IOT INTEGRATED ECG AND PULSE MONITORING SYSTEM WITH AUTOMATIC CPR AND DEFIBRILLATION

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In

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by

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CERTIFICATE

This is to certify that this project entitled **“IOT INTEGRATED ECG AND PULSE MONITORING SYSTEM WITH AUTOMATED CPR AND DEFIBRILLATION** " is the bonafied work carried out by **A. TANMAYI**, **K. RISHWANTH, B. SHRITHA and B. SHIPLA** as a Major project for the partial fulfillment to award the degree **BACHELOR OF TECHNOLOGY** in **ELECTRONICS & COMMUNICATION ENGINEERING** during the academic year 2023-2024 under our guidance and Supervision.

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ABSTRACT

In today’s High-tech world, smart devices became the inherit part of our human lives the field of healthcare is involved with huge number of electronic appliances and more sophisticated equipment’s are made for the benefit of humanity. The devices and equipment used in the field of healthcare to measure, monitor, diagnose, and treat various medical conditions. Human life is Precious, Cardiac arrest is a critical medical condition that requires immediate medical assistance to save the human life. So we came up with a Proposal which will aid the clinical staff in Hospitals, Incorporating this smart setup for monitoring and alerting the clinical staff and patient assistant to initiate life-saving procedures. Our proposed system monitors the patient's vital signs and triggers an automated CPR mechanism. It also includes an automatic external defibrillator (AED).with this we have more chances to save patient . Our work is developed to monitor vital signs and other indicators of cardiac arrest. Our developed module, equipped with various sensors, is attached to the chest of individuals suffering from cardiac arrest. This module continuously transmits data to the Blynk IoT app, which is managed by a doctor. If there is a deviation from normal values is detected, the doctor activates the app's on button. Our module operates in two modes: CPR and AED. During CPR, a centrally positioned Linear Actuator stabilizes the patient's condition. Subsequently, the AED mode delivers internal shocks to restore normal heart function. If the patient's condition improves, then the system can be deactivated using the end button. The CPR mechanism is performed by an actuator whose functions are controlled by L298N drive. While, defibrillation is performed through defibrillation pads by generating internal shocks whose intensity is controlled by 2-channel relay. Our proposed prototype system works efficiently.

This complete work is designed and developed by using IoT Technology which integrates advanced medical sensors based setup Arduino IDE and Blynk IoT Platform.

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LIST OF ACRONYMS

ACRONYM	ABBREVIATION
CPR	Cardio Pulmonary Resuscitation
IOT	Internet Of Things
AED	Automated External Defibrillators
ICD	Implantable Cardioverter Defibrillators

1. INTRODUCTION

1.1 OVERVIEW

Cardiac arrest is the abrupt loss of heart function in a person who may or may not have been diagnosed with heart disease. It can come on suddenly or in the wake of other symptoms. Cardiac arrest is often fatal if appropriate steps aren't taken immediately. Symptoms of sudden cardiac arrest are immediate and severe and include sudden collapse, no pulse, no breathing and loss of consciousness. Sometimes other symptoms occur before cardiac arrest. These might include chest discomfort, shortness of breath, weakness and fluttering.

The development of an advanced cardiac arrest detection system has revolutionized cardiac care by integrating cutting-edge technologies. This system provides real-time detection, swift initiation of cardiopulmonary resuscitation (CPR), and timely notifications for defibrillation, all working together to maximize patient survival. The system uses advanced algorithms and real- time monitoring to analyze electrocardiogram data for anomalies indicative of cardiac arrest, ensuring immediate response. Upon detection, the automatic CPR component is engaged, ensuring consistent and optimal blood circulation to vital organs. The system employs mechanical actuators and sensors to mimic the rhythm and force of effective chest compressions, eliminating variability in manual efforts. This proactive approach minimizes the time between detection and defibrillation, significantly increasing the chances of a successful outcome.

1.2 INTRODUCTION TO INTERNET OF THINGS

The Internet of things (IoT) describes physical objects (or groups of such objects) that are embedded with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks. Defining the Internet of things as "simply the point in time.

when more 'things or objects' were connected to the Internet than people". An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors, and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices for instance, to set them up, give them instructions or access the data.

The internet of things helps people live and work smarter, as well as gain complete control over their lives. In addition to offering smart devices to automate homes, IoT is essential to business. IoT provides businesses with a real-time look into how their systems really work, delivering insights into everything from the performance of machines to supply chain and logistics operations. IoT can also make use of artificial intelligence (AI) and machine learning to aid in making data-collecting processes easier and more dynamic. IoT enables companies to automate processes and reduce labor costs. It also cuts down on waste and improves service delivery, making it less expensive to manufacture and deliver goods, as well as offering transparency in customer transactions.

1.3 CHAPTER WISE SUMMARY

In Chapter 1 presents the introduction of the report, an overview of the project.

In Chapter 2 exhaustive literature survey is presented.

In Chapter 3 the overall solution is explained in detail.

In Chapter 4 the overall survey of Hardware/software tools description presented.

In Chapter 5 describes the project implementation details.

In Chapter 6 Results are disclosed.

Finally, In Chapter 7 Conclusion and Future Scope of the work are presented.

2. LITERATURE SURVEY

2.1 EXISTING METHODS

We have taken some of the research papers and performed the literature review. Below points refers to each paper that what is the content present in those referred papers.

The authors in this paper says that in the recent times, there has been a rise in instances of cardiac arrest occurring while individuals are driving. They mainly focused about the development of an innovative system that aims at combating and safe guarding against heart diseases and attacks. The system should be used when one engages the motorbike. The system functions by monitoring the user's heart rate through a specialized sensor, and in the event of a cardiac arrest, it promptly notifies the user's family and designated emergency contacts.[1]

The authors in this paper outlines a technique for detecting sudden cardiac arrestutilizing the Pan- Tompkins Algorithm. The algorithm's application involves identifying the number of R-peaks in the electrocardiogram (ECG) readings of both sudden cardiac arrest (SCA) patients and individuals without cardiac issues. A comparative analysis is conducted, contrasting the effectiveness of this method against alternative approaches. The evaluation of the algorithm is performed using the MIT-BIH database as a benchmark.[2]

The authors speak about the global prevalence of sudden cardiac death (SCD) and arrhythmia constitutes a significant public health challenge, contributing to 15-20% of total fatalities. Although prompt resuscitation and defibrillation are critical for survival, their widespread adoption and the availability of public defibrillators are currently inadequate. This deficiency leads to suboptimal survival rates for patients upon hospital discharge. Innovative solutions utilizing smart technology present a potential remedy for this issue.[3]

The authors in this paper introduces a feature learning approach for the identification of sudden cardiac arrest (SCA) in electrocardiogram signals, employing a modified variational mode decomposition technique. The ensuing signal analysis and assessment (SAA) incorporate a feature extraction module consisting of a Convolutional Neural Network (CNNE) and a Support Vector machine classifier.[4]

The authors says that this study aims to assess the impact on survival in patients experiencing bystander-witnessed out-of-hospital cardiac arrest of cardiac origin, focusing on the duration between the estimated time of collapse and the call for an ambulance. The survey included 9340 patients with attempted cardiopulmonary resuscitation (CPR). The findingsrevealed a one-month survival rate of 6.9% for patients with a delay in calling for an ambulance of four minutes or less (median) compared to2.8% for patients with a median delay exceeding four minutes (P<0.0001).[5]

The authors says that this study scrutinized records of 1,297 individuals who experienced witnessed out-of-hospital cardiac arrest due to heart disease and received treatment from both emergency medical technicians (EMTs) and paramedics. The investigation aimed to determine whether the initiation of early cardiopulmonary resuscitation (CPR) by bystanders independently contributed to improved survival. Notably, the advantageous impact of early CPR appears confined to a specific timeframe. It needs to be initiated within 4-6 minutes from the time of collapse and must be complemented by advanced life support within 10-12 minutes of the collapse to achieve effectiveness.[6]

The authors speak about the study that was to construct a graphical model depictingthe relationship between survival rates in cases of sudden out-of-hospital cardiac arrest and the time intervals associated with critical prehospital interventions. For each patient, we collected data on the time intervals from collapse to cardiopulmonary resuscitation (CPR), the first defibrillatory shock, and the initiation of advanced cardiac life support (ACLS). This model proves valuable for strategic planning of community Emergency Medical Services (EMS) programs, facilitating comparisons between different EMS systems, and illustrating the impact of varying arrival times on overall survival rates within a given system.[7]

The aim of this study was to create a straightforward and widely applicable predictive model for predicting survival following out-of-hospital cardiac arrest attributed to ventricular fibrillation. All incidents were witnessed and occurred prior to the arrival of emergency responders, with the initial observed cardiac rhythm being ventricular fibrillation. The primary outcome assessed was survival until hospital discharge. Significant factors linked to survival included patient age, initiation of bystander CPR, time interval from collapse to CPR, time interval from collapse to defibrillation.[8]

In this paper they analyzed the temporal symptomatic patterns of 171 patients who experienced cardiac arrest in Intensive Care Units. To capture the temporal and feature dependencies in the data, they employed a mixture of matrix normal distributions. Their findings highlight that the most informative temporal signature for cardiac arrest is contained within the six-hour window preceding the events.[9]

In this paper they discussed that a set of sixteen conventional heart rate variability (HRV) parameters and eight vital signs have demonstrated potential in forecasting cardiac arrest within a 72- hour window. In addition to these 24 parameters, we suggest incorporating two novel features for enhanced cardiac arrest prediction: approximate entropy (ApEn) and sample entropy (SpEn). ApEn and SpEn, both nonlinear HRV parameters derived from electrocardiography recordings, offer unique insights into heart conditions.[10]

In this paper they discussed about Agonal breathing, an audible sign of severe hypoxia, often goes unnoticed. This study introduces a support vector machine (SVM) thatcan classify agonal breathing in real-time within bedroom settings. Trained on actual 9-1-1 audio data, the SVM achieves impressive accuracy. Notably, the false positive rates during sleep lab and home sleep environments are minimal, emphasizing the potential of this contactless system.[11]

In this paper they said that their emphasis is on the administration of medication to patients experiencing cardiac arrest, necessitating the performance of Cardiopulmonary Resuscitation (CPR). They aim to investigate the impact of medications on predicting thedeterioration of the patient's health condition.[12]

Utilizing an algorithm solely reliant on the impedance cardiogram (ICG) obtained through two defibrillation pads, the system employs the most robust frequency component and its amplitude. This integration into a defibrillator facilitates the prompt identification of circulatory arrest, potentially minimizing delays in initiating cardiopulmonary resuscitation (CPR).[13]

This study examines the feasibility of utilizing photoplethysmography (PPG) to detecta natural pulse in the finger, nose, or ear, with the aim of improving pulse assessments during cardiopulmonary resuscitation (CPR).[14]

In this paper they have said that the primary objective of this investigation was to determine the effectiveness of a smartwatch's photoplethysmography (PPG) sensor in accurately identifying the return of spontaneous circulation (ROSC) during cardiac arrest situations. The study sought to compare the smartwatch's performance with traditional carotid artery palpation as a reference, providing valuable insights into the potential of wearable technology for real-time monitoring in emergency medical scenarios.[15]

This paper details the development of a cross-platform software application designedto assist ambulance paramedics during Cardio-Pulmonary Resuscitation (CPR). The application is engineered to operate seamlessly on both iOS and Android devices, acknowledging their predominant positions in the mobile industry.[16]

Termed as a cardiac arrest, a heart attack comprises a range of heart-related disorders and has emerged as the predominant cause of global mortality in recent decades. Numerous risk factors are associated with heart ailments, underscoring the urgent requirement for precise, efficient, and feasible approaches for early diagnosis and treatment of the disease.[17]

The authors says that the Cardiac arrest (CA) involves the halt of circulation to vital organs, necessitating swift and appropriate interventions for potential reversal. Exploring sensor technologies for early detection and activation of the emergency medical system holds the promise of facilitating prompt responses to CA, thereby enhancing the likelihood of survival. This systematic review aims to consolidate existing literature on the efficacy of sensor technologies in detecting out-of-hospital cardiac arrest (OHCA).[18]

2.2 PROBLEM STATEMENT

When the heart's electrical system malfunctions, it can lead to irregular heartbeats, causing the heart to stop pumping blood effectively. This resultsin a sudden loss of heart function, breathing, and consciousness, posing a grave risk to the individual's life. Timely treatment is paramount in cases of cardiac arrest, as every minute counts. Research suggests that if medical assistance is provided within the first 8 minutes of experiencing cardiac arrest, the likelihood of survival significantly increases. This highlightsthe importance of prompt recognition of symptoms, quick activation of emergency medical services, and initiation of cardiopulmonary resuscitation (CPR) to maintain blood flow and oxygenation to vital organs until further medical intervention can be provided. In India, the burden of sudden cardiac death is substantial, with more than 7 lakh cases reported annually. This staggering figure underscores the urgent need for increased awareness, education, and access to emergency medical services across the country. Measures such as widespread CPR training, public access to automated external defibrillators (AEDs), and community-based initiatives to promote heart health and early detection of cardiac conditions can play a crucial role in reducing the incidence of sudden cardiac death and improving outcomes for affected individual.

3. PROPOSED METHODOLOGY

3.1 PRESENT WORK

The advanced cardiac arrest detection system with CPR and defibrillation solves the problem of cardiac arrest by providing early detection and treatment. This can help to save lives and improve the quality of life for survivors. Once cardiac arrest is detected, the system can be handled by the trained personnel nearby, such as paramedics or lifeguards. The proposal is to develop a device to monitor vital signs and other indicators of cardiac arrest. The system would also provide instructions on how to perform CPR and defibrillation for no voice users.

This concept redefines cardiac arrest detection system by considering the smart system training profile to attempt cardiac failures. It represents a promising innovation in cardiac arrest detection to improve treatment assistive outcomes and reduce complications associated with cardiac arrest and its recovery.

What sets this system apart is its inclusion of smart system training profiles, which enable it to adapt to various scenarios and individual needs. By providing instructions on CPR and defibrillation that are accessible to non-voice users, the system ensures that assistance can be effectively rendered regardless of communication barriers.

Overall, this innovative approach represents a paradigm shift in cardiac arrest detection and treatment. By leveraging technology and smart training profiles, it not only improves outcomes but also reduces complications associated with cardiac arrest and the recovery process.

BLOCK DIAGRAM:

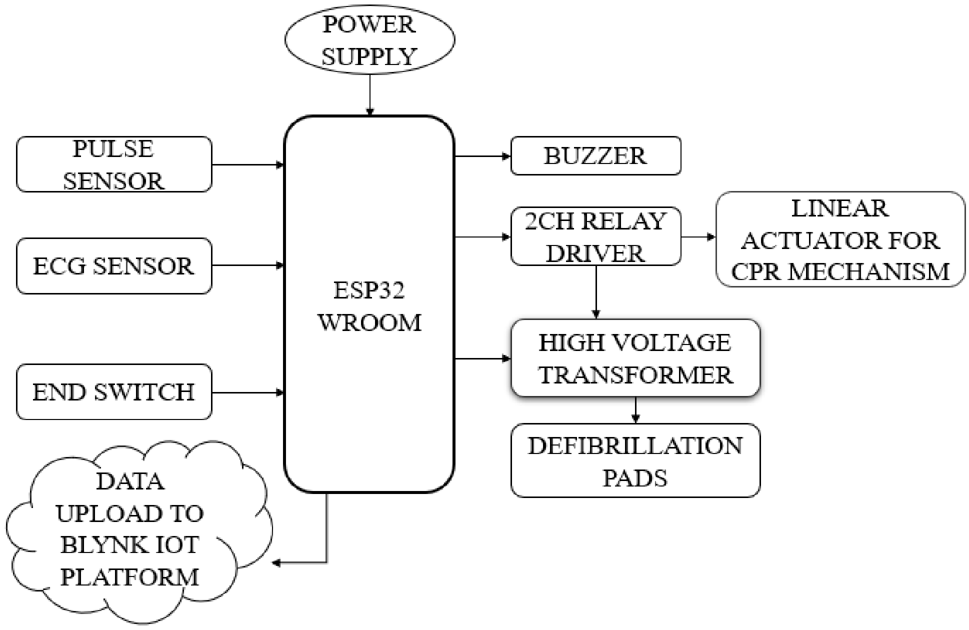


Fig.3.1: Block Diagram of the Present Work

1. ESP-32 is the heart of the module all of the sensors are connected to ESP-32.
2. Pulse sensor and ECG sensor are used for the detection of heart rate values and their output is given to ESP-32.
3. The output from the sensors is sent to Blynk IoT platform.
4. There is a buzzer connected to ESP-32 that gives the indication between 2 methods.
5. The L298N motor driver is a high-power motor driver for driving DC, which can operate the 100mm linear actuator upwards and downwards, where it can be used like CPR mechanism.
6. The 2-channel relay acts as a switch, where it can be connected via ESP-32 to high voltage transformer, the shocks can be gained from this to internally to defibrillation pads.
7. These shock pads are attached to patient's body.

3.2 OBJECTIVES

The motive behind this work is to

1. Study the various methods available for preventing Cardiac Arrest System.
2. To study the ways available for Cardiac Arrest.
3. Save the life of pupil who get affected by cardiac arrest.
4. Advance knowledge in Cardiac Arrest and implement further new systems.
5. Understand new technologies and implement/develop such modules to prevent Cardio vascular problems.
6. Make products with available facilities in our own country- A motive towards “make in India”

3.3 METHODOLOGY

The procedure in developing the system and the method the system works is given by the following steps:

The developed module is initialized with normal parameters governing the heart problems. First checks the heart rate and heart functioning by ECG and pulse sensors.

1. This module with various sensors is fixed on the chest of the person who is diseased with blood pressure and or cardio vascular disease.
2. The data of this sensors are uploaded to Blynk IoT app time to time. This app is operated by doctor.
3. Any deviations from the normal values doctor presses the on button in the app.
4. The functioning is divided into 2 mechanisms – CPR mechanism and AED mechanism.
5. In CPR mechanism, the Linear Actuator which is placed in middle of the chest position, will start functioning to stabilize the patient for normal value.
6. After CPR mechanism, the module initiates the AED. In AED mechanism, internalshocks will be given to the person to normalize the heart condition.
7. We can also turn off the system if the person comes to normal condition with the endbutton.

4. HARDWARE/SOFTWARE TOOLS

4.1 HARDWARE DESCRIPTION

The hardware components used in this system are Buzzer, ESP-32, Mannequin, 2 Channel Relay, Defibrillation pads, Shock pad transformer, Pulse sensor, ECG Sensor, 100mm Linear Actuator, End switch.

4.1.1 ESP-32 WROOM

ESP32 is a series of low-cost, low-power system on a chip micro controller with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, Xtensa LX7 dual-core microprocessor or a single-core RISC V microprocessor and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Espress if Systems, a Chinese company based in Shanghai, and is manufactured by TSMC using their 40 nm process.[2] It isa successor to the ESP8266 microcontroller.

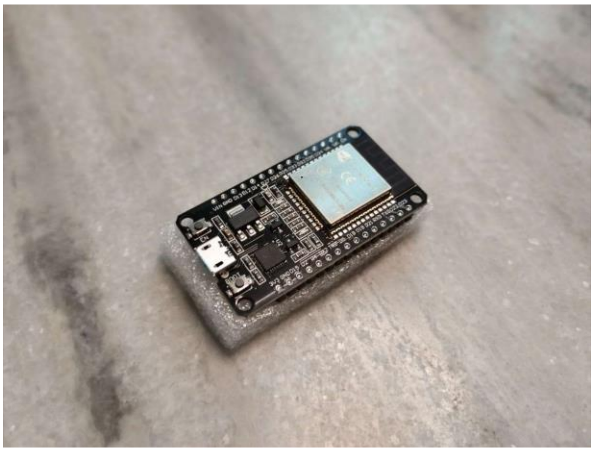


Fig. 4.1: ESP-32

The ESP32 is a popular microcontroller developed by Espressif Systems. It's widely used in IoT projects for its versatility, low power consumption, and built-in Wi-Fi and Bluetooth capabilities. Developers often use it for tasks like sensing, controlling, and communicating with other devices. Its dual-core architecture and ample memory make it suitable for a wide range of applications.

Features:

One of the standout features of the ESP32 is its built-in connectivity options. Withboth Wi-Fi and Bluetooth capabilities integrated directly into the chip, the ESP32 can easily connect to a variety of networks and devices. This makes it ideal for projects requiring wireless communication, such as home automation, remote monitoring, and industrial control systems. In addition to its connectivity features, the ESP32 also includes a rich set of peripherals and interfaces. These include SPI, I2C, UART, ADC, DAC, and GPIO pins, providing flexibility for interfacing with a wide range of sensors, actuators, and other external devices. This versatility makes it well-suited for applications ranging from sensor nodes to motor control systems.

Another key aspect of the ESP32 is its ample memory and storage capabilities. Withup to 520 KB of SRAM and 4 MB of flash memory, developers have plenty of resources to work with when designing and implementing their projects. This allows for the storage oflarge amounts of data and the execution of complex algorithms, without sacrificing performance or efficiency. Furthermore, the ESP32 is supported by a robust ecosystem of development tools and software libraries. Espressif provides an official development framework called ESP-IDF (Espressif IoT Development Framework), which includes everything developers need to get started with ESP32 development, including a comprehensive set of documentation, examples, and debugging tools. Additionally, the ESP32 is compatible with the Arduino IDE, making it accessible to a wide audience of developers familiar with the Arduino platform. Overall, the ESP32 offers a compelling combination of performance, connectivity, and versatility, making it an excellent choice for a wide range of IoT and embedded projects. Its powerful features, coupled with its ease of use and extensive support, have cemented its position as one of the most popular microcontrollers in the maker and developer communities.

4.1.2 TWO CHANNEL RELAY

The 2 Channels Relay Module is a convenient board which can be used to control high voltage, high current load such as motor, solenoid valves, lamps and AC load. It is designed to interface with microcontroller such as Arduino, PIC and etc. The relays terminal (COM, NO and NC) is being brough out with screw terminal. It also comes with a LED to indicate the status of relay.

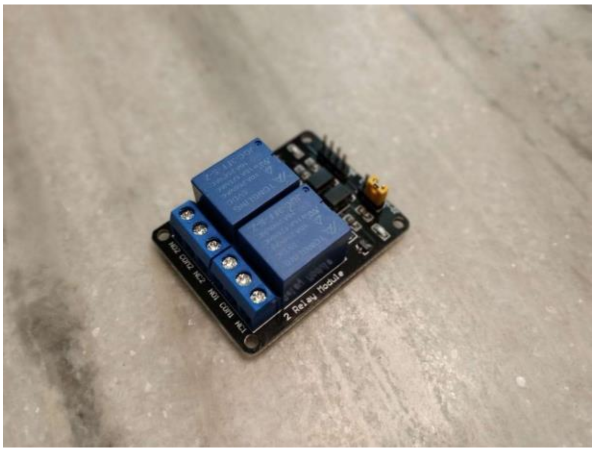


Fig.4.2 :2 channel Relay

Features:

One notable feature of a 2-channel relay is its ability to be controlled remotely, typically through a microcontroller, a digital signal, or even a smartphone app. This remote-control capability enables users to operate electrical devices from a distance, adding convenience and automation to their projects. Additionally, 2-channel relays often come with isolation between the control signal and the output circuits. This isolation helps protect sensitive control circuitry from potential damage caused by voltage spikes or electrical interference, ensuring reliable operation and longevity. Overall, the features of a 2-channel relay make it a valuable component in electronics, automation, and control systems, providing users with the ability to efficiently manage multiple circuits or devices with ease and reliability.

4.1.3 BUZZER

An audio signaling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical type. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren.

Fig.4.3: Buzzer

The pin configuration of the buzzer is shown below. It includes two pins namely positive and negative. The positive terminal of this is represented with the '+' symbol or alonger terminal. This terminal is powered through 6Volts whereas the negative terminal is represented with the '-'symbol or short terminal and it is connected to the GND terminal. Features: One prominent feature of buzzers is their ease of use and installation. Typically, they require only two connections to a power source to produce sound, making them straightforward to integrate into electronic circuits or systems. This simplicity makes buzzers accessible even to beginners in electronics or DIY projects. Furthermore, buzzers often have adjustable sound output levels or frequencies, allowing users to customize the alert tone or volume according to their preferences or the requirements of the application. This flexibility enables buzzers to adapt to different environments or scenarios where specific auditory cues are needed. Overall, the features of buzzers make them indispensable components in electronics, security systems, alarm systems, appliances, and various other devices where audible alerts or notifications are required. Their simplicity, versatility, and reliability make them valuable tools for enhancing user experience and safety.

4.1.4 MANNEQUIN

A mannequin (sometimes spelled as manikin and also called a dummy, lay figure, or dress form) is a doll, often articulated, used by artists, tailors, dressmakers, window dressersand others, especially to display or fit clothing and show off different fabrics and textiles. Previously, the English term referred to human models and muses (a meaning which it still retains in French and other European languages); the meaning as a dummy dating from the start of World War II.

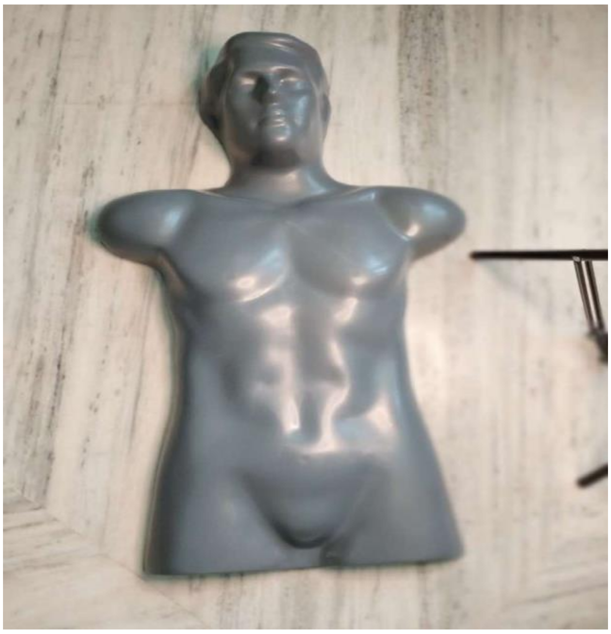


Fig.4.4: Mannequin

Life-sized mannequins with simulated airways are used in the teaching of first aid, CPR, and advanced airway management skills such as tracheal intubation. During the 1950s, mannequins were used in nuclear tests to help show the effects of nuclear weapons on humans. Also referred to as mannequins are the human figures used in computer simulation to model the behavior of the human body. Mannequin comes from the French word mannequin, which had acquired the meaning “an artist’s jointed model”, which in turn came from the Flemish word mannikin, meaning “little man, figurine”, referring to late Middle Ages practicein Flanders whereby public display of even women’s clothes was performed by male page.

4.1.5 DEFIBRILLATION PADS

Defibrillator AED pads are an essential part of an automated external defibrillator to treat a sudden cardiac arrest emergency. These electrode pads are placed on the bare chest of a victim of Sudden Cardiac Arrest (SCA). Once the defibrillator pads are placed at the specified location, an automated external defibrillator will monitor the heart rhythm of the patient and diagnose whether a defibrillator shock is required or not. Defibrillator pads are essential to create a connection between the SCA victim’s body and the AED.

Fig.4.5: Defibrillation pads

AEDs are used to treat the victim of Sudden Cardiac Arrest (SCA) which is a leading cause of death in the US and throughout the world. Sudden cardiac arrest is the result of irregular heart rhythms (arrhythmias) that can cause the heart to suddenly stop beating. According to the American Heart Association, every year roughly 326,000 people in the US suffer from sudden cardiac arrest and almost 90% of them die. SCA is most often caused by coronary artery disease.

4.1.6 PULSE HEART RATE SENSOR

A pulse heartbeat sensor in electronics, often referred to as a heart rate sensor or pulse sensor, is a device designed to measure a person's heart rate or pulse rate. It typically worksby detecting the subtle changes in blood flow through blood vessels, usually near the surface of the skin, caused by the beating of the heart. These sensors are commonly used in various applications, including fitness trackers, wearable devices, medical monitoring equipment, and even some DIY electronics projects.

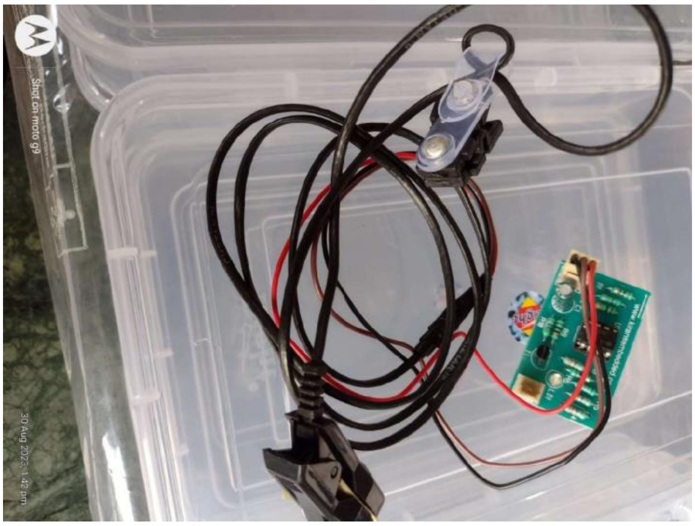


Fig.4.6: Pulse Sensor

A pulse heartbeat sensor in electronics, often referred to as a heart rate sensor or pulse sensor, is a device designed to measure a person’s heart rate or pulse rate. It typically worksby detecting the subtle changes in blood flow through blood vessels, usually near the surface of the skin, caused by the beating of the heart. These sensors are commonly used in various applications, including fitness trackers, wearable devices, medical monitoring equipment, and even some DIY electronics projects.

4.1.7 ECG SENSOR

An ECG (Electrocardiogram) sensor in electronics is a device or component used to measure and record the electrical activity of the heart. It's a crucial tool in medical and healthcare applications for monitoring and diagnosing cardiac conditions. Here are some key points about ECG sensors:

Fig.4.7: ECG Sensor

1. Principle of Operation: ECG sensors work on the principle of detecting the electrical signals generated by the heart during each heartbeat. These signals are known as ECG or EKG signals and represent the depolarization and repolarization of heart muscle cells.
2. Electrodes: ECG sensors typically use electrodes, which are attached to specific points on the body (usually the chest, arms, and legs). These electrodes pick up the electrical signals generated by the heart.
3. Lead Configurations: ECG sensors use different lead configurations to capture the electrical activity from various angles. Common lead configurations include the standard 12-lead ECG, which provides a comprehensive view of the heart's electrical activity.
4. Amplification and Signal Processing: The signals captured by the electrodes are very lowin amplitude. ECG sensors include amplification and signal processing components to enhance the quality of the signal and filter out noise

4.1.8 100MM LINEAR ACTUATOR

A 100mm linear actuator is a type of electromechanical device used in electronics and various other applications to provide linear motion or positioning. It's designed to extend or retract along a straight line, typically with a travel distance of 100mm (approximately 3.94 inches). Here are some key points about a 100mm linear actuator:

Fig.4.8:100MM Linear Actuator

1. Linear Motion: Linear actuators are used to convert rotational motion into linear motion. They are often used to move or position objects in a straight line.
2. Construction: A linear actuator typically consists of a housing, a motor (often electric), a screw or rod, and sometimes additional components like gears and encoders. The motor drives the mechanism to extend or retract the actuator.
3. Applications: Linear actuators are used in various electronics and automation applications, including robotics, 3D printers, CNC machines, adjustable furniture (e.g., electric sit-stand desks), home automation, and more. They are also employed in industrial settings for taskslike valve control and conveyor belt adjustments.
4. Speed: The speed of a linear actuator can vary, with some models designed for slower and more precise movements and others for faster positioning.

4.1.9 END SWITCH

An end switch in electronics, also known as an end stop switch or limit switch, is a device used to detect the physical limits of movement in various mechanical systems or machines. It's commonly used in applications where it's important to know when a moving component, such as a motorized actuator.

Fig.4.9: End switch

1. Function: End switches are designed to stop or trigger an action when a mechanical component reaches its predefined end position. They provide feedback to a controller or system, indicating that a limit has been reached.
2. Types: End switches come in different types, including lever switches, push-button switches, and proximity switches. The choice of switch type depends on the specific application and the nature of the mechanical movement.
3. Activation: When the moving part comes into contact with the end switch, it triggers an electrical signal. This signal can be used to stop or reverse the motion, trigger an alarm, or perform other actions depending on the application.
4. Applications: End switches are used in a wide range of applications, such as CNC machines, 3D printers, conveyor systems, garage door openers, and industrial machinery. In robotics, they are used to define the boundaries of a robot's movement.

4.2 SOFTWARE DESCRIPTION

Software used in this project for uploading code onto Arduino is Arduino IDE, ISP tool and Blynk IOT app.

4.2.1 ARDUINO IDE

Arduino IDE is an open-source software platform used for programming and developing various micro-controller-based projects. The Arduino IDE is designed to simplify the process of programming micro-controllers such as the popular Arduino boards. It allows users to write code, compile and upload it onto the board without needing to have a deep understanding of the underlying hardware or programming languages.

The Arduino IDE is built on a simplified version of C++ programming language. which makes it easy to learn for beginners. It includes a code editor, compiler, and uploader.and supports many common programming features, such as functions, variables, and conditional statements. It also provides a vast library of pre-written code, known as sketches, which can be used to get started with a project quickly.

Fig.4.10: Arduino IDE

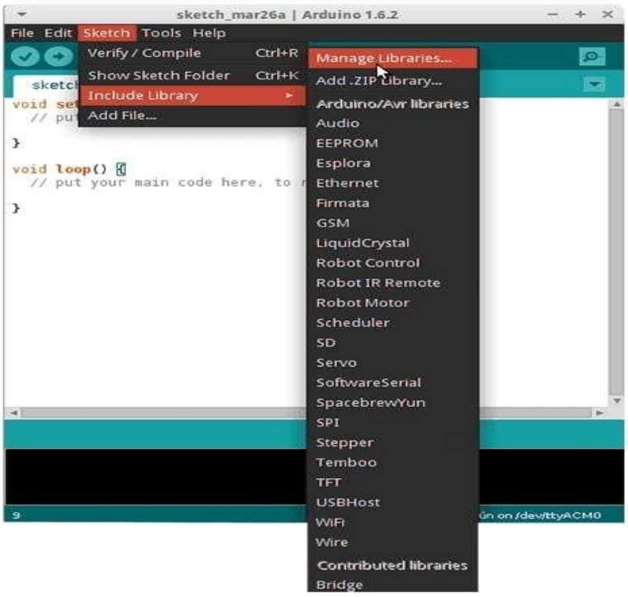
One of the unique features of the Arduino IDE is its ability to work with a wide range of hardware platforms, including various Arduino boards, as well as other micro-controllers such as ESP8266 and ESP32. This means that users can develop and test their projects on different hardware before choosing the one that best suits their needs. In summary, the Arduino IDE is a user-friendly software platform that makes it easy for beginners and professionals alike to develop microcontroller-based projects.

Programs written using Arduino Software (IDE) are called sketches. These sketchesare written in the text editor and are saved with the file extension ion. The editor has features for cutting/pasting and searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board. and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and openthe serial monitor.

Installing Libraries

Libraries are a collection of code that makes it easy to connect to a sensor, display, module, etc. For example, the Liquid Crystal library makes it easy to talk to character LCD displays. There are thousands of libraries available for download directly through the Arduino IDE, and you can find all of them listed in the Reference. To install a new library into your Arduino IDE you can use the Library Manager (available from IDE version 1.6.2).

Fig.4.11: Library Manager



The Library Manager will open and we will find a list of libraries that are already installed or ready for installation. In this example, we will install the Bridge library. Scroll the list to find it, click on it, then select the version of the library you want to install. Sometimes only one version of the library is available. If the version selection menu does not appear,don't worry: it is normal. Finally, click on install and wait for the IDE to install the new library. Downloading may take time depending on your connection speed. Once it has finished, an Installed tag should appear next to the Bridge library. We can close the library manager.

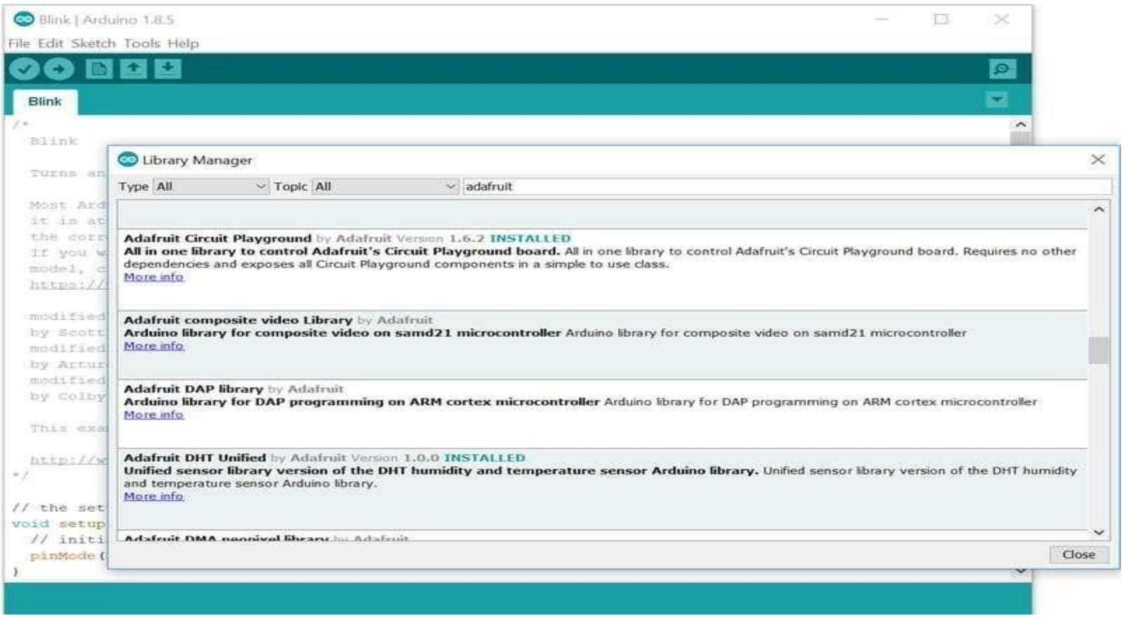


Fig.4.12: Library installation

Toolbar section

The toolbar is the most important section in the Arduino software because it contains the toolsthat you will use continuously while programming the Arduino board. These tools are:

1. Verify: this button uses to review the code, or make sure that is free from mistakes.

2. Upload: this button is used to upload the code on the Arduino board.

Fig.4.13: Tool Bar

3. New: this button uses to create a new project, or sketch (sketch is the file of the code).
4. Open: is used when you want to open the sketch from the sketchbook.
5. Save: save the current sketch in the sketchbook.
6. Serial monitor: showing the data which have been sent from Arduino.

How to use Arduino software

After installation of electronic components by using input/output pins on an Arduino board Connect software. the Arduino board to the computer with the USB cable, then openthe Arduino First in the menu, click on "Tools", then click on "Board" and select the Arduino board. Second: in the menu click on "Tools" again, click on "Port" and select the Serial port that connected the Arduino board.

Third: in "Code editor" write the programming code, then click on "Verify" to verify its correctness. Fourth: click on "Upload" to upload the code on the Arduino board.

5. PROJECT IMPLEMENTATION

5.1 PROJECT DESCRIPTION:

The advanced cardiac arrest detection system with automatic CPR and defibrillation notification alerts and solves the problem of cardiac arrest by providing early detection and treatment. This can help to save lives and improve the quality of life for survivors.

The proposal is to develop a device to monitor vital signs and other indicators of cardiac arrest. Once cardiac arrest is detected, the system can be handled by the trained personnel nearby, such as paramedics or lifeguards. The system would also provide instructions on howto perform CPR and defibrillation for no voice users.

Detailed Workflow

• A patient is wearing a wearable device to monitor their vital signs.

• The device detects a sudden change in the patient’s vital signs that is indicative of cardiacarrest.

• The device sends these signals data to trained smart models.

• The trained personnel will press the ON switch in the Blynk IoT app and arrive at the sceneto assess the patient’s condition.

• If the patient is in cardiac arrest, the intelligent algorithm performs CPR and defibrillation.

• The wearable device provides the smart model with feedback on their CPR and defibrillationtechnique.

The trained personnel will be informed about the patient’s condition through IoT app. This concept redefines cardiac arrest detection system by considering the smart system training profile to attempt cardiac failures. It represents a promising innovation in cardiac arrest detection to improve treatment assistive outcomes and reduce complications associated with cardiac arrest and its recovery.

5.2 INITIALIZATION AND WORKING:

Implementation of IoT integrated ECG and Pulse monitoring system with automated CPR and Defibrillation, the various devices are connected to check the functionality of the various devices are ECG sensors are applied to the chest positions which can detect the heart rates from high blood pressure to low blood pressure ,automatic external defibrillators pads (AED) are attached to the chest in diagonal which is convenient to the hear, while giving the shock absorbs from high voltage to low voltage, pulse sensor required to connect to the left hand index finger to check the pulse rate, the100mm linear actuator performs like a CPR mechanism where the patient heart rate &pulse rate downs, these system starts the pumping mechanism to awake the heartbeat ,here we are implementing the two type of modes to working of system where it can be controlled through Blynk IoT app.

Fig.5.1: All system performances notifications alerts send to the IOT Blynk application to verifythe system configurations.

The operation of IoT integrated ECG and Pulse monitoring system with automated CPR and Defibrillation, there are five modes of operations are occurred, in first mode the control system of ECG sensors detects the low and high heart beat rates efficiently. In second mode of operation pulse sensor detect the blood pressure through left index finger. In third mode of operation the trained person will ON the system if they detect any deviation from normal values. In fourth mode of operation actuator performance like a CPR mechanism with the help of first &second mode of operation value rates it can be perform, if the CPR mechanism not works initially suitable, then the fifth mode of operation automatic external defibrillators pads (AED) gives the shock absorbs diagonally to awake the heart rate, with this all of five modes can balance the perform an operates the system.

5.2.1 WORKING:

1. If the system is in ON condition.
2. There will be 2 mechanisms involved in it.
3. Firstly, the Linear Actuator is placed in the middle of the chest position, which can make the action of CPR mechanism.
4. And the next mechanism is Automatic External Defibrillation pads (AED) leads a key roleof this system, like pumping mechanism with suitable relevant high/low voltages.

Fig.5.2: Implementation of IOT based advanced cardiac arrest detection system with automaticCPR & defibrillation, notification to save patients life.

Working mechanism:

Our project works by the following steps

STEP-01:- ECG/pulse sensor detection the heart rate values from high to low

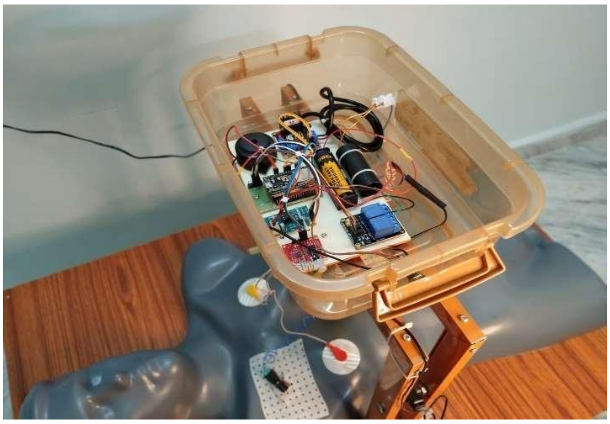


Fig.5.3 Detection

An ECG (Electrocardiogram) or pulse sensor is designed to detect and measure the heart rateby recording the electrical activity of the heart. This activity produces a waveform that can be analyzed to determine the heart rate.

Typically, heart rate values are not detected as "from high to low" by the sensor itself. Instead, the sensor provides a continuous stream of data that represents the electrical activity of theheart. To determine the heart rate, you would need to process and analyze this data.

Here's a general idea of how you can extract heart rate values from ECG or pulse sensor data:

1. Signal Acquisition: The ECG or pulse sensor records electrical signals from the heart, andthe data is collected over time.

2. Preprocessing: The collected data may undergo preprocessing to filter out noise, baselinedrift, and other artifacts.

3. Peak Detection: Heart rate is typically determined by detecting the R-peaks in the ECG waveform. These are the highest points of the QRS complex, which represents the electrical depolarization of the ventricles. In the case of a pulse sensor, you would typically detect the peak of each pulse.

4. Calculate RR Intervals: RR intervals represent the time between successive R-peaks (in ECG) or pulse peaks (in pulse sensor data). By measuring these intervals, you can determine the heart rate. The formula to calculate heart rate is often expressed as Heart Rate (in beats per minute) = 60 / Average RR Interval.

5. Heart Rate Display: Once you have calculated the RR intervals and the heart rate, you can display or log the heart rate value.

The heart rate can vary naturally and respond to factors like exercise, stress, or changes in body position. It may increase (from low to high) or decrease (from high to low) based onthese factors.

The sensor itself does not determine whether the heart rate is increasing or decreasing; it provides data that can be used to calculate the current heart rate.

To continuously monitor heart rate changes, you would need to continuously acquire and process the sensor data, updating the heart rate value as needed. Many wearable fitness devices and medical monitoring systems use this approach to provide real-time heart rate information to users.

STEP-02:- Actuator performing the CPR mechanism

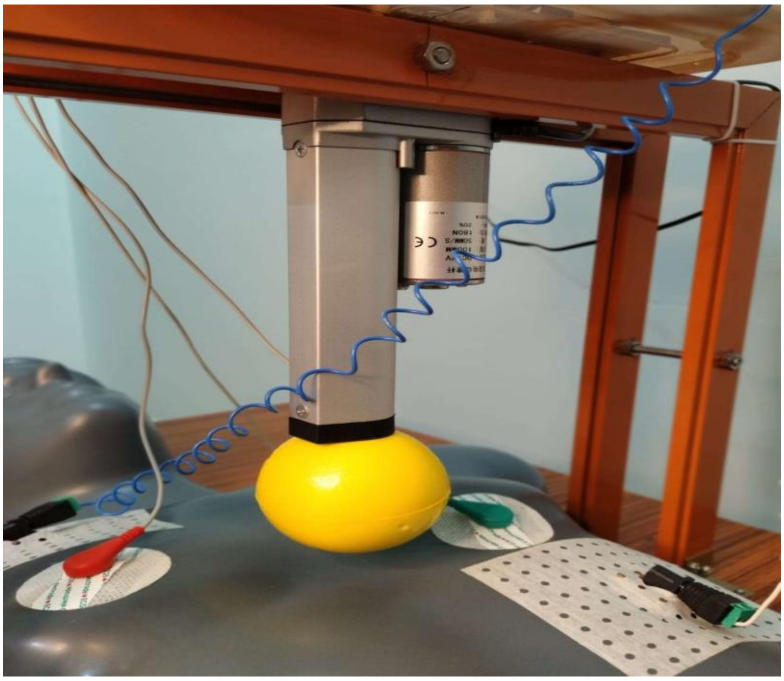


Fig.5.4 CPR Mechanism

Performing CPR (Cardiopulmonary Resuscitation) is a life-saving medical procedure that involves chest compressions and rescue breaths to help someone in cardiac arrest. CPR is typically performed by trained individuals, such as healthcare professionals, first responders, or bystanders in emergency situations. While CPR is typically performed manually by individuals, there are automated CPR devices known as "CPR devices" or "mechanical chest compression devices" that can assist or perform chest compressions during cardiopulmonary resuscitation.

These mechanical chest compression devices are often used in healthcare settings, including hospitals and ambulances, and are designed to ensure consistent and high-quality chest compressions, which can be challenging to maintain manually for extended periods. Some key points about mechanical chest compression devices are:

1. Consistency: They can provide consistent chest compressions at the recommended rate anddepth, ensuring optimal blood flow to the brain and vital organs during CPR.

2. Reduced Fatigue: They help reduce rescuer fatigue during prolonged CPR efforts, especially in high-stress situations.

3. Adjustable Settings: Many mechanical devices allow for adjustments to compression depthand rate to suit the patient's needs.

4. Monitoring: Some devices may have monitoring capabilities to assess the quality of CPRbeing delivered and provide feedback to rescuers.

5. Integration with Other Equipment: They can be integrated with other life support equipment, such as automated external defibrillators (AEDs).

However, it's important to note that mechanical chest compression devices are not a replacement for trained healthcare professionals but rather a tool to assist in providing high-quality CPR in certain situations. Proper training and understanding of CPR guidelines are essential, and these devices are typically used by healthcare providers who are familiar with their operation.

STEP-03:- Automatic External Defibrillators pads(AED) giving the shocks between Low Voltage to High Voltage.

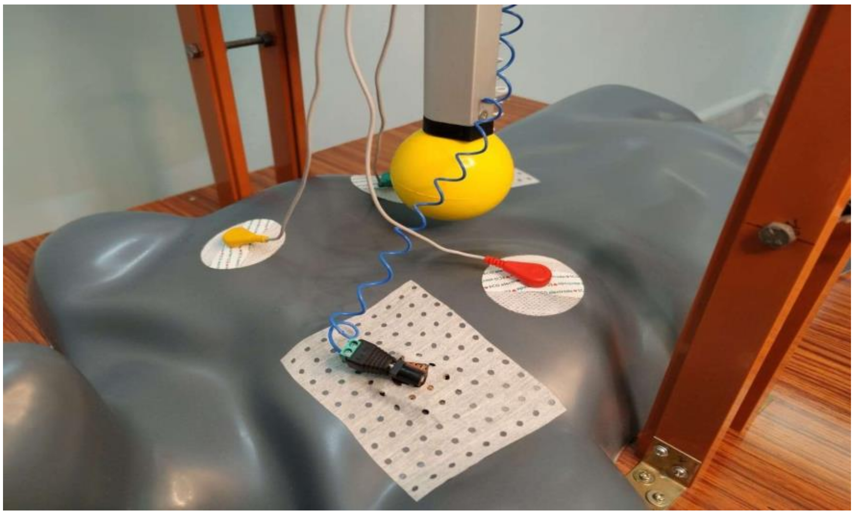


Fig.5.5 AED Mechanism

Automatic External Defibrillators (AEDs) are designed to deliver an electrical shock to the heart during a cardiac arrest in an attempt to restore a normal heart rhythm. These shocks are delivered in a controlled and specific manner. AEDs do not deliver a variable range of voltages from low to high; instead, they typically deliver a biphasic waveform with a specific energy level.

Here's how AEDs work in terms of voltage delivery:

1. Fixed Energy Levels: AEDs are programmed to deliver a specific amount of electrical energy in joules. This energy level is typically pre-set by the manufacturer and is based on clinical guidelines. Modern AEDs often use biphasic waveforms, which are effective at lower energy levels compared to older monophasic waveforms.

2. Biphasic Waveform: Biphasic waveforms deliver electrical energy in two phases, an initial phase and a reverse phase. The energy is delivered in a controlled manner, with a specific pattern designed to maximize the chance of successfully restoring a normal heart rhythm. The exact waveform and energy levels can vary among different AED models but are within safe and effective ranges.

3. Energy Adjustment: In some cases, particularly in professional defibrillators used by healthcare providers, there may be an option to manually adjust the energy level. This adjustment is typically made based on the patient's age and size, and it is done by a trained medical professional.

AEDs are designed to be user-friendly, and they guide laypersons or rescuers through the process of attaching the pads, analyzing the heart rhythm, and delivering a shock if necessary. The energy delivered by an AED is within a safe and effective range, and it is designed to minimize harm to the patient while maximizing the chance of restoring a normal heart rhythm.

It's important to note that AEDs are highly regulated and undergo rigorous testing and certification to ensure their safety and efficacy. They are a critical tool for providing early defibrillation to individuals experiencing sudden cardiac arrest, and when used correctly, they can significantly improve the chances of survival. Proper training in AED use is recommended to ensure safe and effective use in emergency situations.

STEP-04:- All system performances information send to the IoT Blynk application to verify the system configurations.

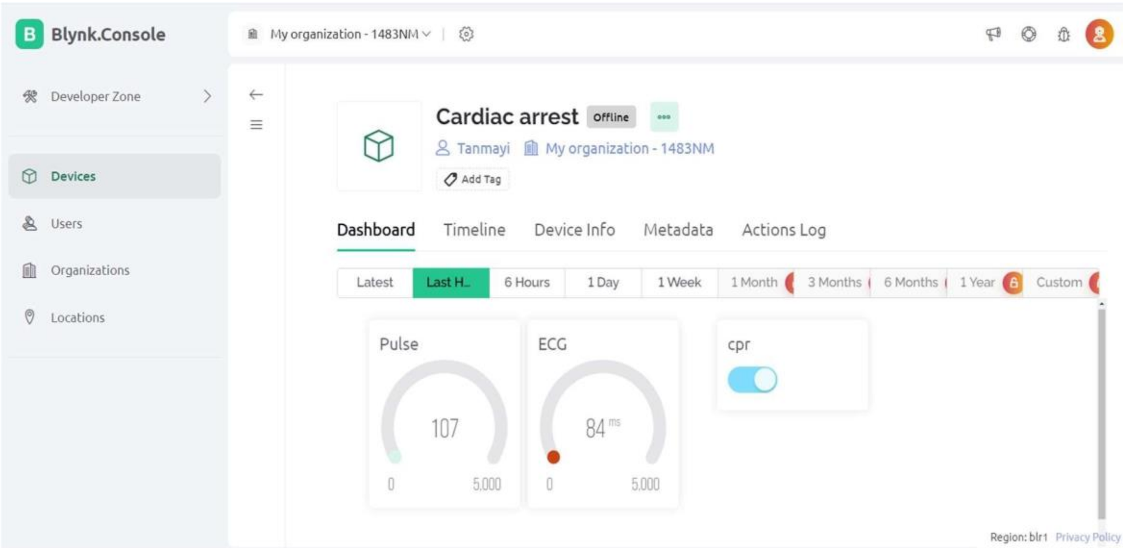


Fig.5.6 Data Upload

It sounds like you want to set up a system where performance notifications and alerts are sentto an IoT (Internet of Things) platform like Blynk for monitoring and verifying system configurations. Here's a general outline of how you can achieve this:

1. Set Up the IoT Device: First, you need IoT devices or sensors that can monitor the performance of your systems. These devices could be temperature sensors, motion detectors,or any other type of sensor relevant to your application. Make sure these devices are compatible with Blynk or can send data to a platform that Blynk supports.

2. IoT Gateway/Controller: You might need a central gateway or controller that aggregates data from these sensors and communicates with the Blynk platform. This can be a microcontroller or a single-board computer (e.g., Arduino, Raspberry Pi) equipped with the necessary communication modules (e.g., Wi-Fi, cellular, or Ethernet).

3. Connect to Blynk: Set up an account on the Blynk platform and create a project to receive and display data. Blynk provides APIs and libraries for different hardware platforms, making it relatively easy to connect your IoT devices to the Blynk app. Follow the documentation for your specific hardware and Blynk for instructions on how to establish this connection.

4. Monitor System Performance: Configure your IoT devices to monitor the relevant performance metrics. For example, if you're monitoring a server, you can track CPU usage, memory usage, and disk space. If it's an environmental monitoring system, you might be monitoring temperature, humidity, or air quality.

5. Set Thresholds and Alerts: Define thresholds for these performance metrics. When a metric exceeds a certain threshold, your IoT device should send an alert to the Blynk app. This could be in the form of a push notification or an on-screen alert.

6. Configure Alerts: On the Blynk app, configure how you want to receive alerts. You can setup push notifications, emails, or even SMS alerts.

7. Verify System Configurations: The alerts and notifications will allow you to verify the system configurations in real time. If a metric exceeds its threshold, you can investigate the issue and make necessary adjustments.

8. Logging and Analytics: Consider implementing a logging system to keep historical data of system performance. This data can be valuable for analyzing trends and making long-term improvements.

6. RESULTS

6.1 RESULTS

A module equipped with various sensors is affixed to the chest of individuals afflicted with blood pressure and/or cardiovascular diseases. These sensors continuously transmit data to the Blynk IoT app, which is managed by the attending doctor. Any deviations from normal physiological parameters prompt the doctor to activate the system via the app's interface. The module operates through two main mechanisms: CPR and AED. During CPR, a Linear Actuator positioned at the chest's center initiates to stabilize the patient's condition towards normalcy. Subsequently, the module transitions to the AED mechanism, administering internal shocks to restore the heart's rhythm. If the patient stabilizes and returns to a normal state, the system can be deactivated using the end button. This integrated approach offers real-time monitoring and intervention, potentially saving lives in critical situations.

7. CONCLUSION

7.1CONCLUSION

This report concluded a basic of a IoT integrated ECG and pulse monitoring systemwith automated CPR and defibrillation. The concept introduced is to bring an idea of Cardiac arrest, by measuring ECG and pulse rate with suitable sensors to detect the signals of heart beat. Any fluctuation above and below the normal value the developed system will take care as shown in flow graph. During variation the actuator performs a CPR mechanism by pumping the chest in the event of CPR failure mechanism, automatic external defibrillation mechanism starts functioning. The defibrillation pads (AED) play a key role by giving the shock treatment to improve the heartbeat. The complete system is automized for care taking besides sending the information through the IoT Blynk application to verify the configurations. It isthe part of Bio medical instrumentation, where it can used in medical equipment’s various industries and revolutionaries. Now a days a Bio-medical instrumentation project inventions can save’s the mankind life& it is a Make in India project.

7.2 FUTURE SCOPE

An IoT- integrated ECG and pulse monitoring system with automated CPR and defibrillation, is developed in this work in future the system can be advanced by integration of cutting-edge technologies to improve the system's effectiveness and efficiency, by incorporating AI and ML. Further, Using WIFI public awareness by means of GMS GPS. The system can be deployed in health care in hospitals, residencies so that the patients are takencare to save them from disaster.

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SOURCE CODE

```
#define pulse 35

#define ecg 34

#define sw 21

#define buzzer 13

#define taz 25

int i=0;

#define BLYNK_TEMPLATE_ID "TMPL3AeFZXTWd"

#define BLYNK_TEMPLATE_NAME "Cardiac arrest"

#define BLYNK_AUTH_TOKEN "kSaQKmBCHHJ3BfZ8PAz-
91cLe5vUiShr"

#define BLYNK_PRINT Serial

#include <WiFi.h>

#include <WiFiClient.h>

#include <BlynkSimpleEsp32.h>

char auth[] = BLYNK_AUTH_TOKEN;

char ssid[] = "OPPO A78 5G";

char pass[] = "b43ycdvs";


void setup() {
```

```
  pinMode(pulse, INPUT);
  pinMode(ecg, INPUT);
  pinMode(sw, INPUT_PULLUP);
  pinMode(buzzer, OUTPUT);
  pinMode(taz, OUTPUT);
  digitalWrite(taz, HIGH);
  digitalWrite(buzzer, LOW);
  pinMode(27, OUTPUT);
  pinMode(26, OUTPUT);
  STP();
  Blynk.begin(auth, ssid, pass);
}
void IN()
{
  digitalWrite(27, LOW);
  digitalWrite(26, HIGH);
}
void OUT()
{
  digitalWrite(27, HIGH);
```

```
  digitalWrite(26, LOW);
}
void STP()
{
  digitalWrite(27, LOW);
  digitalWrite(26, LOW);
}
void kill()
{
  if(digitalRead(sw)==LOW)
  {
    digitalWrite(buzzer, HIGH);
    IN();
    delay(1000);
    STP();
    digitalWrite(taz, HIGH);
    digitalWrite(buzzer, LOW);
    while(1);
  }
}
```

```
BLYNK_WRITE(V3) {
  kill();
  digitalWrite(buzzer, HIGH);
  delay(3000);
  kill();
  digitalWrite(buzzer, LOW);
  for(i=1;i<=5;i++)
  {
    kill();
    OUT();
    delay(800);
    kill();
    IN();
    delay(800);
  }
  STP();
  kill();
  digitalWrite(buzzer, HIGH);
  delay(3000);
  kill();
```

```
  digitalWrite(buzzer, LOW);
  delay(1000);
  kill();
  digitalWrite(taz, LOW);
  delay(1000);
  kill();
  digitalWrite(taz, HIGH);
}

void loop() {
  int pv = map(analogRead(pulse), 0, 4095, 0, 150);
  int ev = map(analogRead(ecg), 0, 4095, 0, 150);
  Blynk.virtualWrite(V1, random(90, 120));
  Blynk.virtualWrite(V2, random(70, 89));
  Blynk.run();
  delay(1000);
}
```

PATENT PROOF

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Ministry of Commerce & Industry,
Government of India

INTELLECTUAL PROPERTY INDIA
PATENTS | DESIGNS | TRADE MARKS
GEOGRAPHICAL INDICATIONS

Application Details	
APPLICATION NUMBER	202341080227
APPLICATION TYPE	ORDINARY APPLICATION
DATE OF FILING	25/11/2023
APPLICANT NAME	SR University
TITLE OF INVENTION	CARDIAC ARREST DETECTION SYSTEM WITH CARDIOPULMONARY RESUSCITATION AND METHOD THEREOF
FIELD OF INVENTION	BIO-MEDICAL ENGINEERING
E-MAIL (As Per Record)	patent.ipo@ipqrate.com
ADDITIONAL-EMAIL (As Per Record)	
E-MAIL (UPDATED Online)	
PRIORITY DATE	
REQUEST FOR EXAMINATION DATE	--
PUBLICATION DATE (U/S 11A)	22/12/2023

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APPLICATION STATUS	Awaiting Request for Examination

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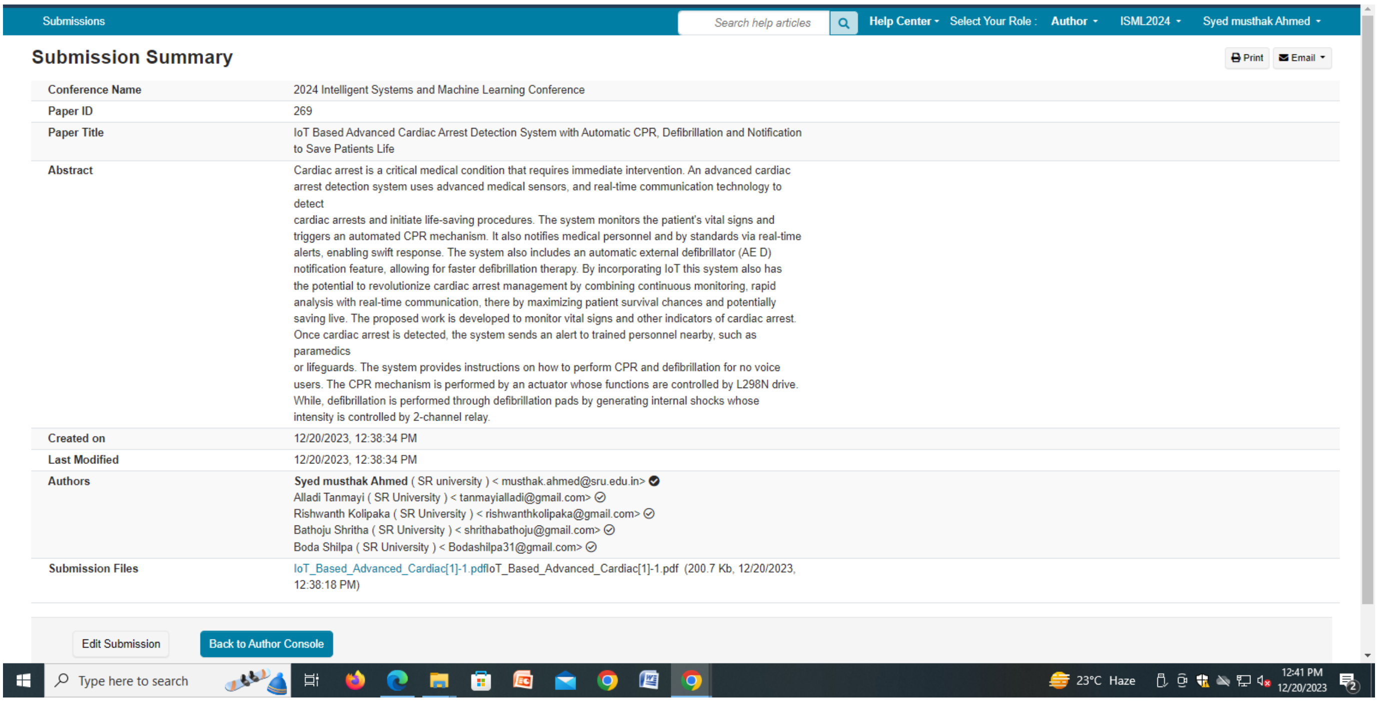
Submissions

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Submission Summary

Print | Email

Conference Name	2024 Intelligent Systems and Machine Learning Conference
Paper ID	269
Paper Title	IoT Based Advanced Cardiac Arrest Detection System with Automatic CPR, Defibrillation and Notification to Save Patients Life
Abstract	Cardiac arrest is a critical medical condition that requires immediate intervention. An advanced cardiac arrest detection system uses advanced medical sensors, and real-time communication technology to detect cardiac arrests and initiate life-saving procedures. The system monitors the patient's vital signs and triggers an automated CPR mechanism. It also notifies medical personnel and by standards via real-time alerts, enabling swift response. The system also includes an automatic external defibrillator (AE D) notification feature, allowing for faster defibrillation therapy. By incorporating IoT this system also has the potential to revolutionize cardiac arrest management by combining continuous monitoring, rapid analysis with real-time communication, there by maximizing patient survival chances and potentially saving live. The proposed work is developed to monitor vital signs and other indicators of cardiac arrest. Once cardiac arrest is detected, the system sends an alert to trained personnel nearby, such as paramedics or lifeguards. The system provides instructions on how to perform CPR and defibrillation for no voice users. The CPR mechanism is performed by an actuator whose functions are controlled by L298N drive. While, defibrillation is performed through defibrillation pads by generating internal shocks whose intensity is controlled by 2-channel relay.
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Last Modified	12/20/2023, 12:38:34 PM
Authors	**Syed musthak Ahmed** (SR university) < musthak.ahmed@sru.edu.in> Alladi Tanmayi (SR University) < tanmayialladi@gmail.com> Rishwanth Kolipaka (SR University) < rishwanthkolipaka@gmail.com> Bathoju Shritha (SR University) < shrithabathoju@gmail.com> Boda Shilpa (SR University) < Bodashilpa31@gmail.com>
Submission Files	IoT_Based_Advanced_Cardiac[1]-1.pdfIoT_Based_Advanced_Cardiac[1]-1.pdf (200.7 Kb, 12/20/2023, 12:38:18 PM)

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