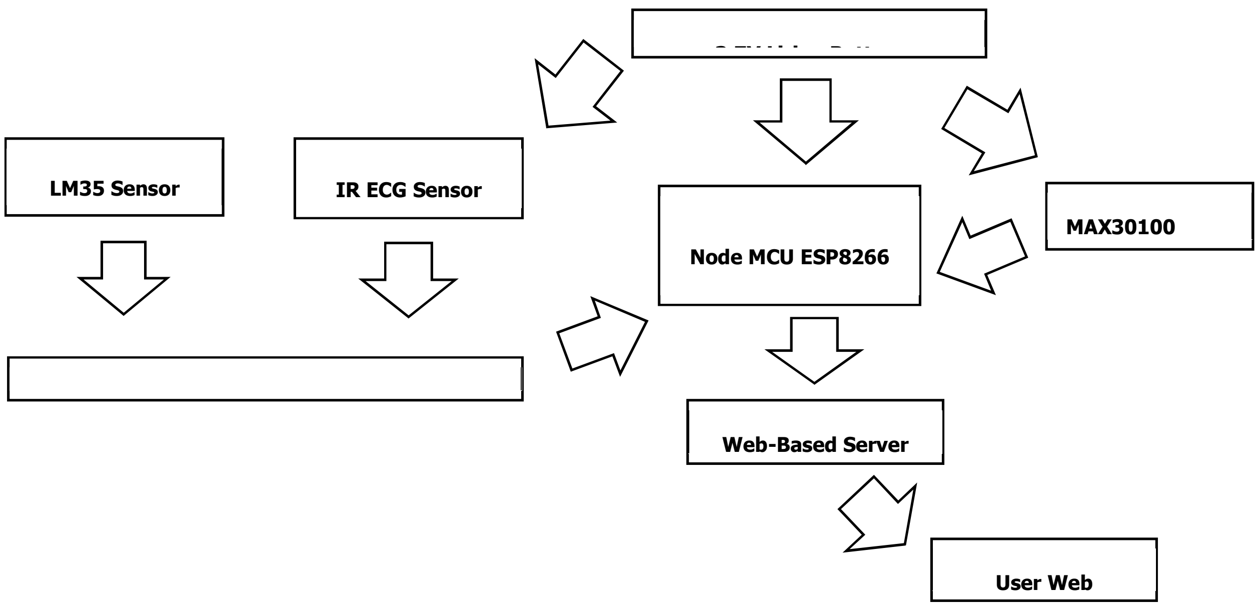

Figure 1. Conceptual Design

The design depicted in Figure 1 discusses the functioning of a proposed portable health monitoring system powered by a 3.7 V lithium rechargeable battery is power-on-demand, serviceable in remote locations. The flow of data is described through various components of the system as follows. The LM35 sensor measures the body temperature, and the IR ECG sensor detects the ECG signal. The two sensors give analog signals, which are converted using an MCP3008 ADC into digital signals. The MAX30100 sends pulse rate and SpO2 readings directly to NodeMCU ESP8266 via I2C. The NodeMCU is the main controller in the system, receiving digitized signals, enabling a local server, and sending real-time health parameters to a remote server. The server thus facilitates an end-user data visualization through a graphical meaningful interface that the user's web browser can load, thereby completing the path of the data flow from the sensor input to the final user output. The LM35 sensor is quite famous for measurement due to its accuracy and linear response to temperature changes, probably making it the most appropriate sensor for monitoring body temperature. For every degree Celsius, the analog voltage output is generated and is consistent over a large range from -55°C to +150°C with excellent precision ±0.5°C. Conversion of the voltage takes place at a rate of 10 mV per degree Celsius.

The analog signal of the LM35 is fed into the MCP3008 ADC, which converts it to a digital signal in order to neatly integrate temperature readings into the digital processing activity of the system for accurate and timely monitoring. The MAX30100 is a versatile pulse oximeter sensor designed to measure heart rate and blood oxygen (SpO2) level using photoplethysmography (PPG)-a technique detecting change in light absorption due to blood flow. Low power consumption in conjunction with I2C communication capability makes this a power-efficient health monitoring wearable. The I2C interfacing makes interfacing with the NodeMCU much easier, thus eliminating the need for an external signal processing module. The NodeMCU processes the data from the MAX30100 sensor for high-fidelity real-time monitoring, an important issue in monitoring cardiovascular health. In the infrared ECG variant, the electrical impulses of the heart are characterized by sensing the voltage changes during various phases of the cardiac cycle. The analog real-time data provided for conversion to the MCP3008 is a must-have for health-related purposes, like detecting arrhythmias. The MCP3008 can be fitted with multiple analog sensors simultaneously, for example, the LM35 temp sensor and ECG sensors, being an 8-channel 10-bit converter. It also enables quick and accurate data transfer followed by conversion with the use of the SPI protocol. The NodeMCU would process this data, enabling the user to view real-time ECG waveforms and health parameters. The IR ECG and the ADC of MCP3008 excellently complement each other for accurate and dependable heart measurements.

The real-time data which is created from these sensors gets transmitted to the remote server through wireless communication protocols at ESP-NOW. Wi-Fi Capability would allow these systems to be installed in nearly every nook and cranny of the healthcare system with very little added financial infrastructure burden. Further definitions may result in measuring health parameters including blood pressure, respiratory rate, and blood sugar levels for a more extensive monitoring of the patients. There can be possibilities for improving the communication ability of the system in the areas sparsely populated with Internet-downgrade-able facilities through LoRa or satellite communication. Protection of the sensitive data and information related to a patient is essential for carrying out their principles concerning privacy and winning user trust. Data protection is ensured in transit using end-to-end encryption and enhanced strong authentication methods.

4. RESULTS AND DISCUSSIONS

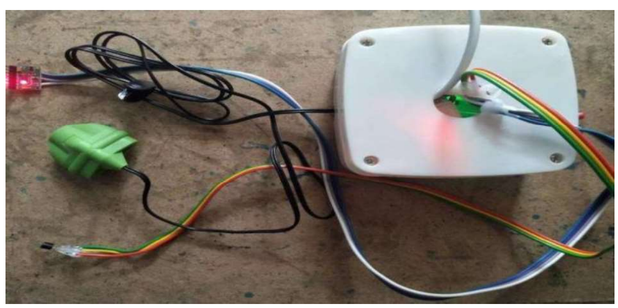

Figure 2. Submitted System

Figure 2 presents the proposed system is designed using a number of sensors, such as LM35, MAX30100, IR-based ECG to monitor temperature, heart rate, SpO2 and cardiac activity respectively. It utilizes the NodeMCU ESP8266 microcontroller along with MCP3008 ADC for the conversion of the analog signal, together with access to a local webserver.

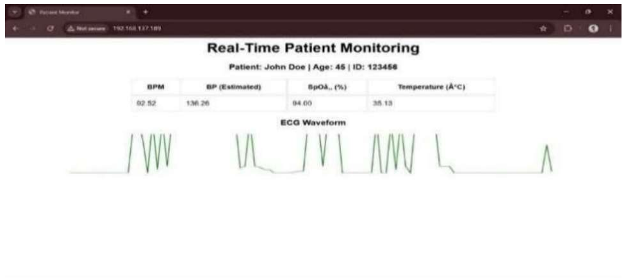

Figure 3. The Comprehensive Vision for an Innovative System

The sensor values change dynamically, providing near real-time feedback on what is going on with the patient. Additionally, the live ECG waveforms displayed just beneath the vital sign data, depicts the electrical signals of the heart in a visual format, making it easier for healthcare professionals to analyze the heart's performance and detect any abnormalities quickly. The design is efficient and easy to read for effective remote patient monitoring. The system, designed to be portable and user-friendly, features a microcontroller that collects and processes data from the server. This web interface was made using technologies like HTML, CSS, and JavaScript to make it responsive to devices like smartphones, laptops, and tablets. Under 500ms latency made real-time data possible: The prototype was able to monitor vital signs (HR, SpO2, BT and ECG) successfully. Based on this prototype, initial tests were conducted, both in controlled environments and in daily life, with reliably good performance: effective sensor integration and data transfer through Wi-Fi. The wearable showed real-time data on a dashboard, so health could be monitored at all times. We focused further analysis on the ECG and SpO2 sensors: these outputs were generally accurate under normal use conditions, but in high-motion scenarios, there was minor jitter in the results that showed noise, emphasizing the need to optimize the signals. This alert system sends a notification within seconds of identifying any anomalies.

Table 1. Measured Sample Patient Readings

Parameters	Readings
Heart Rate (bpm)	74
Oxygen Level (SpO_2)	96
Temperature (Degree Celsius)	34
Blood Pressure Estimated (mmHg)	127

The table 1 shows the measured values of Heart Rate, Oxygen Level, Temperature, and ECG Signal of a patient. Through the measured Heart Rate (bpm) values the blood pressure (BP) of patient is calculated. The proposed systolic blood pressure (BP) is calculated with respect to heart rate (BPM) and systolic blood pressure:

$$\text{Blood Pressure} = 120 + (\text{BPM} - 60) \times 0.5 \qquad (1)$$

$$\text{Blood Pressure} = 127\,\text{mmHg} \qquad (2)$$

Figure 5. Standard Blood Pressure Meter

Figure 5 shows the actual measurement of the blood pressure (BP) of patient through the Standard Meter for blood pressure from SinoCare which shows the value of Systolic Pressure as 129mmHg for the Sample Patient.

$$\text{Standard Blood Pressure: } 129\text{ mmHg} \qquad \text{Proposed Blood Pressure: } 127\text{ mmHg}$$

Accuracy**:** Measured as the percentage agreement between the proposed and standard systolic BP.

$$\text{Accuracy} = \frac{(1 - \text{Standard BP} - \text{Proposed BP}) \times 100}{\text{Standard BP}} = 98.45\ \% \qquad (3)$$

Table 2. Calculated blood pressure values using the proposed system are accompanied by the respective accuracies for the ten patients.

Patient Id	Heart Rate bpm	Standard Bp Systolic (mmHg)	Proposed Bp Systolic (mmHg)	Accuracy (%)
1	62	120	121	99.2
2	65	130	131.5	98.8
3	58	115	118	97.5
4	63	125	126	98.6
5	67	135	136.5	98.7

The diastolic BP is the blood pressure in the arteries as the heart rests between beats. In contrast to systolic pressure, which can be estimated using heart rate data and the proposed formula, diastolic pressure encompasses more complex pathophysiological factors, including stiffness and resistance of the arteries. These cannot be accurately sensed by heart rate measurement alone as they require specialized equipment for measuring the relaxation phase of the cardiac cycle, such as a sphygmomanometer or Oscillo metric devices. This is why studies emphasizing the use of only heart rate for blood pressure estimation generally restrict their findings to the systolic one. The problem observed during execution is Motion Artifacts. Inaccuracy is observed when the patient moves excessively. Future moves will build refined filtering algorithms to reduce motion designs.

5. CONCLUSION AND FUTURE WORK

The presently available wearable patient-monitoring system can be further updated with extra sensors such as motion sensors for fall detection or GPS for location-tracking in emergencies. The wearable sensors which are used to collect the health data and upload it to the cloud with the help of microcontrollers. Machine learning plays a crucial role in processing real-time data, enabling healthcare professionals to identify potential health risks early and take preventive measures before they escalate into critical conditions. With the rapid advances in IoT and AI, the patient monitoring system can graduate to a fully automated AI-health monitoring solution with real-time diagnostics and emergency alerts, thus revolutionizing the area of remote patient care.

6. REFERENCES

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