Construction Electrocardiograph Using Arduino

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Abstract

Heart diseases are becoming a major issue for the last few decades, and many people die because of certain health problems. Consequently, heart disease should not be treated lightly. This disease can be prevented by analyzing or monitoring the Electrocardiogram (ECG) signal at the initial stage. ECG is a common medical test for assessing cardiac function by measuring the heart's electrical activity. ECG is considered a fairly routine and sufficient indication of heart health and is performed with 3, 5, 12, or 15-lead ECG machines. In this study, an experimental device is constructed using an AD8232 sensor board and Arduino to obtain an ECG signal for monitoring cardiac function. On a participant, a basic and inexpensive Arduino circuit based on an AD8232 ECG was connected and tested. The AD8232 is a smart little device used to measure the heart's electrical activity. This electrical activity can be represented on an ECG. ECG is used to aid in the diagnosis of various cardiac disorders. These promising results suggested that the presented system is feasible for monitoring the heart, which can find applications in many areas, including healthcare services. The device was constructed and designed to monitor cardiovascular disease.

Chapter One

Introduction

Auscultation of heart sounds, heart rate variability, and electrocardiography (ECG) are the most common heart condition monitoring techniques (Al-Turjman et al., 2020). ECGs present variations in the electrical activities of the heart. The heartbeat signal has P and T waves and QRS complexes which describe the electrical forces generated by ventricular depolarization. R-R intervals are obtained using the time intervals between consecutive R-R peaks. HRV can be described as the variation of R-R intervals with respect to the time or beat number (Colak, 2009). ECGs have long been around in hospitals and many healthcare centers to diagnose cardiac activities and screen for heart diseases. ECG is used to measure heart rate, regularity of heartbeat, size and position of chambers, and presence of any heart damage. Also, it is used to observe cardiac activity for people with impairment and the effects of drugs or devices used to regulate the heart, such as pacemakers (Jeevan vijay, 2013). Throughout the decades, there have been a number of attempts to develop clinical information systems which are reliable, affordable, and accessible over the entire hospital. The situation is made possible today with the development of wireless technologies, powerful personal computers, and international standards. These factors also have enabled data acquisition from a wide range of medical equipment, such as electronic stethoscopes and ECG devices. With the advent of technology, IoT-driven bio-acoustic sensors can be utilized for continuous monitoring (Al-Turjman and Al-Turjman, 2019). Wearable devices enable continuous monitoring of patients anywhere within the hospital environment. On the other hand, further research is required to develop continuous monitoring tools (Guvenc, 2020). Similarly, the health industry is using smart technologies for patient monitoring (ehealth), management, maintenance and security to achieve more efficient hospitals (Ulusar et al., 2020).

In order to monitor the heart, many ECG devices have been proposed as a promising method in recent years. (Guvenc, 2020) present an experimental device that obtains an ECG signal using the AD8232 sensor board. The device operates in real-time and transmits data wirelessly using nRF24L01+ RF modules located on Arduino Mega2560 I/O boards. (Rumpa et al., 2020) designed ECG instruments capable of measuring or detecting the human pulse, particularly when affected by emotional changes. This system was constructed using the E-Health Sensor Platform v2.0 and

the Arduino Uno. E-Health Sensor Platform v2.0 includes a number of sensors that can measure the biological state of humans, including pulse rate, respiration, skin conductance, and many others. When connected to Arduino Uno, this device can function as a microcontroller. Prasad et al. designed a simple ECG monitoring system utilizing the AD8232 and Arduino microcontrollers. "The system receives the pulse input from Ag/Cl 3-lead electrodes positioned on the arms and right leg of the patient being examined." The model includes an ECG module (AD822), which is utilized for signal conditioning of the input pulse from the patient's body (Prasad and Kavanashree, 2019). Das et al. developed a device with an Arduino (UNO/MEGA) microprocessor and a real-time ECG graph display function. The AD8232 sensor, which converts the sense voltage derived from ECG electrodes placed on the body, is the primary instrument for measuring the pulse (Das et al., 2022). As preliminary research, this research focused on the development of a low-cost and portable ECG device based on Arduino. The device can monitor the user’s electricity of the heart.

Chapter Two

Materials and Methods

2.1 Materials

The materials used in this study include an Arduino UNO board, AD8232 ECG sensor, and IDE.

Electrocardiography

It is the process of recording the electrical activities during the contraction and relaxation of the heart on a special paper or digital environment (Fig.1). Generally, the frequency range is 0.1~100Hz, and the maximum amplitude of a normal ECG signal is 1mV. It consists of PQRST waveforms (Rumpa et al., 2020). The first upward of the ECG tracing is the P wave. It indicates atrial contraction. The QRS complex begins with Q, a small downward deflection, followed by a larger upwards deflection, a peak (R), and then a downwards S wave. This QRS complex indicates ventricular depolarization and contraction. Finally, the T wave, which is normally a smaller upwards waveform, represents ventricular re-polarization.

Fig. 1 The ECG environment.

Arduino UNO board

Arduino UNO (Fig. 1) is an electronic device that interacts with connected devices with processing power, memory, and IO ports. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno board is the first in a series of USB Arduino boards and the reference model for the Arduino platform; for an extensive list of current, past, or outdated boards, see the Arduino index

of boards (Pranava Madan, 2019). The Arduino board can also be used to upload a new code to the Arduino board by using a USB cable to upload (Ismailov and Jo‘Rayev, 2022).

Fig. 1 Arduino UNO board.

This sensor is a cost-effective board used to measure the heart’s electrical activity. The AD8232 (Fig. 2), which is the base of the sensor board, is designed for ECG and other biopotential measurement applications (Rumpa et al., 2020). It is designed to extract, amplify, and filter small biopotential signals in noisy environments, such as those caused by motion or remote electrode implantation. The AD8232 module breaks out nine connections from the IC that you can solder pins, wires, or other connectors to. SDN, LO+, LO-, OUTPUT, 3.3V, and GND provide essential pins for operating this monitor with an Arduino or other development board. Also provided on this board are RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins to attach and use your own custom sensors. Additionally, an LED indicator light will pulsate to the rhythm of a heartbeat (Project, 2019).

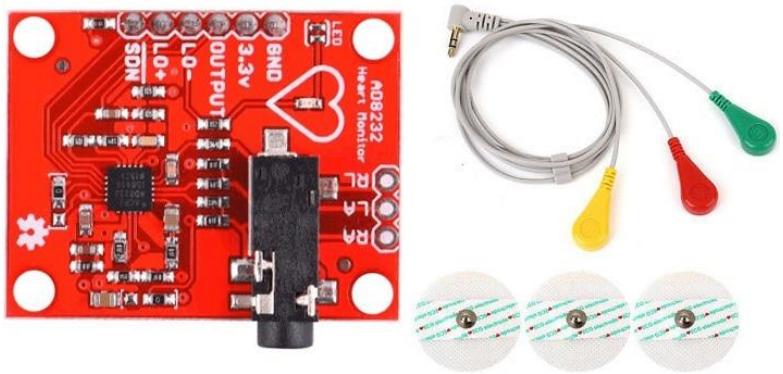

Fig. 2 The A8232 ECG sensor.

AD8232 ECG Sensor Placement on Body

Before applying to the body, it is recommended to snap the sensor patches onto the leads. The better the measurement, the closest the pads are to the heart. The cables are color-coded to facilitate appropriate placement identification. The colors red, yellow, and green are placed on the right arm, left arm, and right leg, respectively (Fig. 3) (Project, 2019).

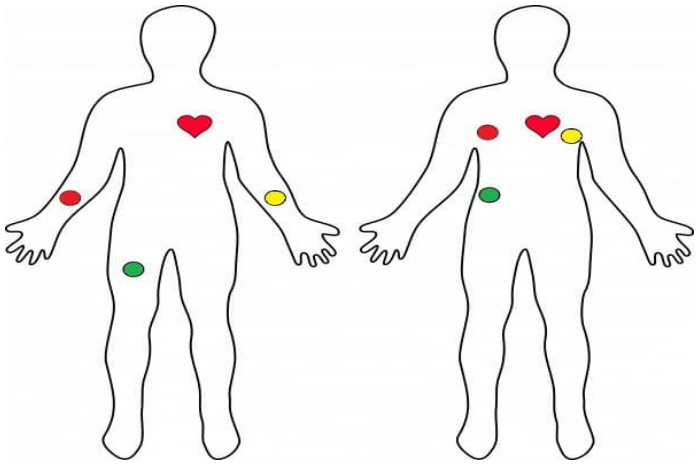

Fig. 3. Place the ECG leads on the body.

Arduino Integrated Development Environment (IDE)

IDE is open-source and allows users to write, upload, and compile the code to any Arduino board. Arduino IDE is written in Java and is compatible with Windows, macOS, and Linux operating systems. The IDE environment mainly contains two basic parts: editor and compiler. The former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module (Fezari and Al Dahoud, 2018).

2.2 Methods

The connection between Arduino and ECG Sensor AD8232

The Heart Rate Monitor AD8232 separates nine connections from the integrated circuit (IC). Traditionally, these connections were referred to as "pins" because they originated from the pins on the IC, but they are truly solderable holes or header pins. The ECG sensor AD8232 is used to monitor the heart's electrical activity. The ECG sensor consists of six pins (GND, 3.3 v, OUTPUT, LO-, LO+, and SDN), but five of them were connected. Therefore, it was connected to an Arduino

board, which was then connected to a computer. The GND, 3.3 v, OUTPUT, LO-, and LO+ were wired to GND, 3.3 v, A0, pin 11, pin 10, and not used, respectively (Fig. 4).

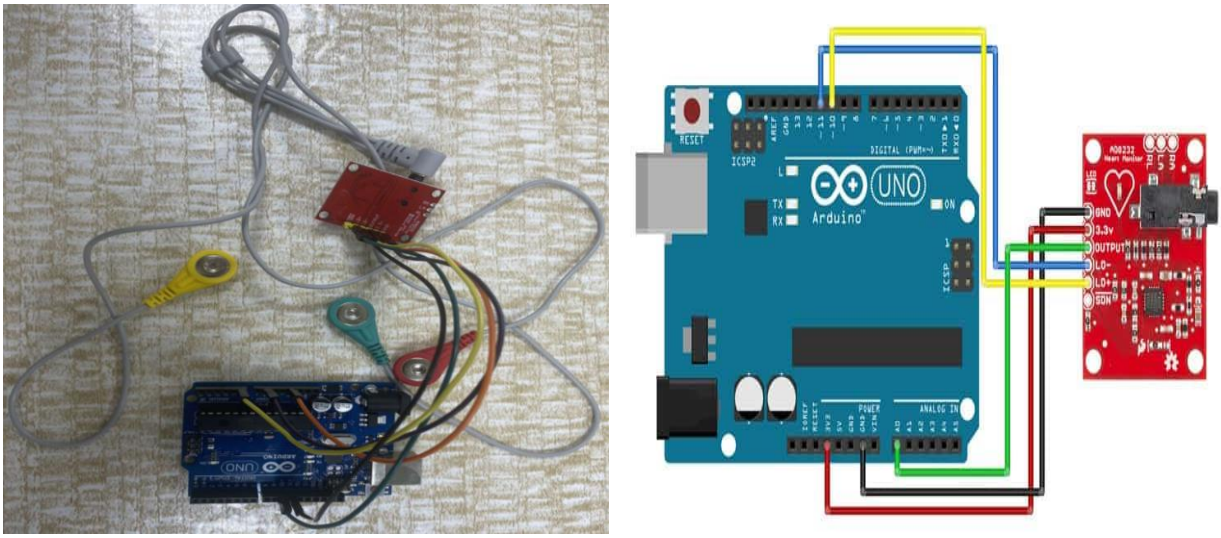

Fig. 4. Circuit connection consists of Arduino UNO and ECG sensor.

Codes are required to operate any Arduino circuits. Therefore, the code has been compiled and uploaded to the Arduino board. After connecting the circuit and running the code, the device was applied to the participants. Hence, the ECG and heart rate were recorded.

Chapter Three

Results and Discussion

Heart disease was becoming a big disease that health killer people for many years. Therefore, this disease cannot be taken lightly. Hence, most healthcare equipment and monitoring systems are designed to keep track of the disease. By analyzing or monitoring the ECG signal at an early stage, it is possible to prevent these diseases. Hence, this study proposed a portable, low-cost device for monitoring heart conditions using Arduino. This is possible with a programmed ECG sensor that is highly sensitive to monitor the heart (Fig. 5). Once the circuit is connected and the code is uploaded, the ECG diagram can be viewed on the serial plotter and serial monitor (Fig. 6). Heart rate can also be recorded.

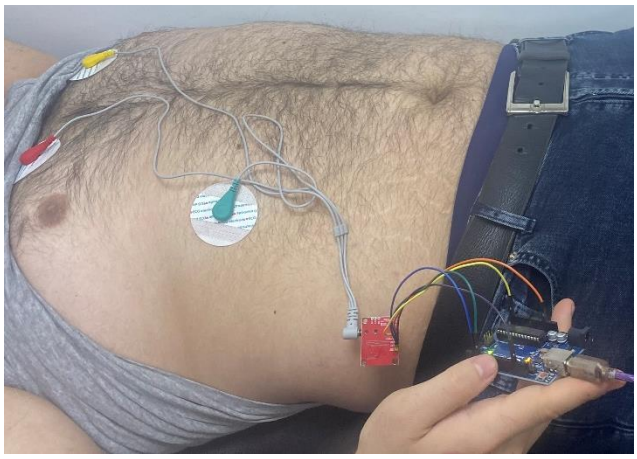

Fig. 5 Electrodes Placement.

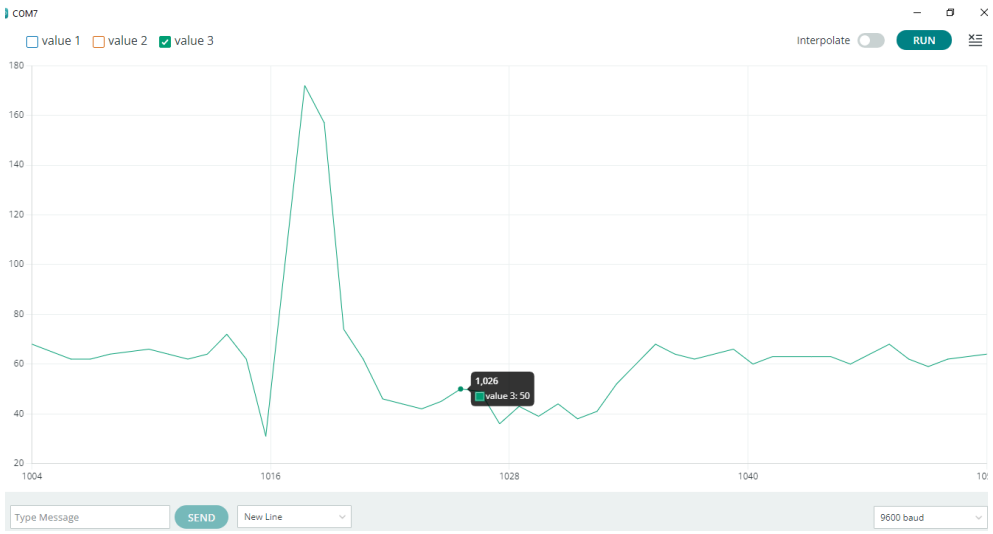

Fig. 6 ECG diagram from a participant.

Various studies were conducted to build a small device to get ECG in order to monitor the heart's electrical activity. Rumpa et al. designed ECG instruments that could measure or detect the human pulse, particularly its sensitivity to mood changes (Rumpa et al., 2020). Halil exhibited an experimental device that acquires an ECG signal using an AD8232 sensor board (Guvenc, 2020). Guedes et al. developed an ECG prototype that monitors the electrical activity signal of the heart based on the cardiac sensor AD8232 designed to extract, amplify, and filter the biopotential ECG signal with three electrodes, in which it is coupled essential to operate on Arduino with the goal of digitizing the analog signal by the microprocessor from the lines of codes configured in a script enabling its use via a USB connection (Pedro Miguel Lira Guedes et al., 2022).

Chapter Four

Conclusion and Future work

In this work, an ECG system was constructed using Arduino to monitor human heart diseases. The result indicated that the developed device could monitor the human body's heart conditions and help in advocating a better monitoring system. This is to reduce health risks. The project is based on an ECG sensor tested on the individual’s chest. In the future, more individuals will participate in experiments. Further devices can be designed with a simple and inexpensive technology that enables the development of scientific research in the area of cardiovascular health and cardiac monitoring in isolated communities that have difficulty in access to professional ECG.

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