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Automated ECG Monitoring and Alert System using Arduino

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ABSTRACT: Cardiovascular diseases, particularly heart attacks, are among the leading causes of death worldwide, with a significant impact in rural areas due to limited access to advanced medical facilities. Early detection of heart abnormalities can help prevent fatal incidents, especially for elderly individuals in old age homes and patients in small healthcare centers. This project presents an Arduino-powered ECG monitoring and alerting system that continuously tracks the heart's electrical activity and provides real-time updates. The system consists of an ECG sensor that captures the heart's electrical signals and processes the data using an Arduino microcontroller. This data is then uploaded to the Thing Speak cloud platform, allowing remote access with date and time stamps for continuous monitoring. If any abnormalities, such as arrhythmias, are detected, the system triggers a voice alert and an SMS notification to a predefined mobile number, alerting caregivers or medical personnel for immediate intervention. Designed to be cost-effective and user-friendly, this system can be deployed in rural areas, old age homes, and small hospitals, where conventional ECG machines may not be readily available. Its ability to provide real-time monitoring and instant alerts enhances patient safety by enabling early detection of heart conditions, reducing the risk of fatal cardiac events. With a simple and efficient design, this device serves as a valuable tool for improving healthcare accessibility and ensuring timely medical attention, ultimately saving lives in resource-limited settings.

KEYWORDS: ECG monitoring, heart disease detection, real-time health monitoring, rural healthcare, cardiac abnormalities, IoT in healthcare, continuous heart monitoring

I. INTRODUCTION

Cardiovascular diseases continue to be a major contributor to global morbidity and mortality, highlighting the necessity for reliable and continuous cardiac monitoring solutions. Timely detection and intervention play a critical role in managing heart conditions and reducing the risk of severe cardiac events. However, conventional ECG monitoring systems are typically restricted to clinical environments, limiting their effectiveness for continuous patient observation, particularly in home-based or remote settings. An Electrocardiogram (ECG) is a widely used medical test that records the heart's electrical activity over a specific duration. This non-invasive and painless procedure involves placing electrodes on the skin to capture and analyze electrical signals from the heart [1]. The emergence of the Internet of Things (IoT) in healthcare is transforming patient monitoring and medical diagnostics, enabling real-time data collection and remote accessibility. One of the most significant advancements in this field is the development of IoT-powered medical devices, which enhance the efficiency and accessibility of cardiac monitoring systems [2].

Figure-1 illustrates the IoT-based ECG monitoring system, which includes sensors attached to the body to capture heart activity, transmitting the results to the cloud for real-time monitoring. This project presents an advanced Arduino-powered ECG monitoring and alerting system, designed to overcome the limitations of traditional cardiac monitoring in non-clinical settings. By utilizing cost-effective and readily available components, this system provides a practical and accessible solution for continuous heart monitoring beyond hospital environments [3].

The system integrates ECG sensors to record the heart's electrical activity, with data being processed in real-time by an Arduino microcontroller. To enhance its functionality, the project employs the AD8232 ECG module for accurate ECG signal acquisition, while the APR33A3 voice module generates voice alerts in case of irregularities. Additionally, an ESP8266 Wi-Fi module is incorporated to facilitate real-time data transmission to the ThingSpeak cloud, ensuring remote accessibility along with timestamped recordings [4].

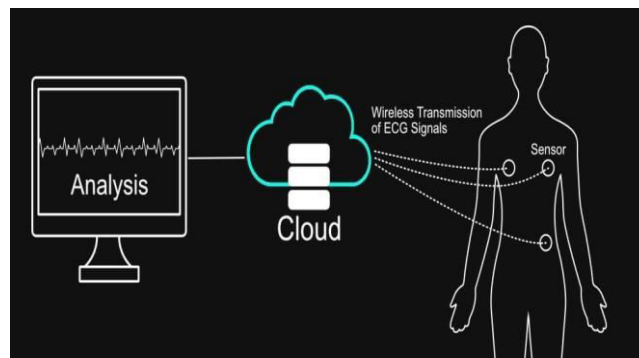


Fig1: IOT based ECG monitoring system

In this project, a comprehensive health monitoring system is developed by integrating multiple sensors and communication modules to ensure real-time data acquisition and accessibility. The system utilizes an Arduino microcontroller to process physiological signals, with the AD8232 ECG module accurately capturing the heart's electrical activity. To provide immediate auditory alerts in case of abnormalities, the APR33A3 voice module is employed, enhancing the system's responsiveness. Furthermore, real-time data transmission is facilitated through the ESP8266 Wi-Fi module, enabling seamless connectivity to the Thing Speak cloud for remote monitoring and analysis. This integration ensures continuous health tracking with timestamped recordings, making it a reliable solution for real-time cardiac health assessment [5].

II. LITERATURE SURVEY

While working on our system, it's essential to have knowledge about the existing work or published papers related to our system's design. These resources serve as valuable references for study, helping us analyse productive ways to build and incorporate components that we might not be familiar with additionally, we can gather information from sources detailing safety measures when dealing with fire or flames, especially in the context of utilising a microcontroller and necessary flame sensors for study purposes. We also need to explore the suitable Integrated Development Environment (IDE) required for programming microcontroller.

Sohit Agarwal | Devashish Desai "IoT-Based ECG Monitoring System for Health Care Applications" Mathematical Statistician and Engineering Applications 2022. Internet of Things (IOT) –enhanced ECG monitoring system that can either send data to a server in real time and can be seen in using Smartphone GSM modules will be integrated into the system allowing for phone calls and SMS messaging to be made [6].

Mamoona Humayun et al. proposed a standardised method of transmitting patient data across the Internet of Things in E-health contexts within hospitals. Internet of Things devices are widely employed in the healthcare business for real-time data collection and transmission. These are, unfortunately, insecure and call for the implementation of specialised, lightweight security measures due to limitations in available resources. To address these concerns, we developed a strategy that makes use of many groups of nodes and involves multiple rounds of node registration and key authentication to shorten the distance data can travel while simultaneously increasing the amount of energy required to transmit the data [7].

Sarada Prasad Gochhayat et al. proposed a method to implement key management across a heterogeneous network of devices running various Internet of Things applications. Therefore, it is critical that IoT applications have strong data management skills, such as the capacity to collect, store, and transport data safely [8].

Ashutosh Sharma ET. al (2019) proposed a method to implement healthcare CPS that is secure, SLA- compliant, and energy- efficient to ensure the confidentiality of all communications between patients and healthcare providers and the timely fulfilment of all user demands. By identifying the required service time and adjusting in AODV process methods, a secure and efficient communication mechanism is given by recognising the residual energy information at the node prior to transmission [9].

Mohamed Elhoseny proposed a method to Secure transmission of diagnostic information about patients via colour and gray scale images is presented as a new paradigm within the medical IoT. The proposed model utilised AES and RSA encryption alongside 2D-DWT-1 or 2D-DWT-Steganography. The test used both colour and black and white images with varying font sizes. Six statistical markers of success were used to evaluate the outcomes (PSNR, MSE, BER, SSIM, SC, and correlation) [10].

Sohail Saif et. proposed a method to implement cloud enabled the development and implementation of a programme for secure WBAN communication in healthcare. It will be challenging for unauthorised users to access any node that depends on the authentication of patients' and doctors' bio signals. Every person has their own unique bio signal. Thanks to AES ciphering technology, wireless networks are safe against intrusion [11].

Hai Tao et. proposed a method to implement to ease customers' minds about the safety of their personal information when utilising IoT- based healthcare apps, we developed a new method of data collecting we term "Secure Data." We introduce, implement, and optimise the KATAN secret cypher algorithm on the FPGA hardware platform. Protecting the security of the KATAN encryption relies on secret cypher exchange and mending. The analysis demonstrates that the Secure Data system reduces costs across the board, including processing, energy use, and security [12].

Munish Bhatia ET proposed a method to implement a close look at one promising area of future Internet of Things application: health monitoring during exercise. The proposed model may quickly assess the susceptibility of a particular health state to injury by incorporating a wide variety of health-related characteristics. The model's layered structure was also designed to carry out a series of predetermined tasks in a synchronised method, maximising efficiency. As a first step, we use the Internet of Things to gather data on the state of various parts of a workout [13].

Haiping Huang ET. proposed a method to implement to address these issues, the authors of this study propose a new paradigm for e-/m- healthcare systems they refer to as "HES." There are three distinct categories for HES characteristics: By using low- cost and easily deployed wireless sensor networks as the relay infrastructure for GSRM-based secure transmission of medical data from WBANs to WPANs, we first solve the issue of ad hoc communications between users' mobile terminals and embedded (wearable) medical devices (nodes); second, we apply privacy-preserving strategies like HEBM to achieve satisfactory performance [14].

Mohamed Elhoseny ET proposed a method to implement the WSN's limited resources and often hostile conditions, security is of the utmost significance. The proposed cluster-based paradigm has the potential to reduce network energy consumption and thereby lengthen their lifetimes. Protecting data clusters in wireless sensor networks is an area that has seen a lot of discussion and debate, with a number of different solutions proposed. Several safe clustered routing strategies have been developed for WSN [15].

III. METHODOLOGY

The proposed system is designed for real-time ECG monitoring using an Arduino-based platform. The methodology involves several key stages: data acquisition, processing, alert generation, and remote monitoring. First, ECG probes are attached to the patient to capture the heart's electrical activity. These signals are then fed into the AD8232 ECG module, which filters and amplifies them for better accuracy. The processed signal is sent to the Arduino microcontroller, which continuously monitors the data in real-time. To enhance functionality, an APR33A3 voice module is integrated into the system. This module generates voice alerts when irregular heart activity is detected, providing immediate feedback to the user. Additionally, a GSM module is incorporated to send SMS notifications to a registered mobile number in case of emergencies. For remote monitoring, an ESP8266 Wi-Fi module is used to transmit ECG data to the Thing Speak cloud. This ensures real-time data accessibility for healthcare professionals and caregivers, allowing continuous cardiac health assessment. The system operates on a stable power supply, ensuring uninterrupted performance. By integrating wireless communication, voice alerts, and cloud storage, this methodology provides an efficient and accessible solution for ECG monitoring, improving early detection and response to cardiac abnormalities.

Figure-9 shows about the block diagram of the project; it represents different parts of the system and lines or arrows that illustrate the relationships and flow of information or materials between these parts.

An Arduino controller is a versatile, microcontroller- based platform designed for creating interactive electronic projects. It serves as the central processing unit for a wide array of applications, from simple DIY electronics to complex automation systems. Below is a detailed description of an Arduino controller, including its features, capabilities, and typical use cases. This serves as the main control unit. It interfaces with and coordinates the operation of other modules.

The AD8232 is an integrated signal conditioning block for ECG and other biopotential. It is designed to extract, amplify, and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement. Connected to the Arduino, it allows voice commands or audio prompts to control or interact with the system. Total 11 minutes of recording time each channel (M0toM7) having 1.3 minutes of recording time. Single chip, high quality voice recording and playback solution, low cost enables communication over GSM networks. It can send SMS alerts or data to remote locations (Electrocardiogram) sensors are devices used to measure the electrical activity of the heart. These sensors play a crucial role in medical diagnostics by providing data that helps in assessing heart health. Below is a detailed description of ECG sensors, focusing on their working principles, features, and typical applications. These sensors monitor and measure electrocardiogram signals.

Arduino Powered ECG Monitoring System

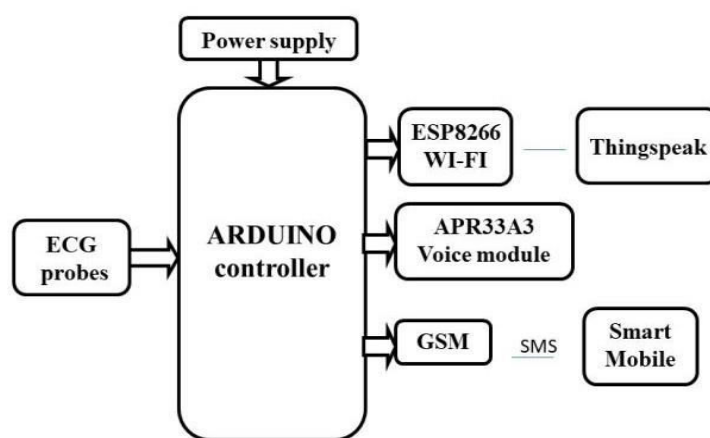


Fig 2: Proposed block diagram

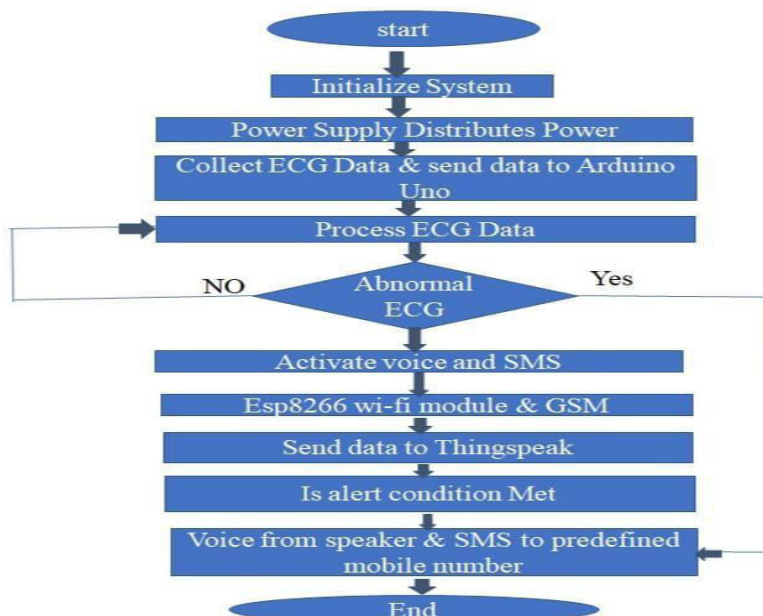


Fig 3: Flow chart

GSM is a mobile communication modem; it stands for global system for mobile communication (GSM). When the system detects any abnormal condition, it will send the alert SMS to the predefined mobile number via Sparoids Wi-Fi connectivity. It allows the Arduino to send data to the internet or receive commands remotely. Think Speak is an open-source Internet of Things (IoT) platform that allows users to collect, store, analyse, and visualise data from sensors and devices. Developed by MathWorks, Think Speak is particularly useful for projects involving real-time data analytics,

monitoring, and remote control. Below is a detailed description of ThinkSpeak, its features, and its applications. An IoT platform where sensor data can be uploaded and analyzed. The Arduino can upload ECG sensor data to Thing Speak for real-time monitoring or analysis. A power supply is a device that provides electrical energy to one or more electric loads. It converts and regulates electric power from a source to the correct voltage, current, and frequency required by the load.

IV. EXPERIMENTAL RESULTS

The Arduino Uno is a versatile and user- friendly open-source microcontroller board, widely popular. It is built around the ATmega328P microcontroller, a robust and efficient 8-bit processor by Atmel.[1] The board features 14 digital input/output pins, 6 of which can be used as PWM outputs, and 6 analog inputs, providing ample connectivity for various sensors, actuators, and other peripherals. Its ease of programming via the Arduino IDE, which supports C/C++ language, combined with an extensive library ecosystem, allows both beginners and experienced developers to rapidly prototype and deploy in the project [16].

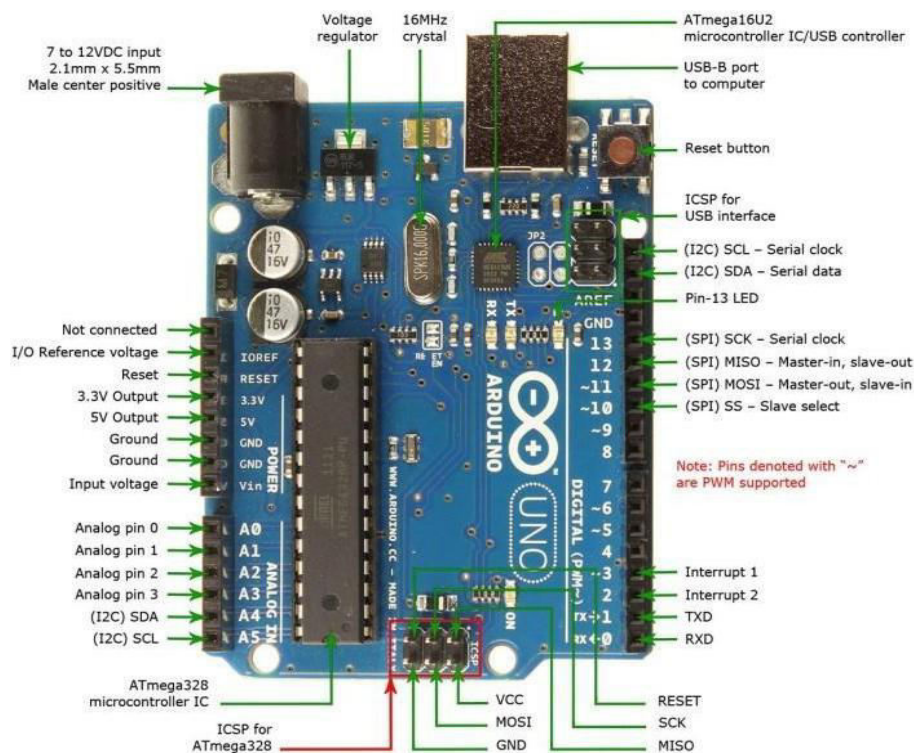


Fig 4: Physical outlook of Arduino Uno

The AD8232 ECG sensor is a compact and efficient module designed for monitoring heart activity using electrocardiography (ECG). It captures the heart's electrical signals and processes them to provide a clear and accurate ECG output. The sensor features an instrumentation amplifier, which amplifies the weak electrical signals generated by the heart, ensuring precise measurements. Additionally, an operational amplifier further refines the signal, enhancing its quality for analysis. Designed for low-power applications, the AD8232 is ideal for wearable health devices, fitness tracking, and medical diagnostics. It effectively reduces noise and interference, making it suitable for real-time monitoring. The sensor is commonly used in Arduino-based projects, enabling seamless integration with microcontrollers for ECG data processing and transmission. With its compact size, high accuracy, and ease of use, the AD8232 ECG sensor is widely used in biomedical applications, remote patient monitoring, and personal health tracking systems.

The Internet of Things (IoT) is a system of connected things. The thing generally comprises an embedded operating system and an ability to communicate with the internet or with neighboring things. One of the key elements of a generic IoT system that bridges the various 'things' is an IoT service. An interesting implication from the 'things' comprising the IoT systems is that the things by themselves cannot do anything. Project Is Implemented Using Following Software's:

Express PCB—for designing circuit Arduino IDE Studio compiler- for compilation part Arduino IDE Compiler: This instructible adds to any of the Arduino on a Breadboard instruct Ables. Not all AT mega 328' sare equal (A boot loader, very simply, is a programmer that sits on the chip and manages the upload of your sketches on to the chip) [17].



Fig 5: ADE8232 ECG sensor



Fig 6: ECG monitoring using ThingSpeak

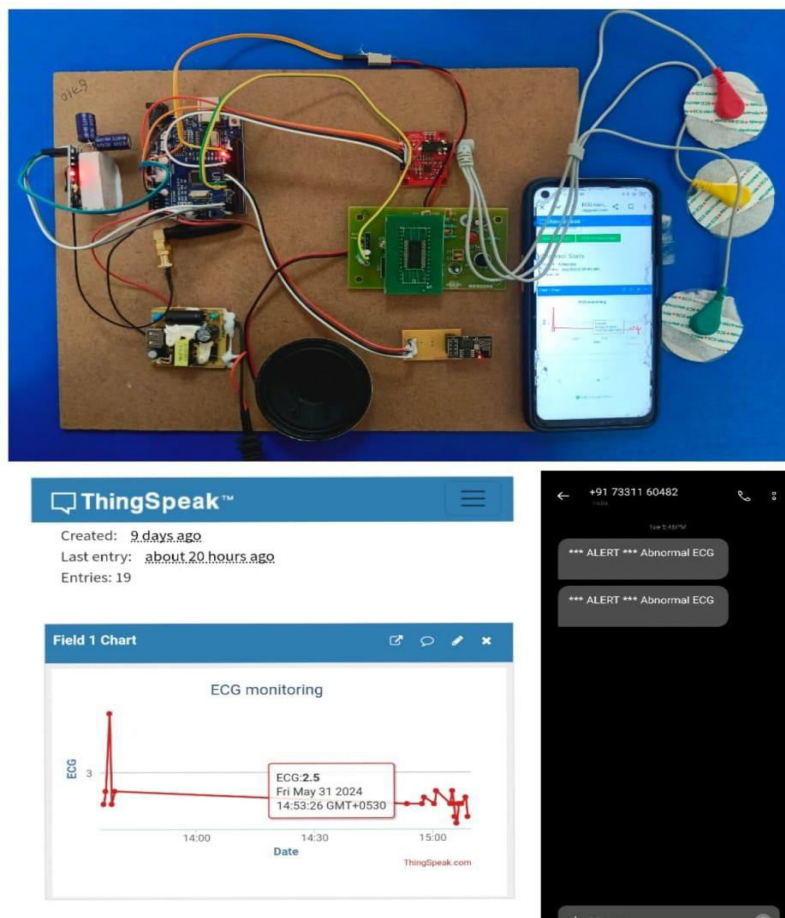


Fig 7: Building an arduino-Powered ECG Monitor and Alerting System

V. CONCLUSION

The Arduino-powered ECG monitoring system presents an innovative, cost-effective, and efficient solution for real-time cardiac health tracking. By integrating ECG probes with an Arduino microcontroller, the system continuously records the heart's electrical activity, ensuring accurate and timely monitoring. The collected data is uploaded to the ThingSpeak cloud, allowing remote access for healthcare professionals and caregivers. This cloud-based storage enables real-time analysis and historical data tracking, improving the ability to detect abnormalities early. To enhance patient safety, the system is equipped with an alert mechanism. In case of irregular heart activity, a GSM module sends an emergency SMS alert to a predefined mobile number, ensuring prompt medical attention. Additionally, an APR33A3 voice module provides audible alerts through a speaker, making the system more user-friendly for patients, especially in critical situations. The system's advantages include real-time monitoring, remote accessibility, cost-effectiveness, and ease of use, making it suitable for homes, old-age homes, hospitals, and rural healthcare centers. Its non-invasive nature makes it a comfortable option for long-term monitoring, allowing for early detection and timely intervention, particularly for patients in critical care settings. By integrating wireless communication, cloud-based data storage, and voice alert functionalities, this project provides a comprehensive solution for cardiac health monitoring. With continuous improvements and potential AI-based analysis, such a system can play a crucial role in reducing cardiac-related emergencies and ensuring better patient outcomes in both urban and remote healthcare settings.

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