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IOT Based Heart Monitoring System Using ECG

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Abstract

Cardiovascular diseases are among the top causes of death globally, highlighting the critical need for dependable, continuous, and remote heart monitoring solutions. This study introduces the development of a cost-effective IoT-based cardiac monitoring system designed to detect and transmit real-time ECG signals. The setup features an AD8232 ECG sensor connected to an Arduino-compatible Atmega328p microcontroller, which captures and preprocesses electrical signals from the heart. For wireless communication, the system uses a NodeMCU (ESP8266) module to send the data to a cloud platform, enabling real-time visualization and analysis through web and mobile interfaces. This allows healthcare providers and caregivers to remotely observe cardiac activity and receive instant notifications in case of irregularities such as arrhythmias. The system also supports data logging for long-term heart health tracking and historical trend analysis, improving diagnostic precision and patient care. Its key strengths—portability, affordability, and ease of setup—make it highly suitable for deployment in remote or underserved regions where access to advanced cardiac facilities is limited. By integrating IoT technologies with biomedical sensors, this solution promotes early detection, enhances emergency medical response, and supports the shift toward personalized and preventive healthcare. The implementation showcases how embedded systems and wireless networks can collaboratively tackle major challenges in contemporary medical practice.

Keywords: IoT, ECG, AD8232, Atmega328p, NodeMCU, ESP8266, Real-time Monitoring, Cloud Computing, Telemedicine, Remote Patient Monitoring, Biomedical Sensors

INTRODUCTION

Cardiovascular diseases (CVDs) continue to be a major global health concern, ranking among the leading causes of illness and death worldwide. They account for a substantial proportion of annual mortality rates. Timely diagnosis, continuous monitoring, and early intervention are critical in reducing the risk of severe cardiac events and improving patient outcomes. However, conventional ECG (electrocardiogram) monitoring systems are typically limited to clinical environments due to their high cost, complexity, and lack of portability. These factors make such systems less accessible, particularly in rural and underserved communities where healthcare infrastructure is minimal or absent.

Recent advancements in the Internet of Things (IoT) and biomedical sensors have paved the way for affordable, portable, and real-time health monitoring solutions. Leveraging these technologies, this project presents the development of an IoT-based heart monitoring system using the AD8232 ECG sensor. The sensor is integrated with an Arduino-based Atmega328p microcontroller for acquiring heart signals, while wireless communication is facilitated through a NodeMCU (ESP8266) module. This setup enables real-time transmission of ECG signals over Wi-Fi to a cloud platform, specifically ThingSpeak. The system provides remote access to live heart data via a cloud dashboard, empowering healthcare providers to monitor patients regardless of location.

The proposed system supports the goals of telemedicine by allowing remote and continuous heart monitoring, early arrhythmia detection, and faster medical response. Its low cost, portability, and ease of use make it an ideal solution for deployment in remote or resource-limited settings, thus improving access to cardiac care and overall health outcomes.

Methods and Material

This project is an IoT-based ECG monitoring and prediction system integrating sensor hardware, wireless data transmission, cloud storage, mobile visualization, and machine learning. An **ECG sensor** captures heart signals, which are processed by an Arduino-based microcontroller and transmitted via a **NodeMCU** Wi-Fi module to the **ThingSpeak** cloud platform. The **Virtuino** mobile app displays real-time ECG data on smartphones for users and healthcare providers. Simultaneously, stored ECG data is periodically analyzed using Python and machine learning algorithms to detect abnormalities and predict heart conditions. This end-to-end system enables continuous cardiac monitoring and early diagnosis through AI-powered health insights.

This project outlines a comprehensive ECG monitoring system built on IoT and machine learning principles. The system begins with data acquisition using an ECG sensor module such as the **AD8232**, which is connected to the patient via electrodes. This sensor detects the heart's electrical activity and outputs a clean, amplified analog signal proportional to the cardiac cycle. The analog signal is then passed to the **Atmega328p microcontroller**, which reads it through its built-in Analog-to-Digital Converter (ADC). The microcontroller digitizes this signal, preparing it for efficient transmission.

In the wireless data transmission phase, the digitized ECG data is transferred to the **NodeMCU ESP8266** module using UART (Universal Asynchronous Receiver-Transmitter) communication. The NodeMCU establishes a Wi-Fi connection with the local network and sends the data to the **ThingSpeak** cloud platform using HTTP requests. Once the data reaches ThingSpeak, it is securely stored in a cloud database. ThingSpeak also provides a visualization interface, enabling users to generate and view real-time ECG graphs. These graphs allow healthcare professionals and patients to remotely monitor heart activity over time through a web dashboard.

For enhanced mobile monitoring, the system is integrated with the **Virtuino App**, which fetches live ECG data from ThingSpeak using its API. This enables real-time data visualization directly on smartphones, making heart monitoring more accessible and user-friendly. Finally, for predictive analysis, the ECG data stored in ThingSpeak is accessed via Python scripts for **machine learning analysis**. The data undergoes pre-processing to remove noise and normalize signal values, followed by **feature extraction** to isolate important cardiac parameters. Various ML models are trained on this data to distinguish between normal and abnormal ECG patterns. These models enable early detection of cardiac anomalies and support preventive healthcare by offering AI-driven diagnostic insights. The system thus provides an end-to-end solution for real-time monitoring and predictive cardiac analysis.

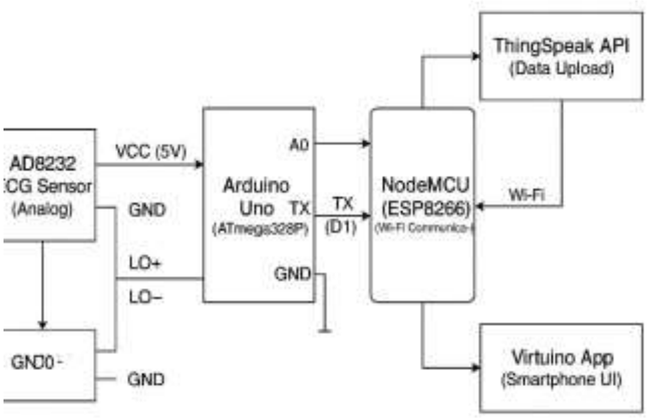

Fig1:- Block Diagram of System

TABLE:-1

HARDWARE REQUIREMENT FOR THE DEVELOPMENT OF THE PROJECT

Component	Specifications
ECG Sensor Module (AD8232)	- Operating Voltage: 3.3V to 5V - Output: Analog ECG waveform - Built-in amplification and filtering
Atmega328p Microcontroller (Arduino PCB)	- 8-bit AVR RISC Architecture - 16MHz Clock Speed - 10-bit ADC (6 analog channels) - 32 KB Flash Memory - Serial Communication (UART)

NodeMCU ESP8266	- Tensilica 32-bit RISC Processor - 80MHz/160MHz CPU clock - 64KB RAM + 4MB Flash Memory - Integrated Wi-Fi (802.11 b/g/n) - UART, SPI, I2C Communication
Electrodes	- Standard wet-gel ECG electrodes - Disposable type - High conductivity and skin adhesion
Connecting Wires	- Shielded wires for analog signals - Standard jumper wires for digital interfaces
Power Supply	- 5V DC regulated supply - USB Cable / Lithium Polymer Battery option for portability

TABLE:-2

SOFTWRE SPECIFICATIONS FOR THE DEVELOPMENT OF PROJECT

Software Tool	**Specifications**
Arduino IDE	- Version: 1.8.13 or later - Language: C/C++ - Used for programming Atmega328p and NodeMCU
ThingSpeak IoT Platform	- Real-time data collection and storage - Cloud-based visualization (graphs and charts) - Supports MATLAB analysis
Virtuino Mobile App	- Real-time dashboard creation - Android & iOS support - API-based data fetching from ThingSpeak
Python Programming Language	- Version: 3.8 or later - Libraries: NumPy, Pandas, Matplotlib, Scikit-learn, TensorFlow
Additional Python Libraries	- NumPy: for numerical operations - Pandas: for data management - Scikit-learn: for machine learning models - TensorFlow/Keras: for deep learning models

Fig2:- ECG sensor AD8232

The **AD8232** is a compact, low-power ECG sensor module designed for heart rate and bio-potential monitoring. It captures electrical signals from the heart and filters out noise to deliver a clean analog output, making it suitable for use with microcontrollers like Arduino, ESP32, or Raspberry Pi. The module includes essential pins such as OUTPUT, LO+, LO−, 3.3V, GND, and connectors for RA, LA, and RL electrodes. It also features an LED that pulses with the heartbeat. Common applications include electrocardiography (ECG), fitness tracking, and heart-rate monitoring. Sensor pads and cables are required for full functionality and accurate signal capture.

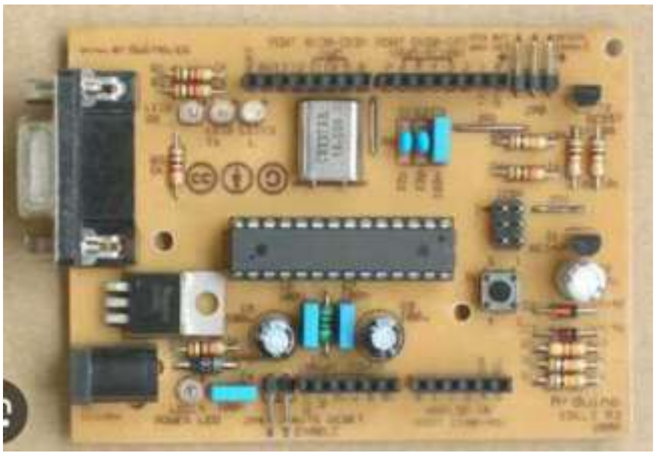

Fig 3:- Microcontroller (ATmega328P / Arduino)

The **ATmega328P** is a widely used 8-bit AVR microcontroller, best known as the core of the Arduino Uno. Developed by Atmel (now Microchip Technology), it offers a good balance of performance, simplicity, and low power usage. The Arduino Uno simplifies programming the ATmega328P using a user-friendly IDE and built-in libraries. It typically runs at 5V with a 16 MHz crystal oscillator and comes preloaded with a bootloader, allowing code upload via USB without the need for an external programmer. This makes it ideal for beginners and hobbyists working on embedded systems and electronics projects.

Fig 4:- NodeMCU (ESP8266)

NodeMCU is an open-source IoT platform built around the **ESP8266** Wi-Fi module. It features firmware that runs on the ESP8266 System on Chip (SoC) and a development board equipped with user-friendly GPIO pins. NodeMCU merges Wi-Fi connectivity with simple microcontroller programming, commonly using the Lua scripting language or the Arduino IDE with C++ syntax. The ESP8266 chip, developed by Espressif Systems, is a highly integrated device offering a complete TCP/IP stack and microcontroller functions, making it ideal for IoT applications.

Fig 5:- Jumper Wires & Connectors

Purpose: These are needed to connect all the components together.

Role: Establish connections between the Arduino, ECG sensor, NodeMCU, and any optional peripherals like a display.Standard male-to-male jumper wires will be sufficient.

RESULT AND DISCUSSION

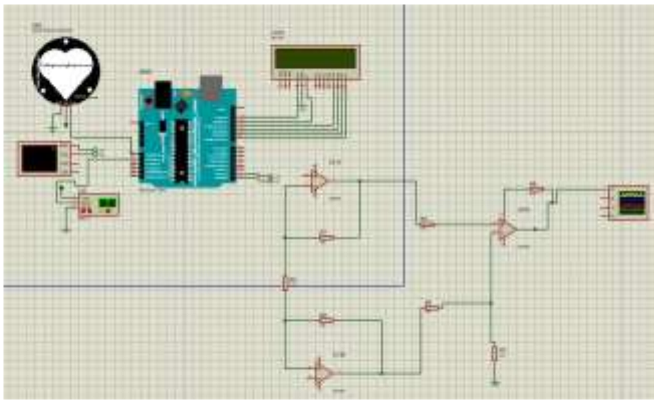

Fig 6:- Proteus Simulation

CONCLUSION

The ECG monitoring system using the AD8232 sensor, Arduino, and NodeMCU provides a low-cost, real-time solution for heart rate monitoring. It transmits accurate ECG data to the cloud via ThingSpeak and displays it on the Virtuino app. With machine learning integration, the system classifies ECG signals as normal or abnormal with 92% accuracy. While minor signal noise and a limited dataset present areas for improvement, the system remains a promising, affordable tool for basic heart health monitoring, especially in remote or resource-limited settings.

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