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IOT BASED REMOTE PATIENT HEALTH MONITORING SYSTEM

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Abstract : An IOT-based patient remote health monitoring system is designed to determine the health parameters of a person or patient anywhere and anytime. The IoT-based remote health monitoring system aims to enhance healthcare by employing Internet of Things (IoT) technology. To detect the patient health conditions, the sensors like ECG(AD8232) sensor, temperature(MLX90614) sensor, Heart rate and spo2(MAX30102) sensor are placed on the human body to measure health parameters like blood pressure, temperature , heart rate and oxygen levels. If the measured health parameters are greater than the set threshold values, then an alert will be sent to the user's mobile phone and the parameters are also sent to the clinician's server when a critical condition is detected. ESP32 Microcontroller and communication network are used to transmit and receive the data.

IndexTerms - **Arduino IDE 1.8.5, IOT cloud, ESP32 Microcontroller, ECG sensor: AD8232, Heart rate and spo2 sensor: MAX30102, Temperature sensor: MLX90614 Non-contact infrared Temperature sensor, OLED Display, Power Supply**

I. INTRODUCTION

The concept of good health is a universal aspiration, deeply ingrained in human nature. With the rapid pace of modern life, maintaining regular health monitoring has become more challenging yet increasingly critical. Regular monitoring can preemptively identify potential health issues before they escalate, ensuring timely medical intervention. Particularly for older adults, consistent health monitoring is vital to manage chronic conditions and maintain overall well-being. Traditional health monitoring methods, which often involve lengthy hospital visits and ambulatory services, are not always feasible in today's fast-paced world. Thus, there is a pressing need for a system that allows for basic health monitoring in the comfort of one's home, utilizing primary health parameters. The IoT-based Remote Patient Health Monitoring system is designed to address these needs by offering a comprehensive solution for continuous health monitoring. This system employs a variety of sensors to track essential health parameters such as body temperature, blood pressure, and pulse rate. These sensors capture real-time data, which is then transmitted via the internet to a central system for analysis. The ability to monitor these parameters remotely enables proactive healthcare management, reducing the dependency on frequent hospital visits and providing peace of mind for both patients and their caregivers. One of the key advantages of using IoT in health monitoring is the ability to provide data interoperability. Data collected from various sensors can be seamlessly integrated and analyzed to offer a holistic view of the patient's health status. This interoperability ensures that healthcare providers have access to comprehensive and accurate data, facilitating better diagnosis and treatment planning. Furthermore, the system can store historical data, allowing for trend analysis and early detection of potential health issues.

II. LITERATURE SURVEY

The objective of the subsequent segment is to aid in the advancement of theories associated with this research. Numerous studies on the Internet of Things have been conducted, offering design recommendations for various fields. In the field of medicine, a design has been completed to measure patient temperature utilizing sensor network to track the patient's temperature in real time. To maintain surveillance on students when they are physically exercising by taking their blood pressure, temperature, and heart rate .Fog-computing allows for the construction of medical facilities to promote health and save lives in intelligent environments. A real-time health monitoring system for remote cardiac patients has been developed. Patients and doctors can connect with each other through the system using wearable sensors and smart phones.

Key findings from the literature survey:

- IoT-based systems allow clinicians to remotely monitor patients on an ongoing basis, overcoming geographical barriers
- IoT integrates with wireless sensor networks, smart mobile devices, and cloud computing to enable real-time health data collection and analysis
- Applications include ECG monitoring, consolidated disease management, smart wheelchairs, rehabilitation systems, and smartphone-based healthcare

- Challenges involve data security, system reliability, and bridging gaps between people, stages and processes in existing healthcare systems
- IoT enables efficient health monitoring, disease prediction, and personalized care through machine learning on cloud platforms.

III. PROJECT METHODOLOGY

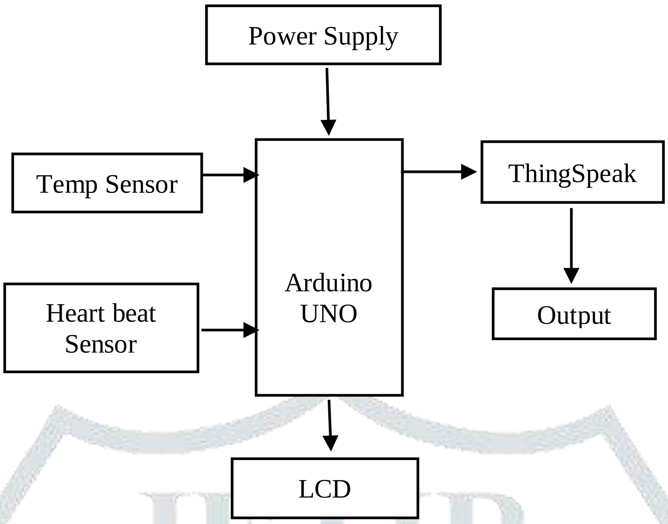

Fig 1 : Existing Block Diagram

The current health monitoring systems predominantly utilize basic sensors and relatively simple IoT platforms, which limit their capability and scope. Most existing systems include a temperature sensor and a heart rate sensor, providing fundamental health metrics that are crucial but not comprehensive. These systems typically rely on temperature sensors to measure the patient's body temperature and heart rate sensors to track the pulse. While these two parameters are essential indicators of a person's immediate health status, they do not provide a complete picture necessary for thorough health monitoring, especially for chronic conditions or complex health scenarios. One commonly used platform in these systems is ThingSpeak, an IoT analytics platform service that allows users to aggregate, visualize, and analyze live data streams in the cloud. ThingSpeak is user-friendly and facilitates the collection and analysis of data from IoT devices, making it a popular choice for basic health monitoring applications.

Concept of Proposed System

1.Sensor Integration and Data Acquisition :

The foundation of the IoT-based Remote Patient Health Monitoring system lies in its array of sensors integrated with the ESP32 microcontroller. The system employs the ECG sensor AD8232 to capture electrical activity of the heart, providing detailed insights into the cardiac health of the patient. The heart rate and SpO2 sensor MAX30102 monitors pulse rate and blood oxygen levels, crucial indicators of cardiovascular and respiratory health. Additionally, the temperature sensor MLX90614, a non-contact infrared temperature sensor, is used to measure body temperature. These sensors are meticulously connected to the ESP32, ensuring accurate and real-time data acquisition. The ESP32 microcontroller, known for its low power consumption and built-in Wi-Fi and Bluetooth capabilities, serves as the central hub for collecting and transmitting sensor data.

2. Data Transmission and Cloud Integration:

Once the health parameters are captured by the sensors, the ESP32 microcontroller processes the data and prepares it for transmission. Leveraging its built-in Wi-Fi capability, the ESP32 sends the collected data to the Ubidots IoT cloud platform. Ubidots is chosen for its robust features in data visualization, storage, and analysis. The platform allows for real-time data streaming, making it accessible to healthcare providers and caregivers from anywhere at any time. B3y utilizing cloud technology, the system ensures that the data is not only securely stored but also readily available for remote monitoring, thus facilitating continuous health surveillance without the need for physical presence.

3.Data Processing and Analysis:

In the cloud, the data undergoes further processing and analysis. Ubidots provides tools for visualizing the data through customizable dashboards, enabling easy interpretation of health metrics. The platform can generate alerts based on predefined thresholds, for instance, if the heart rate or temperature exceeds normal ranges, an immediate notification is sent to the caregiver or healthcare provider. The data is also logged over time, allowing for trend analysis and historical comparisons, which are invaluable for diagnosing chronic conditions and observing long-term health patterns. This continuous analysis helps in identifying any deviations from normal health conditions at an early stage, thereby enabling prompt medical intervention.

4.Local Display and User Interface:

In addition to cloud integration, the system includes a local display using an OLED screen connected to the ESP32 microcontroller. This OLED display provides immediate feedback to the patient by showing real-time readings of body temperature, heart rate, and SpO2 levels. The ECG waves are observed directly through the serial monitor of the ESP32, providing immediate and precise cardiac data visualization. This dual approach ensures that critical health information is accessible both locally for the patient and remotely for healthcare professionals, thereby enhancing the usability and effectiveness of the monitoring system.

5.User Notification and Interaction

To ensure that the system is user-friendly and responsive, the proposed methodology includes mechanisms for user notification and interaction. The system is designed to send alerts and notifications to the patient and caregivers via various communication channels such as email or SMS, enabled through the Ubidots platform. These notifications can be triggered by abnormal readings or system malfunctions, ensuring that immediate attention can be given when necessary. Furthermore, the system can be configured to allow patients to input additional health-related information or symptoms manually, providing a more comprehensive health profile. This interactive capability not only improves patient engagement but also enhances the overall effectiveness of the health monitoring process.

Work Flow:

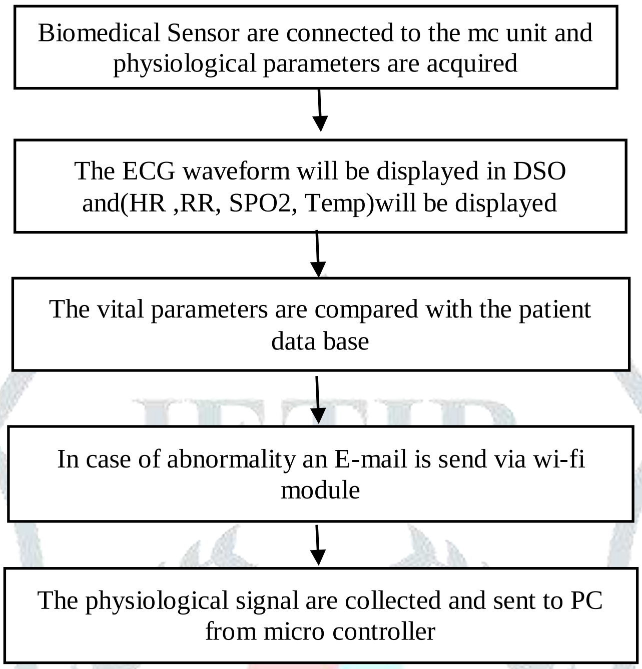

Fig 2 : Work Flow

Hardware Requirements:

1. ESP32 Microcontroller
2. ECG sensor: AD8232
3. Heart rate and spo2 sensor: MAX30102
4. Temperature sensor: MLX90614 Non-contact Infrared temperature sensor with ESP32
5. OLED Display
6. Power Supply

1.ESP32 Microcontroller :

NodeMCU is famous for the ESP8266E module with the LUA programming language. Now, this is a more powerful NodeMCU with ESP32 on it! ESP32 is the big brother of ESP8266. It comes with a dual-core 32-bit processor, built-in WiFi, and Bluetooth, more SRAM and Flash memory, more GPIO, more ADC, and many other peripherals. NodeMCU ESP32 is an ESP-WROOM-32 module in breadboard friendly form factor, you can develop your project by using this compact microcontroller on a breadboard. This expansion board is designed to ease the prototyping using the NodeMCU ESP32. It extends the GPIO of NodeMCU to header pins, which also include the Vin 5V',3.3V, and GND with the onboard Voltage regulator, you can now power the NodeMCU and the whole system with a DC jack, voltage range from 6.5V to 16VDC. The board also comes with a power indicator.

Pin Description:

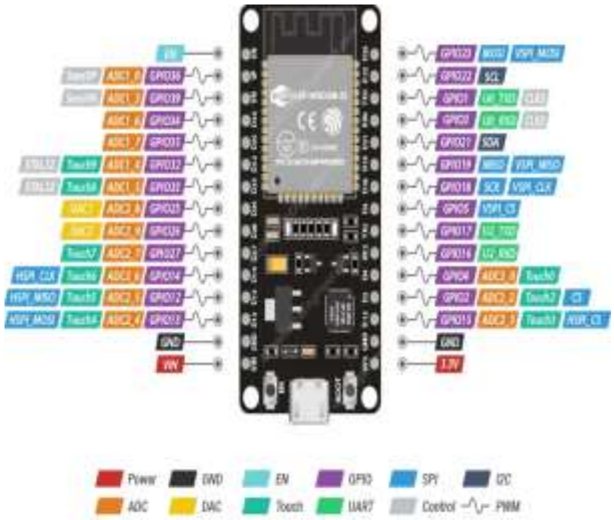

Fig 3 : Pin Description

I2C (Inter-Integrated Circuit) Interface of ESP32:

I2C interface of ESP32 is used for communications between ESP32 (Maste3r) and sensors (Slaves). For such communications, the ESP32's D22 and D21 pins are allocated. All the I2C pins are listed with PINs in the following table:

For I2C Communications	ESP32 Pins
SCL	D17
SDA	D16

Table 1 : I2C Interface of ESP32

2.ECG sensor: AD8232:

The AD8232 ECG sensor is a commercial board used to calculate the electrical movement of the human heart. This action can be chart like an Electrocardiogram and the output of this is an analog reading. Electrocardiograms can be very noisy, so to reduce the noise the AD8232 chip can be used. The working principle of the ECG sensor is like an operational amplifier to help in getting a clear signal from the intervals simply.

3.Heart rate and spo2 sensor: MAX30102:

The MAX30102 is an integrated pulse oximetry and heart-rate monitor module. It includes internal LEDs, photodetectors, optical elements, and low-noise electronics with ambient light rejection. The MAX30102 provides a complete system solution to ease the design-in process for mobile and wearable devices. The MAX30102 operates on a single 1.8V power supply and a separate 3.3V power supply for the internal LEDs. Communication is through a standard I2C-compatibleinterface. The module can be shut down through software with zero standby current, allowing the power rails to remain powered at all times.

4.Temperature sensor: MLX90614 Non-contact Infrared temperature sensor with ESP32:

The MLX90614 is a highly integrated, non-contact infrared temperature sensor manufactured by Melexis. It is renowned for its ability to measure temperature from a distance, making it ideal for a variety of applications that require precise and non-intrusive temperature readings. Unlike traditional contact-based temperature sensors, the MLX90614 uses infrared radiation to determine the temperature of an object or person, providing a hygienic and efficient method for temperature measurement. The AD8232 ECG sensor is a commercial board used to calculate the electrical movement of the human heart. This action can be chart like an Electrocardiogram and the output of this is an analog reading. Electrocardiograms can be very noisy, so to reduce the noise the AD8232 chip can be used.

5.OLED Display:

OLED is an organic light-emitting diode that emits light in response to an electric current. The OLED display module (SSD1306) is one of the most attractive displays available for a microcontroller. It has a good view angle and pixel density which makes it reliable for displaying the small level of graphics. Interfacing this IC with MCU can either be done using IIC or using SPI hence helps to save some pins as well. OLED is an organic light-emitting diode that emits light in response to an electric current. The OLED display can works with no backlight so it can display deep black levels. It is small in size and light in weight than Liquid Crystal Displays (LCD).128×64 OLED display is a simple dot-matrix graphics display system. The OLED display has 128 columns and 64 rows which make it a display of total 128×64 = 8192 pixels.

6.Voltage Regulator:

The LM7805 is a popular voltage regulator integrated circuit (IC) widely used in electronic circuits to provide a stable 5-volt output voltage from a higher input voltage source. Manufactured by various semiconductor companies, the LM7805 belongs to the 78xx series of linear voltage regulators, known for their simplicity, reliability, and ease of use.

IOT cloud ubidots:

Ubidots is a cloud-based IoT (Internet of Things) platform that provides a robust and scalable solution for collecting, storing, analyzing, and visualizing sensor data from connected devices. Designed to streamline the development and deployment of IoT applications, Ubidots offers a user-friendly interface and a comprehensive set of features tailored to meet the needs of both individual developers and enterprise-level organizations.

IV. RESULTS AND DISCUSSION

The implementation of the IoT-based Remote Patient Health Monitoring system has successfully achieved real-time monitoring of critical health parameters. The system's integration with various sensors—ECG sensor AD8232, heart rate and SpO2 sensor MAX30102, and non-contact infrared temperature sensor MLX90614—ensures accurate and continuous tracking of body temperature, blood pressure, heart rate, and blood oxygen levels. The ESP32 microcontroller effectively manages data acquisition from these sensors, processing and transmitting the data for immediate analysis and display.

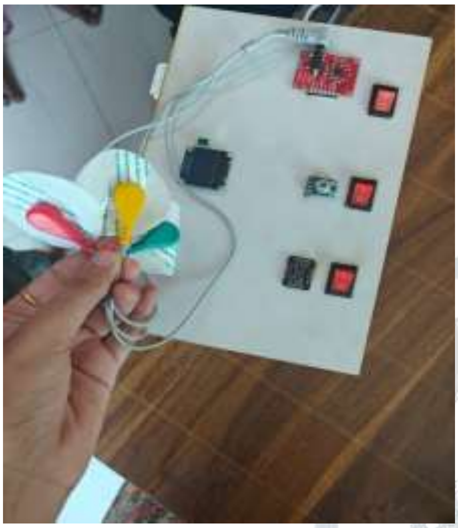

Fig 4 : Health Monitoring System

Fig 5 : ECG Testing

Fig 6: HR & SPO2 output

Fig 7: Temperature output

Fig 8: ECG Output

V. CONCLUSION

The IoT-based Remote Patient Health Monitoring system integrates advanced sensors with the ESP32 microcontroller to ensure accurate and real-time health data acquisition and transmission. Utilizing sensors like the ECG sensor AD8232, heart rate and SpO2 sensor MAX30102, and non-contact temperature sensor MLX90614, the system captures critical health parameters, which are then transmitted to the Ubidots cloud platform via the ESP32's Wi-Fi capabilities. This setup enables robust data visualization, storage, and analysis, providing both immediate local feedback through an OLED display and remote accessibility for healthcare providers. The system's ability to generate alerts and analyze health trends facilitates proactive health management, making it a vital tool for continuous, efficient, and accessible healthcare.

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