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IoT Based Health Monitoring System

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Abstract: This paper presents a comprehensive system designed for continuous monitoring of patients' physiological parameters using Internet of Things (IoT) technology. In recent times, patient monitoring systems have gained significant traction among researchers and caregivers alike. The proposed system is adept at monitoring key physiological indicators such as pulse rate, body temperature, and heart rate from the patient's body. Data collected by the system is transmitted to an IoT cloud platform via a Wi-Fi module, where the patient's health status is securely stored. This setup allows medical professionals or authorized individuals to remotely monitor the patient's condition in real-time through the cloud server. The primary aim of this research is to provide efficient and effective healthcare facilities to patients, thereby enhancing overall patient care.
Keywords: IoT, Wi-Fi Module, Health Care, Medical Services, authorized, efficient

I. INTRODUCTION

In contemporary society, individuals are confronted with an array of diseases and health challenges, with Chronic Heart Failure (CHF) being notably prevalent among the elderly population. CHF stands as a leading cause of hospital admissions, particularly among older adults, with prevalence rates reaching 1.3%, 1.5%, and 8.4% among the segments aged 55-64, 64-74, and 75 years or older, respectively. Healthcare facilities often grapple with the complexities of managing multiple patients simultaneously, leading to issues such as queueing, transportation delays, patient mobility constraints, and prolonged wait times for medical attention. These challenges are exacerbated during emergency situations, elevating the potential risks to patients' lives.

Continuous monitoring of critical patients around the clock is imperative for mitigating life-threatening risks. The integration of wireless technology has revolutionized healthcare services, offering substantial benefits such as improved operational efficiency and reduced costs for healthcare institutions. Wireless applications in medical science offer advantages including ease of use, decreased infection risks, and enhanced patient mobility. By leveraging wireless systems, healthcare providers can efficiently monitor multiple patients concurrently.

This paper proposes an IoT-based health monitoring system designed to execute various functions within predefined parameters of time, accuracy, and cost. This IoT-based system is characterized by its affordability and remote operability. The system employs sensors to detect the biological parameters of patients, with the integration of Arduino enhancing the effectiveness of the patient monitoring system.

II. LITERATURE REVIEW

In the medical field, IoT-based systems have garnered significant attention, driving extensive research efforts. Various studies have focused on developing IoT-based medical devices to address healthcare needs efficiently. For example, a patient monitoring system introduced by [3] aims to collect data for clinical research and academic studies, facilitating faster preventive care, cost reduction, and patient-centred practices. Similarly, [4] implemented a system utilizing an Arduino processor to monitor vital body parameters like pulse rate, providing real-time data visualization and issuing notifications for abnormal readings. Additionally, [5] devised an electronic device using wireless sensor technology to monitor the health of elderly individuals at home, ensuring continuous surveillance and timely intervention. Moreover, [6] established a remote healthcare system for monitoring patients' health conditions using medical-grade instruments, facilitating remote monitoring and prompt medical intervention.

III. METHODOLOGY

The methodology employed in this study involved the utilization of two sensors: a pulse rate sensor and a body temperature sensor (DS18B20). These sensors transmit their signals to a microcontroller, with the Arduino UNO serving as the primary infrastructure, connected via a Wi-Fi module (ESP8266).

A. System Architecture

This article outlines the selection criteria for sensors, emphasizing their essential nature, ease of use, and efficacy.

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The study focuses on two fundamental sensors utilized for monitoring vital signs, including pulse rate and body temperature, with data collection conducted within a hospital environment.

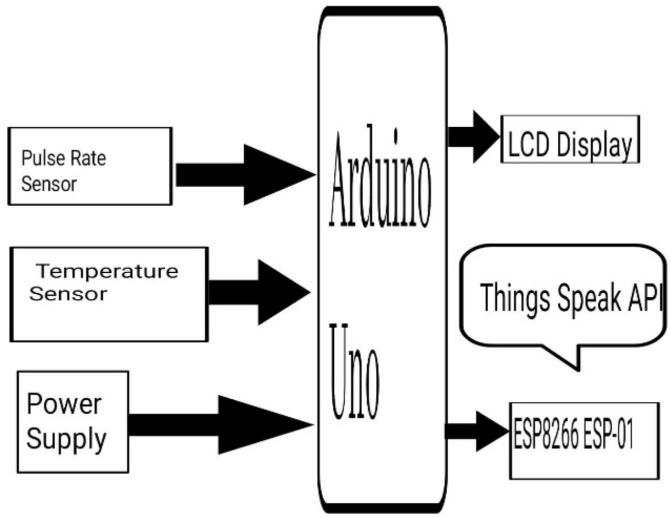

Figure 1: System Architecture

B. Software Architecture

The software execution serves as a crucial component of this project, functioning as the core of the health monitoring system while maintaining user flexibility. The microcontroller serves as the central infrastructure for processing and transmitting data based on sensor readings. Data is processed by Arduino and transmitted to the ThingSpeak online platform, which provides robust cloud storage for real-time data. Access to this database is protected by user authentication, requiring proper user ID, password, and write API key for data submission. This password-protected database ensures authorized access only, safeguarding the confidentiality of patient information. The subsequent steps depicted in the figure pertain to software development.

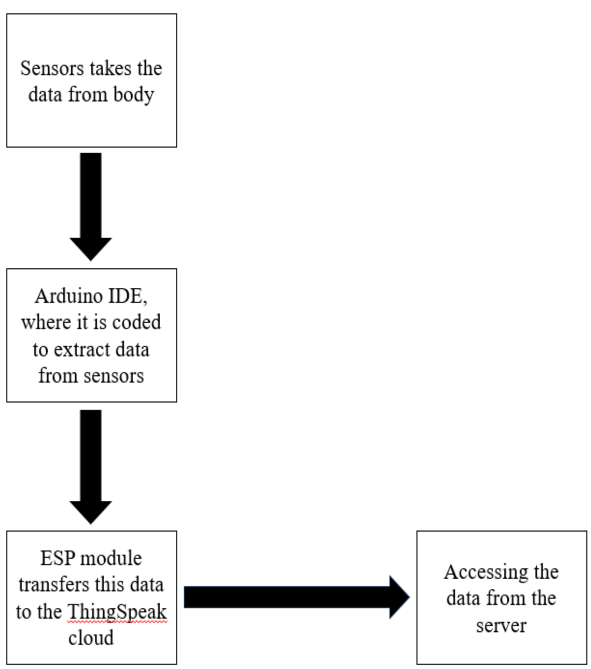

Figure 2: Software Architecture

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IV. HARDWARE IMPLEMENTATION

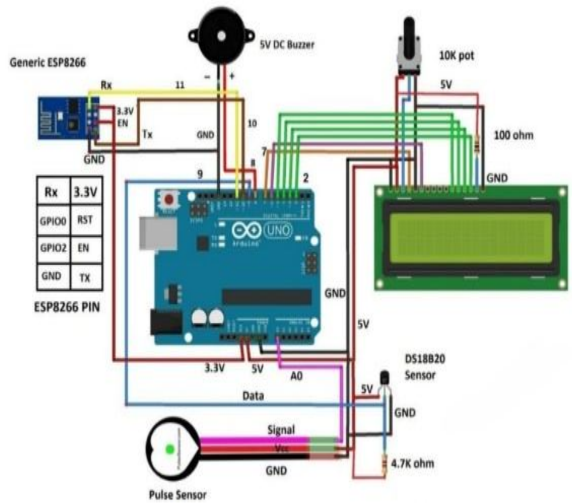

Figure 3: Circuit diagram

Figure 4: Hardware implementation

1) *Arduino UNO*: The Arduino Uno is an open-source board featuring the ATmega328P microcontroller, renowned for its low cost, reliability, and user-friendly design. Serving as the central controller in our system, it encompasses essential components such as USB type B connector, power port, analog and digital pins, ATmega328P microcontroller, UART, reset button, voltage regulator, and crystal oscillator. With 32KB flash memory and 2KB RAM, it operates at 5V and accepts input voltages between 7V to 12V. Programmable using the Arduino IDE, supporting C or C++ languages, the Arduino Uno facilitates seamless integration of sensors and modules, playing a pivotal role in system connectivity.

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Figure 5: Arduino UNO board

2) *Node MCU ESP8266 (IoT):* The Node MCU ESP8266 is a widely used, low-cost, open-source IoT board and firmware, integrating functionalities of a Wi-Fi access point and microcontroller. Equipped with 16 GPIO pins and UART (TX, RX pins), it operates at 3.3V voltage range, accepting input voltages between 7V to 12V. With 4MB flash memory and 64KB SRAM, it enables Wi-Fi capability in our system, facilitating data transmission to the server. Additionally, serving as the system's processing unit, it establishes two-way serial communication with the Arduino Uno, ensuring seamless data exchange.

Figure 6: ESP8266 Wi-Fi module

3) *Body Temperature Sensor (DS18B20):* The DS18B20 is a compact, widely adopted digital temperature sensor employing a one-wire protocol to measure temperature ranging from -55°C to +125°C, providing digital output. Requiring only one pin for temperature sensing, it operates ideally with a 4.7 Ohm pull-up resistor and power supply ranging from 3V to 5V. With an accuracy of ±0.5°C, it offers reliability in precisely measuring a patient's body temperature, making it an ideal choice for our system.

Figure 7: DS18B20 temperature sensor

4) *Pulse Sensor (MAX30100):* The MAX30100 is an electro-optical sensor engineered for measuring heart rate and oxygen saturation, utilizing two LEDs (red and infrared) to emit light. Operating at voltages between 1.8V to 3.3V with an input current of 20mA, it employs an I2C protocol for communication with the controller. Used to measure pulse rate and SpO2 (oxygen saturation) of a patient, it provides accurate readings through pulse oximetry, contributing crucial insights into the patient's physiological state.

Figure 8: MAX30100 pulse sensor

V. COST ANALYSIS

Component	Unit Price (INR)	Unit	Cost (INR)
Arduino Uno	500/-	1	500/-
DS18B20	100/-	1	100/-
Pulse Sensor	180/-	1	180/-
ESP8266	250/-	1	250/-
LCD Display	100/-	1	90/-
Breadboard	50/-	1	50/-
Jumper Wire	2/-	50	100/-
Back-up Supply	-	-	630/-
Total	**-**	**-**	**1900/-**

Table 1: Project cost analysis

VI. ANALYSIS

A. Analysis of PPG Signal from Pulse Sensor

The pulse sensor captures readings from blood capillaries using Photo Plethysmography principles. Through corresponding coding algorithms, the obtained PPG signal is utilized to determine the person's heart rate and Inter-Beat Interval. The provided figure depicts an excerpt of a PPG signal obtained during validation. Subsequently, Processing Visualize was employed to generate a graphical user interface displaying the serial plot alongside Heart Rate values in BPM and Inter-Beat Interval.

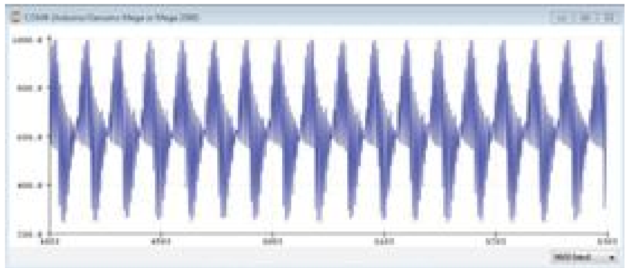

Figure 9: PPG signal in serial monitor

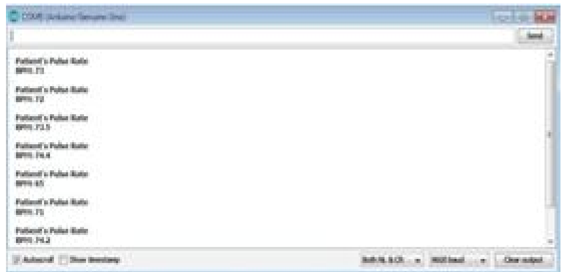

Figure 10: Pulse sensor readings in serial monitor

In this instance, a heart rate of 121 BPM was observed in the monitored patient. Data was collected in two states: relaxation and excitement. During relaxation, heart rates ranged between 80-90 BPM, while excitement, indicative of anxiety or stress, yielded heart rates exceeding 120 BPM. The Pulse Sensor output, indicating these fluctuations, is presented below.

B. Analysis of Body Temperature from DS18B20 Sensor

The body's circulatory system responds to changes in temperature by adjusting blood flow to maintain optimal body temperature. The figure 11 illustrates fluctuations in body temperature observed during patient monitoring. An increase in body temperature was noted during physical exertion, influenced by both internal and external factors such as physical activity and ambient temperature. Conversely, upon cessation of physical activity and rest, body temperature gradually returned to its optimal level. Thus, significant changes in activity levels, whether due to physiological or environmental factors, resulted in corresponding fluctuations in body temperature, prompting adjustments in heart rate to regulate blood circulation and restore optimal body temperature.

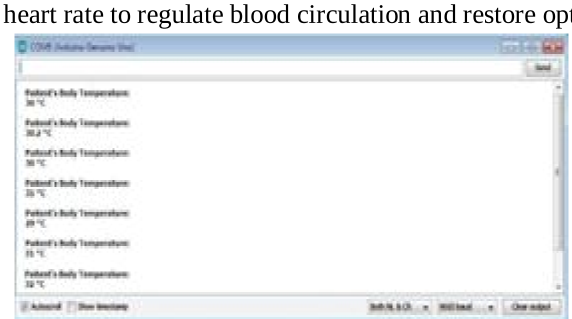

Figure 11: Body temperature readings in serial monitor

VII. RESULT

Upon connecting all sensors to the patient, the module was initiated. Ensuring proper sensor connection, we encountered occasional challenges due to sensor sensitivity, occasionally leading to deviations from standard values. Subsequently, extracted sensor data was stored in cloud storage, accessible through the ThingSpeak cloud server for analysis. To analyse the data, measurements were taken under two conditions. Figure 7 illustrates the patient's health fluctuations during rest and post-exercise. During rest, depicted on the left side, pulse rate remained within the normal range of 65-75 BPM. Following exercise, pulse rate fluctuated between 105-125 BPM, as depicted on the right side. Similarly, Figure 8 presents another depiction of the patient's health fluctuations during rest and post-exercise, reaffirming the observed pulse rate variations.

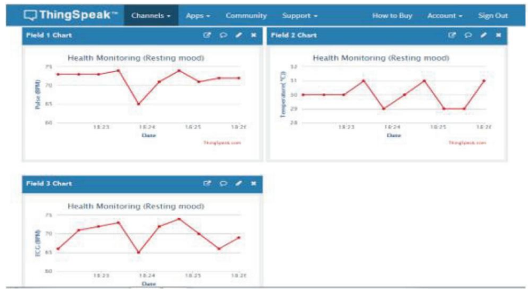

Figure 12: Real time readings on ThingSpeak Channel

Figure 13: Real time readings on ThingSpeak Channel

Figure 13 illustrates the patient's body temperature fluctuations during rest and post-exercise. During rest, shown on the left side, body temperature was approximately 31 degrees Celsius. Post-exercise, there was a noticeable rise in temperature of approximately 5 degrees Celsius, as evidenced in the figure.

VIII. RECOMMENDATION FOR FUTURE DEVELOPMENT

The healthcare sector continues to advance through technological innovations, with researchers continually striving to enhance medical devices. In future development, the integration of additional sensors, such as respiratory, blood pressure, and glucose sensors, could enable the measurement of a broader range of parameters from the patient's body. Additionally, the inclusion of GSM technology could facilitate real-time communication of the patient's condition to their caregivers. By incorporating these sensors, the device could evolve into a comprehensive health monitoring system, offering a complete solution for patient care.

IX. LIMITATION

This IoT-based Emergency Health Monitoring System is subject to several limitations, including accuracy, sensor quantity, and cost-effectiveness. Analysing a patient's health status based solely on three parameters presents complexities, highlighting the need for additional sensors. However, high-quality sensors come at a premium cost, impacting the system's affordability. Moreover, sensor accuracy significantly influences project outcomes, as different sensors and measurement methods yield varying results. To address accuracy concerns, the implementation of precision sensors and rigorous quality standards is imperative. Additionally, exploring diverse measurement methods and conducting comparative analyses can identify the most accurate approach for product integration.

X. CONCLUSION

This paper presents a prototype model aimed at establishing an uninterrupted health monitoring system for patients via a wireless body area network. The primary objective was to enable healthcare professionals to remotely monitor, advise, and diagnose patients and family members prior to emergency situations. Data generated by the system is stored and accessible online, allowing for remote monitoring by professionals and family members at any time. An Android application facilitates patient monitoring, while sensors were individually calibrated before project commencement. Signal analysis involved comprehensive data collection and matching against experimental signals. The final results were transmitted to the cloud through Arduino, with users receiving outputs via messages. The system demonstrates potential for real-life application, offering user-friendly and cost-effective healthcare solutions.

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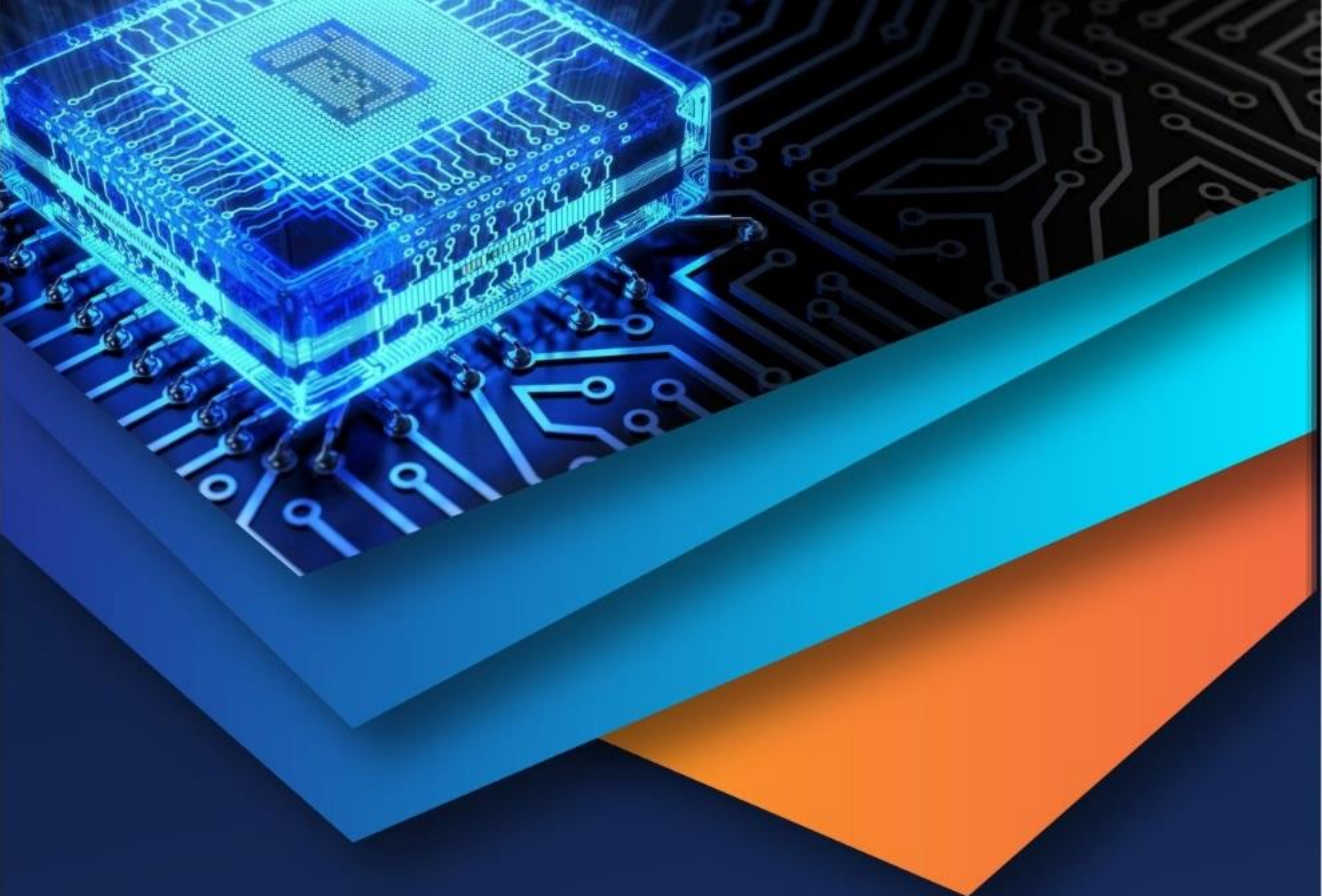

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