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IOT Based HealthCare Monitoring System

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ABSTRACT: This paper dives into the design and taking advantage of wireless connectivity, these implementation of a Health Monitoring System (HMS) that utilizes the ESP32 microcontroller. The system is designed to keep a constant eye on essential health metrics like heart rate, blood oxygen saturation (SpO_2), and body temperature. By taking advantage of the ESP32's energy efficiency, processing power, and wireless capabilities, the HMS provides real-time, dependable, and budget-friendly health tracking. The setup combines physiological sensors with output devices such as LCDs or LEDs to visualize data and send alerts. To ensure that data remains secure and private, it employs encryption protocols, digital signatures, and checksums. This innovative system aims to improve early diagnosis and prompt medical intervention, ultimately enhancing patient care.

Key Words: ESP32 microcontroller, Health Monitoring System, Vital signs monitoring, IoT in healthcare, Real-time data processing, Wireless connectivity, Sensor integration, Data security

1. INTRODUCTION

Healthcare is a crucial part of our overall well-being, but many people—especially those dealing with chronic illnesses—struggle to get the timely and ongoing medical attention they need. Traditional healthcare often depends on scheduled check-ups, which can overlook important changes in a patient's health. This is where IoT-based health monitoring systems come into play, allowing for real-time, remote tracking of vital signs like heart rate, SpO2, body temperature, and ECG. By using smart sensors paired with microcontrollers like the ESP32 andsystems deliver continuous data to healthcare providers and caregivers. This approach not only boosts patient safety and facilitates early diagnosis but also encourages personalized, proactive healthcare—making medical support more accessible, efficient, and responsive.

2. LITERATURE REVIEW

The growing focus on preventive and remote healthcare has sparked a transformation in wearable and portable health monitoring systems. By harnessing the powerful features of the ESP32 microcontroller, recent innovations aim to boost system performance, improve data accuracy, and enhance user experience. Thanks to its built-in Wi-Fi and Bluetooth capabilities, the ESP32 enables real- time tracking of various vital signs, including heart rate, SpO2, ECG, and body temperature. The integration of high-quality sensors, paired with effective signal processing, guarantees accurate and trustworthy data collection. User-friendly interfaces— like OLED displays and mobile apps—make it easy to visualize data, while the low-power operation and compact design make these systems perfect for continuous and on-the-go use. Additional perks include real-time alerts through threshold-based alarms, wireless data transmission to cloud services, and onboard storage options. Security and data privacy are bolstered with encryption protocols, ensuring that sensitive health information is handled safely. The ESP32 also supports the integration of machine learning models for predictive analytics,

allowing for early detection of potential health issues. Affordable and scalable, ESP32-based systems meet a variety of healthcare needs, providing flexible and smart solutions for modern health monitoring..

3. METHODOLOGY

3.1 System Architecture

The health monitoring system we've designed revolves around the ATmega328P microcontroller, which acts as the brain of the operation. It connects with various biomedical sensors, including the MAX30100 for tracking heart rate and SpO_2 levels, the AD8232 for ECG readings, and the LM35/DHT11 for monitoring body temperature. These sensors gather vital physiological data, which is processed in real time and shown on an LCD display. To keep users informed, a buzzer is incorporated to sound an alert if any readings exceed critical limits. The system runs on a stable 12V power supply, ensuring all components function smoothly. Plus, the modular design makes it easy to add more sensors or communication modules like GSM or Bluetooth down the line for enhanced scalability.

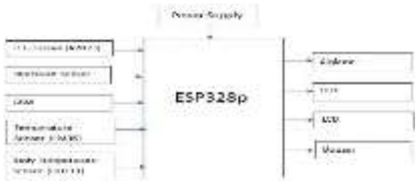

Fig.1.System Architecture of IOT Based Health Care System

3.2 Model Description

The system we're discussing here is an IoT-based Health Monitoring System that utilizes the ESP32 microcontroller. With the ESP32's built-in Wi-Fi and Bluetooth capabilities, it enables real-time wireless data transmission and remote monitoring. This innovative setup incorporates a variety of biomedical sensors, such as the MAX30100 pulse oximeter for monitoring heart rate and SpO_2 levels, the AD8232ECG module, and temperature sensors like the DHT11 and LM35. The ESP32 processes all this sensor data and displays it on a local LCD screen. It operates on a regulated 12V power supply and is neatly mounted on a compact PCB, making it both efficient and portable. This configuration is perfect for continuous health monitoring and is especially suited for personal healthcare and telemedicine.

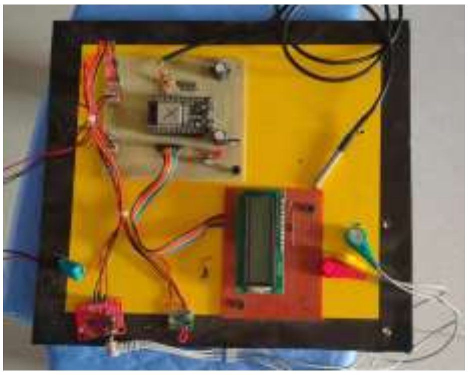

Fig.2 Model of HealthCare Monitoring System

3.3 Software Implementation

The software for the health monitoring system is built using the Arduino IDE, specifically tailored for the ESP32 microcontroller. It starts by initializing and setting up each sensor, then it handles real-time data collection, applies some basic filtering techniques, and manages how the output is displayed and communicated. The system runs on an event- driven logic, which allows for efficient processing and timely alerts. For pre-deployment testing, we utilize Proteus 8 Professional to ensure the circuit functions as intended and that the logic flows seamlessly. Additionally, the code is designed to be modular and scalable, making it easy to adapt for future upgrades and integrate with cloud-based platforms.

3.4 Dataset Processing

The ESP32 microcontroller is a nifty little device that collects real-time data from a variety of sensors. It works with the MAX30100 to track heart rate and SpO_2 levels, the AD8232 for ECG readings, and the DHT11/LM35 to monitor temperature. By converting analog signals into digital data using its ADC, it processes this information with filtering and averaging techniques to ensure accuracy. You can view the results on an LCD screen, and it even has the capability to send data wirelessly via Wi-Fi or Bluetooth for remote monitoring. Plus, it comes with threshold-based alerts to keep users updated on any unusual health readings, enabling quick responses when necessary.

Fig 3 Website Interface

4. IMPLEMENTATION AND RESULTS

Sr.No	Parameters	Normal Range	Abnormal Rage
1	Heart Rate	60 – 100 bpm	< 60 bpm (bradycardia), > 100 bpm (tachycardia)
2	Body Temperature	36.1°C to 37.2°C	< 36.1°C (hypothermia) or > 37.5°C (fever)
3	SpO2	95% – 100%	< 94% (hypoxemia)

4	ECG	Regular P- QRS T wave pattern	Irregular rhythms missing waves abnormal intervals
5	Room Temperature	20°C to 26°C	< 18°C (too cold) or > 30°C

Table.1 Normal Range of Parameters

4.1 Test Result Table and Graph

1 Temperature Accuracy : 94%
2. Heartrate Accuracy: 94%
3.So2 Accuracy: 93-94%
3. Overall system accuracy: 93%

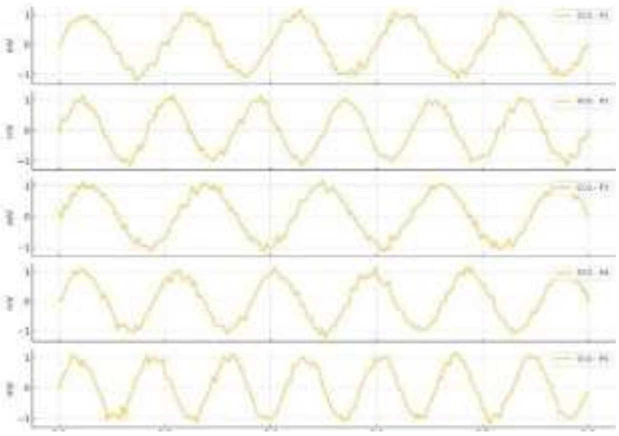

Fig.4.Graph of ECG

Person	ECG	Avg ECG(mV)	Heartrate (bpm)	SpO2 (%)	Body Temp	Room Temp(C)
1	Normal	0.05	72	98	36.7	28.5
2	Abnormal	0.08	110	92	38.1	29.0
3	Normal	0.04	85	95	36.8	27.8
4	Normal	0.06	76	99	37.2	28.2
5	Abnormal	0.09	120	88	39.0	30.0

Table.2. Result Table

The data visualizations we've gathered provide crucial insights into the health parameters of five individuals (P1–P5). The ECG plots reveal consistent cardiac waveforms, with only slight variations in amplitude and frequency, suggesting that while each heart is unique, they all show normal activity. The bar and line graphs depict SpO_2 levels, heart rates, and temperature readings. For instance, P4 has an impressive SpO_2 level of around 99%, whereas P5 is concerningly low at about 88%. The heart rate data indicates that P2 and P5 have elevated beats per minute, which could point to some physiological stress. Meanwhile, the temperature graphs show stable body temperatures ranging from approximately 36.5 to 37.5°C for all subjects, consistently higher than the room temperature. These findings are invaluable for real-time health assessments and spotting any anomalies.

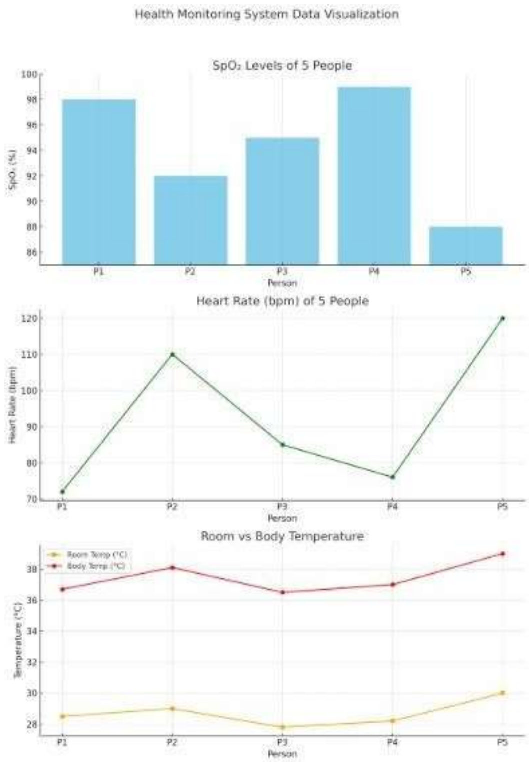

Fig.5.Graph of Health parameters

4.2 Real-Time Performance

The system demonstrated remarkable real-time performance, swiftly acquiring, processing, and displaying sensor data. The ESP32 handled multiple inputs effortlessly, with no noticeable delays, enabling continuous monitoring and rapid alert generation..

5. CONCLUSIONS

The use of an IoT-based health monitoring system powered by the ESP32 microcontroller shows great promise in transforming healthcare today. This system allows for continuous, real-time tracking of vital signs like heart rate, SpO_2, ECG, and body temperature, which helps in spotting any irregularities early on and ensures that medical help can be provided promptly. With features like wireless communication, efficient data handling, and easy-to-use interfaces, it makes healthcare more accessible and user-friendly. In essence, this system encourages preventive healthcare and gives individuals the tools to keep an eye on their health. Its compact, energy-efficient, and adaptable design means it can be used in various settings, from personal wellness to managing chronic illnesses and remote patient monitoring—ultimately leading to better health outcomes.

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