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IoT based ECG Monitoring System

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Abstract:- In the recent human health care scenario, the majority of people are battling from arrhythmia, which is a sort of cardiovascular ailment that develops when a person's heart rate is irregular or unstable. Health monitoring and the numerous technologies that go with it are a viable research topic. The number of ECG monitoring systems available in the literature is rapidly growing. As a result, it's difficult for researchers and healthcare professionals to select, compare, and assess systems that meet their demands while also meeting monitoring criteria. We propose a taxonomy for ECG monitoring systems and conduct a systematic review of the literature in this work.It also provides evidence-based support for deeply recognising ECG monitoring systems components, features, and obstacles in diagnosing various health conditions. Electrocardiogram signal should be continuously monitored regardless of location bounded to the subject and the appropriate physician. In this study, a wireless ECG monitoring system based on the AD8232 signal conditioning module was proposed for real-time signal collecting. The AD8232 ECG Sensor will be connected to the ESP32. Then, by connecting ECG leads to the chest or hand, we'll obtain an ECG signal. We'll transfer the ECG graph to the cloud using MQTT Broker utilising Ubidots parameters like API Key or Token. Additionally, we highlight the necessity of smart monitoring systems that control emerging technologies such as deep learning, artificial intelligence (AI), Big Data, and the Internet of Things (IoT) in order to deliver efficient, cost-aware, and completely linked monitoring systems.

Keywords:- *Health care, Cardiovascular, ECG, IoT.*

I. INTRODUCTION

In every country in the world, the number of deaths caused by chronic and cardiovascular diseases (CVDs) has increased over the last decade. CVDs are ailments that affect the heart and blood vessels. Vascular illnesses, such as coronary artery disease, are CVDs that affect the blood vessels. Heart failure, cardiomyopathy, rheumatic heart disorders, stroke, heart attack, and arrhythmias are among conditions that affect the heart. CVDs are the leading cause of death worldwide, according to the World Health Organization (WHO), with 17.9 million deaths per year. **[1**]. It is still the leading cause of mortality in the United States, killing over 840,000 people in 2016.**[2].**Moreover, according to the 2017 edition of the European Health Network European Cardiovascular Disease Statistics, CVDs cause 3.9 million fatalities in Europe and over 1.8 million people die in the European Union (EU) per year. This accounts for 45% of all deaths in Europe and 37% of all deaths in the European Union. **[3].**Continuous heart rate monitoring and immediate heartbeat detection are important priorities in today's healthcare. As a result, monitoring physiological signals like electrocardiogram (ECG) signals provides a new holistic paradigm for assessing CVDs and aiding disease control and prevention. Sensor technology, communication infrastructure, data processing, modelling, and analytics algorithms have advanced to the point where the risk of impairments can be better addressed than ever before. As a result, a new era of smart, proactive healthcare would emerge, especially given the significant obstacle of limited medical resources. By 2020, the Internet of Things (IoT) will have grown to the point where it will be possible to converse about a billion connected gadgets over the internet. A cloud-based mobile ECG monitoring service was demonstrated. These can detect ECG signals using a sensor and communicate them to a screen using wireless transmission systems like Bluetooth, Low **-** power wireless, and Wi-Fi. An ECG monitoring device that can be worn on the body and delivers data directly to the IoT cloud through Wi-Fi without the use of a mobile terminal is available. When compared to Bluetooth or Zigbee, Wi-Fi can deliver faster data speeds and wider coverage areas. A web-based graphical user interface is built to make it simple for doctors and patients to access data services supplied by the IoT cloud utilising smart phones running on various OS systems. There are several works in electrocardiogram monitoring based IoT. In **[12]**The framework was created using Arduino and GSM module for a home alone elderly patient to determine if there are any heart troubles or if the patient's condition has fallen. The framework delivers data to the specialist by cell phone SMS, and it was created using Arduino and GSM module. The framework sends an alert to designated expected individuals or a medical centre if the Echocardiography and body vibration signals are out of the ordinary. In **[13]**Their method makes use of a Raspberry Pi as a microcontroller and the cloud as a medium for transferring ECG data to a viewing system. This system still has flaws, such as the requirement for a good internet connection so that doctors may access it at any time. [14] presented a system that can send messages to users and doctors if a deformity is discovered following an ECG analysis. The ECG sensor network, IoT cloud, and GUI are the three components of this system. Raspberry Pi Model 2, Arduino Uno, and ECG AD8232 Sensor make up the ECG sensing network. To connect to Wi-Fi, a Raspberry Pi is utilised as a minicomputer. The data ECG from the AD8232 was processed using an Arduino Uno. The ECG signal can then be viewed on a mobile or web device. This process simply increases overall cost.

II. PROPOSED WORK FOR THE IoT BASED ECG MONITORING SYSTEM

We suggested a system that comprises of an ECG sensor that measures an ECG signal from the patient using electrodes linked to the ECG board through normal electrode wires. The data was transferred to the ESP32 controller, which processed it before sending it to the IoT Cloud Platform. The data was then transmitted through WIFI to the user's phone.

We'll need an IoT platform to publish the data to the IoT Cloud. So Ubidots is however one platform that provides a platform for programmers to capture sensor data and transform it into usable information. The Ubidots platform allows any Internet-enabled device to submit data to the cloud, which transforms sensor data into information that is useful for corporate decisions, machine-to-machine interactions, and educational research, resulting in increased global resource economization. It allows us to incorporate the power of the Internet of Things into our study in a simple and cost-effective manner. Its promising application platform will offer interactive, real-time data visualisation.**[16],** The proposed work's functioning principle is depicted in (Figure1). The AD8232ECG sensor is attached to the ESP32 controller. All of the remaining components, as well as the electrodes, are arranged in an assembly box The voltage regulator is provided a 12v switched mode power supply (SMPS) because it will only provide the required voltage to the ESP32 controller.

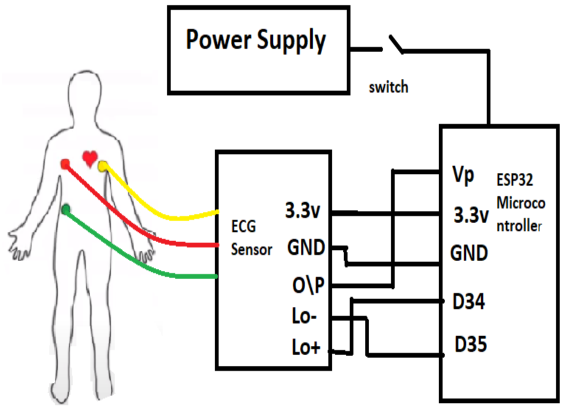

Fig. 1: Circuit\Block Diagram

The ESP32 controller will operate at a voltage of 3.3v. The ESP32 controller will run on a 3.3v power supply. The electrodes are put on the patient's chest, and the patient's heart beats are obtained in analogue form[16]. As a result, the AD8232 ECG sensor is used to transform the data into digital form for efficient transmission. The collected digital data is then provided to the ESP32 controller, which responds on the signal based on embedded C language instructions. The signals are then connected to Ubidots, an IoT platform, which displays the ECG signal. It analyses the ECG data to determine any heart issues.. If the heartbeat rate exceeds a particular threshold (abnormal condition), the Ubidots platform sends an SMS message to the doctor or opens the Ubidots platform, alerting him to the patient's condition. Simultaneously, the buzzer and LED sound an alarm to alert the caretaker to the patient's status.

The ECG sensor utilised is a low-cost circuit that measures the heart's electrical activity. This electrical activity of the heart is recorded as an ECG (Electrocardiogram) and shown as an analogue readout. Because the ECG signal we obtained was noisy, we used an Op-amp, the AD8232, to quickly obtain a clean signal from the PR, QT, and ST intervals. The AD8232 is utilised to measure additional bio-potential measuring signals as well as signal conditioning for ECG. In the presence of noise, it is meant to magnify the bio-potential signal.

There are nine connecting pins and wires on the AD8232 Op-amp. Other connectors include LO+, LO-, OUTPUT, 3.3V, and GND, which are required to use the Op-Amp with an Arduino. This board also includes three lead electrodes: RA (Right Arm), LA (Left Arm), and RL (Right Leg) (Right Leg). The electrodes are put at a specific spot on the body to get an ECG signal since the required cardiac frequency can only be obtained at that location. The AD8232 ECG Sensor is connected to the ESP32 development kit. The AD8232 is powered by the ESP32 module, which provides 3.3V. The AD8232's output pin will be an analog signal. The VP pin of the ESP32 is then linked to this pin. Similarly, the AD8232's LO and LO+ are wired to ESP32's pins D3 and D2, respectively.

III. SYSTEM DESIGN AND IMPLEMENTATION

The integration of a human heartbeat rate monitoring system using a heart vibration sensor and IoT-based technologies are presented in this study. This sensor detects and records the human heartbeat. The ESP32 controller processes the read data before sending it to the Wi-Fi module for uploading to the Ubidots internet server platform for additional analysis and visualisation. When data is captured, it is processed and saved in real time, with a date and time tag. The input units in the proposed work are the ECG sensor unit, the power supply unit, and the user interface unit. The output unit is the Wi-Fi Module unit. The signals are monitored and controlled by the ESP32 controller unit. The integrated C programming language is used to programme the system. The heartbeat will be detected by the ECG sensor. The sensor's sensed data is sent to an analogue to digital converter (ADC), which converts it to a digital signal. After that, the generated digital signal is sent to the ESP32 controller. The ESP32 controller reacts to the signal based on instructions written in the embedded C programming language **[17].** The data is also delivered in real - time basis to the Wi-Fi module and then to the webserver (Ubidots) for more analytics and visualisation. To show the condition of the human heartbeat rate, the analysed data is updated continuously in real-time..It also includes a buzzer and an LED that will activate if the cardiac condition becomes unstable.

The central control unit of the system is Arduino. On the input side, there's also a pulse sensor, an ECG sensor, and numerous manual buttons. The output is displayed on the Arduino com port. The Wi-Fi Module allows data to be uploaded to the cloud, and once there, the results may be accessed by logging into the server with a computer or smartphone.

IV. EXPERIMENTAL CONFIGURATION

Traditional 12-lead devices, which can record accurate ECG signals for experts, are frequently used in medical institutes. Too many electrodes, on the other hand, may compromise the system's portability and the patient's comfort. A three-lead arrangement, according to study[18], is adequate to describe the key aspects of the ECG signal. The electrodes must be arranged in a triangle around the heart in order to best collect the ECG data. Figure 1 depicts the 3-lead placement used in our system. For the goal of confirming the stability and accuracy of the proposed system, several experiments are done on a healthy volunteer using the 3-lead implantation.

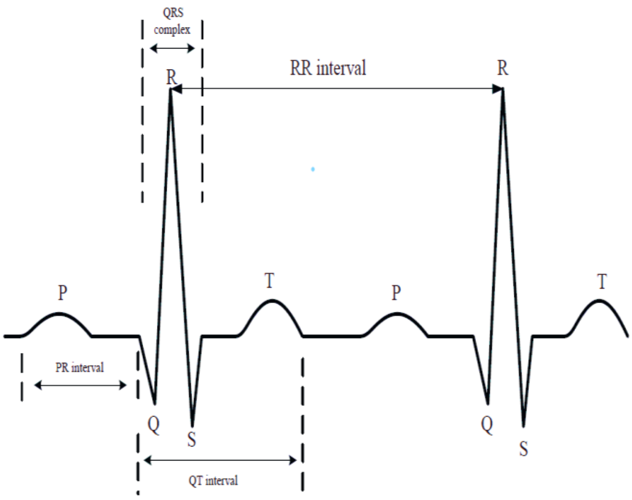

Fig. 4: Standard ECG signal

As shown in Fig. 1, typical ECG signals are made up of five types of waves: P surge, T surge, Q surge, R surge, and S surge. These waves' intervals are commonly utilised to diagnose a number of heart conditions. Among all the features of these waves, four are most commonly used in medical diagnosis **[3]**.

- **RR break**: The R wave is typically used to determine the duration of an ECG signal because it is one of the most essential properties. The RR interval is the temporal gap between two consecutive R waves that can become irregular in some heart disorders, such as arrhythmia **[7]**.
- **PR break**: The duration between the start of the P wave and the start of the QRS complex is measured by the PR interval. It shows how long it takes for an impulse from the sinus node to approach the ventricles.
- **QT break**: The time between the onset of the Q wave and the finish of the T wave, which is connected to ventricular depolarization and repolarization, is known as the QT interval. If the QT interval surpasses value, there is a higher risk of ventricular fibrillation or potentially abrupt cardiac death.
- **QRS break**: The QRS complex is primarily connected with ventricular depolarization, and it is made up of three major waves: Q wave, R wave, and S wave. Certain disorders, such as electrolyte imbalance or drug toxicity, can be diagnosed by analysing the form and duration of the QRS complex..

V. KEY CHALLENGES OF ECG MONITORING SYSTEM

ECG monitoring systems, as detailed in this paper, are made up of a variety of components, frameworks, and technologies. The variety and heterogeneity of ECG sensor based architectures creates a number of issues, as various academics have pointed out. There are a variety of obstacles that can be encountered, including the following:

- Challenges Associated with the Use of Monitoring Devices.
- Signal quality issues are a problem.
- Difficulties with Durability Monitoring
- Issues with the size of ECG signal data.
- Visualization-related difficulties.
- Difficulties with system integration.

VI. CONCLUSION

Only with AD8232 ECG Sensor and the ESP32 development kit, we suggested an IoT-based heartbeat monitoring system. Heart ailments have become more prevalent in recent decades, and many individuals have died as a result of these illnesses. As a result, heart illness should not be regarded lightly. Heart disease could be avoided by studying and constantly monitoring the ECG signal early on. The observed ECG signal is examined and analysed. Early detection, prediction, and management of cardiac disease are all aided by IoT-based statistical frameworks for heart monitoring. This study investigates an IoT-connected low-power wireless sensor interaction technology for long-term cardiac parameter monitoring. Regular usage of the gadget is extremely beneficial for early diagnosis of heart ailments as well as lowering the severity of damage and mortality rates associated with cardiovascular diseases. Additional health monitoring systems, such as temperature measurement, Pulse Rate, Diabetes, and so on, can be constructed utilising IoT in a similar way to this user-friendly ECG surveillance system, and will significantly help to reduce serious health complications to a certain extent. [3] ECG monitoring systems are constantly being implemented using new technologies including as deep learning, AI, Big Data, and IoT to deliver a cost-effective, completely linked, and sophisticated monitoring system. Empowering technologies provide up a wide variety of possibilities for ECG monitoring system improvement.IoT introduces distant, unconstrained communication and services that make use of data to enable fast, meaningful, and crucial lifestyle decisions. Furthermore, fog computing and cloud processing contribute to greater efficiency and the fulfilment of multiple in-demand extensible application services. Furthermore, blockchain enables security for numerous transactions across the many elements of the ECG monitoring system's development in a distributed environment.

VII. FUTURE WORK

Exploring the field of robotics and medical automation as a future direction has the potential to improve future ECG monitoring systems and ease robotic-assisted surgery procedures, senior care, and distant and in-hospital uninterrupted patient monitoring. Robotic surgery should be carried out with more precision, control, and vision, clearing the way for tomorrow's revolutionary healthcare. Understanding the use of the extremely quickly IoT and interconnected smart devices for preventative healthcare, as well as assisting the detection of patients' unique medical concerns or a shift in behavioral traits, are two more potential study avenues Personalized tracking systems should also be taken to the extreme in terms of being extremely personalized according to patients' demands and engaging, enabling for particular setups and modifications to users' wants for a higher quality of life. Finally, adding more intelligence to the patients' surroundings, such as integrating more sensors in the carpet to correctly monitor patients' movements in order to develop patterns of behaviour and detect any irregularities, as indicated in [16], is another interesting study avenue.

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