

ResQ – Automated CPR Wearable for Cardiac Arrest Emergencies

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Abstract - Cardiac arrest remains a major cause of sudden death worldwide, where immediate and effective Cardiopulmonary Resuscitation (CPR) is essential for improving survival rates. The proposed project, "ResQ – Automated CPR Wearable for Cardiac Arrest Emergencies," introduces a compact, affordable, and wearable automated CPR system designed to provide consistent chest compressions during emergency situations. By integrating wearable technology with IoT-based monitoring and alert features, the device enables real-time patient status tracking and faster emergency response. The system is designed for ease of use in homes, workplaces, and public spaces, reducing reliance on trained medical personnel during critical moments. Furthermore, the project establishes a foundation for future integration of Artificial Intelligence to support predictive health monitoring and intelligent emergency decision-making, ultimately aiming to make life-saving CPR assistance more accessible and effective.

Key Words: Automated CPR, Cardiac Arrest, Wearable Device, IoT, Emergency Healthcare, Real-Time Monitoring, Smart Medical System, Portable Healthcare Device

1. INTRODUCTION

In recent years, cardiac arrest cases have increased significantly, making immediate medical response more important than ever. Cardiopulmonary Resuscitation (CPR) is one of the most effective emergency procedures used to restore blood circulation and improve the survival chances of a patient during cardiac arrest. However, timely CPR support is often unavailable due to delayed medical assistance, lack of trained personnel, or limited access to emergency healthcare devices. The project "ResQ – Automated CPR Wearable for Cardiac Arrest Emergencies" is designed to address this problem by developing a wearable and automated CPR assistance system. The device is capable of providing controlled chest compressions and emergency monitoring support during critical situations. It combines healthcare technology with IoT-based communication features to improve emergency response and patient safety. The system aims to provide an affordable, portable, and user-friendly solution that can be used in homes,

workplaces, ambulances, and public places. By integrating automation with healthcare, the project contributes towards smarter and faster emergency medical support systems.

2. RELATED WORK

Several researchers and healthcare organizations have focused on improving emergency cardiac care through automated systems, wearable healthcare technologies, and intelligent monitoring solutions. Cardiopulmonary Resuscitation (CPR) is recognized as one of the most effective emergency procedures for maintaining blood circulation during sudden cardiac arrest [1]. Various studies indicate that immediate CPR significantly increases the survival chances of patients before professional medical assistance becomes available [2].

Traditional CPR procedures are generally performed manually by trained medical personnel or bystanders. However, manual chest compressions require physical strength, proper technique, and continuous effort, making them difficult to maintain for long durations. In many emergency situations, delays in medical response and lack of CPR-trained individuals reduce the effectiveness of emergency treatment [3].

To overcome these limitations, researchers have developed automated CPR devices capable of delivering continuous chest compressions mechanically [4]. Existing automated CPR systems are commonly used in hospitals and ambulances where medical infrastructure is available [5]. These systems provide accurate compression depth and compression rate, reducing human error during emergency treatment. Despite their effectiveness, many commercially available systems are expensive, bulky, and unsuitable for personal or wearable healthcare applications [6].

In recent years, wearable healthcare technologies have gained popularity due to their portability, compact design, and ability to continuously monitor patient health conditions. Smart wearable systems integrated with IoT technology enable real-time monitoring of vital signs such as pulse rate, oxygen level, and heart activity [7]. These systems also support remote healthcare management by transmitting patient data to caregivers or healthcare professionals through cloud communication platforms.

IoT-based healthcare monitoring systems have become an important part of modern smart healthcare applications. Cloud-connected monitoring platforms allow continuous data

Collection, emergency alert generation, and remote patient supervision. Many healthcare researchers are focusing on combining wearable technology with emergency response systems to improve treatment accessibility and reduce medical response time [8].

Artificial Intelligence is also emerging as a major technology in healthcare applications. AI-based predictive analysis systems can identify abnormal patient conditions, detect early symptoms of diseases, and support intelligent medical decision-making [9]. Integration of AI with wearable healthcare systems can further improve emergency response efficiency and predictive healthcare management [10].

Based on the analysis of current technologies and research gaps, the proposed ResQ system focuses on developing an affordable, wearable, portable, and IoT-enabled automated CPR device capable of delivering immediate assistance during cardiac emergencies while providing real-time monitoring and emergency communication[11].

3. SYSTEM ARCHITECTURE OF CPR DEVICE

The architecture of the proposed ResQ – Automated CPR Wearable for Cardiac Arrest Emergencies system is designed to provide automated emergency cardiac support through wearable healthcare technology, IoT communication, cloud monitoring, and real-time emergency alert mechanisms. The overall architecture integrates sensing devices, processing units, cloud services, monitoring dashboards, and communication modules to ensure rapid response.

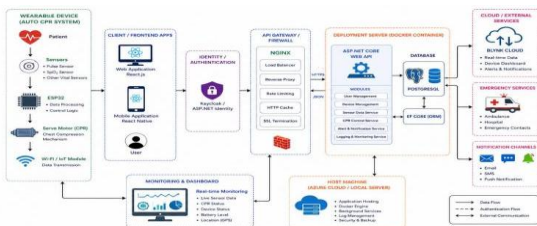


Fig 1 – System Architecture of Auto CPR Device.

The system begins with the **wearable healthcare device**, which is attached to the patient and continuously monitors physiological parameters such as pulse rate, oxygen saturation level, and other vital signs using health monitoring sensors. These sensor readings are transferred to the **ESP32 microcontroller**, which acts as the central processing and control unit of the system. The ESP32 processes incoming health data and analyzes the readings to Detect abnormal cardiac conditions or possible cardiac arrest situations.

When emergency conditions are identified, the controller activates the **servo motor-based CPR mechanism** that performs automated chest compressions according to medically recommended compression rates. The automated CPR mechanism ensures continuous and consistent chest compressions until the patient stabilizes or professional medical support becomes available.

Simultaneously, the ESP32 transmits real-time patient data to the **IoT communication module** using Wi-Fi connectivity. The transmitted information is stored and managed through cloud services and monitoring servers. The architecture includes a secure API gateway, authentication services, backend processing modules, and database management systems for handling patient monitoring data efficiently.

The proposed architecture also supports **web and mobile dashboard applications** that allow caregivers, medical staff, or emergency responders to monitor the patient’s health condition remotely. The dashboard displays live sensor readings, CPR activity status, battery condition, emergency alerts, and location information in real time.

Additionally, the system architecture integrates emergency communication services capable of sending notifications through SMS, email, or push alerts to emergency contacts and healthcare providers during critical situations. This feature improves emergency response time and enhances patient safety.

The proposed typical system architecture combines wearable healthcare technology, automated CPR support, cloud communication, and smart monitoring features into a single integrated platform. The architecture is designed to be portable, scalable, cost-effective, and suitable for deployment in homes, ambulances, workplaces, hospitals, and public emergency environments.

A. DATA FLOW ARCHITECTURE

The Data Flow Architecture of the proposed ResQ – Automated CPR Wearable for Cardiac Arrest Emergencies system illustrates the movement of patient health data through different processing and decision-making modules. The architecture is designed to provide continuous patient monitoring, automated CPR activation, and real-time emergency communication during cardiac arrest situations. The workflow begins with the patient monitoring stage, where wearable sensors continuously collect physiological parameters such as pulse rate and oxygen saturation (SpO₂). These raw sensor readings are forwarded to the Data Acquisition module, where the incoming sensor signals are formatted, filtered, and converted into processed vital data suitable for analysis.

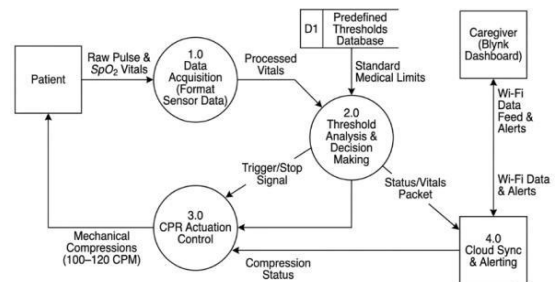


Fig 2: Data Flow of Auto CPR.

The processed patient vitals are then transferred to the Threshold Analysis and Decision-Making module. This module compares the received health readings with predefined medical threshold values stored in the threshold database. The database contains standard medical limits used to identify abnormal cardiac conditions and possible cardiac arrest situations.

If the patient's health parameters remain within normal ranges, the system continues real-time monitoring without activating emergency procedures. However, when abnormal conditions are detected, the decision-making module generates a trigger signal to activate the CPR Actuation Control module. The CPR mechanism then performs automated chest compressions at the medically recommended rate of approximately 100–120 compressions per minute to maintain blood circulation during emergencies.

Simultaneously, the system sends patient status information, compression activity details, and emergency alerts to the Cloud Sync and Alerting module through Wi-Fi communication. The cloud platform enables remote monitoring and stores real-time patient information for emergency management purposes.

The transmitted data is displayed on the Caregiver Monitoring Dashboard, developed using the Blynk IoT platform. The dashboard allows caregivers, healthcare professionals, or emergency responders to monitor patient conditions remotely and receive emergency notifications instantly.

The proposed data flow architecture ensures efficient communication between sensing, processing, CPR execution, cloud synchronization, and monitoring modules. The architecture improves emergency response time, supports automated healthcare assistance, and enhances the reliability of wearable CPR systems for cardiac emergency management.

B. CLASS DIAGRAM

The class diagram of the ResQ – Automated CPR Wearable for Cardiac Arrest Emergencies system represents the static structure of the system by showing different classes, their attributes, methods, and relationships. The Patient class interacts with sensors that continuously collect physiological data. The Sensor class transfers the acquired data to the ESP32 Controller, which processes the readings and determines whether CPR activation is required.

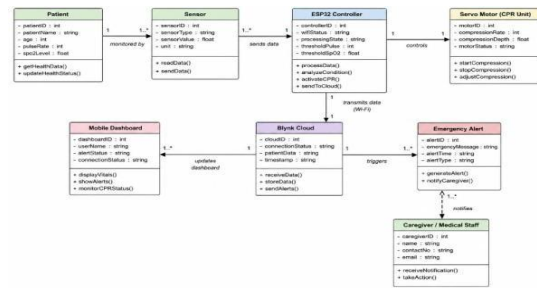


Fig 3: Class Diagram.

If abnormal conditions are detected, the ESP32 Controller activates the Servo Motor class to perform automated chest compressions. Simultaneously, the processed data is transmitted to the Blynk Cloud platform for storage and remote monitoring. The Mobile Dashboard displays real-time patient health status and CPR activity, while the Emergency Alert class generates notifications during critical situations. This class diagram explains the interaction and communication between hardware, software, cloud, and monitoring modules within the proposed system.

C. STATE MACHINE DAIGRAM

If the Patient Monitor system operates as a continuous surveillance loop focused on data acquisition and anomaly detection. It transitions from an initial Standby state into a Monitoring Vitals state as soon as the wear-able sensors begin collecting real-time physiological data. While tracking metrics like heart rate and oxygen levels, the system evaluates the data stream; if the readings remain within safe thresholds, it loops through a Normal Vitals validation state and maintains routine tracking. However, if the data processing layer flags a severe arrhythmia or cardiac arrest pattern, the system enters a high-priority Life Threat Detected state, which immediately triggers a CPR Activation Request to prompt physical intervention.

The CPR Actuator system governs the physical execution and continuous adjustment of the mechanical resuscitation process. It rests in a Waiting for Activation Command state until a critical alert is received, at which point it passes through a brief Calibration phase to ensure precise positioning and force metrics.

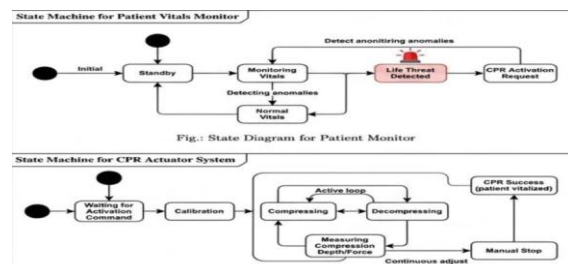


Fig 4: State Machine Diagram.

Once calibrated, the device enters a continuous active loop alternating rapidly between mechanical Compressing and Decompressing states, while concurrently executing a Measuring Compression Depth/Force state to maintain adherence to medical guidelines. This synchronized feedback loop dynamically self-adjusts until it meets a designated stop condition either achieving a CPR Success (Patient Vitalized) state or being manually overridden via a Manual Stop command upon the arrival of emergency personnel.

4. IMPLEMENTATION PLAN

Table -1: Implementation Plan

Task No.	Task to be Accomplished
T1	Project Topic Finalization and Problem Identification.
T2	Requirement Analysis and Literature Survey.
T3	Study of ESP32, Sensors, Servo Motor, and Blynk Platform.
T4	Hardware Component Selection and System Setup.
T5	Sensor Integration and Health Data Acquisition.
T6	Development of ESP32 Monitoring and Processing Module.
T7	Servo Motor CPR Compression Mechanism Implementation.
T8	Wi-Fi and Blynk Cloud Connectivity Integration.
T9	Mobile Dashboard Design for Real-Time Monitoring.
T10	Emergency Alert and Notification System Development.
T11	System Testing and CPR Compression Validation.
T12	Documentation and Report Preparation.
T13	Maintenance and Future Enhancement Planning.

5. FUTURE SCOPE

The proposed system provides several opportunities for future enhancement and research development. Artificial Intelligence algorithms can be integrated for predictive cardiac analysis and intelligent emergency decision-making. Additional sensors can be incorporated to improve patient health assessment and monitoring accuracy.

Future versions of the project may include GPS tracking for faster emergency response, machine learning-based abnormality prediction, advanced cloud databases for medical record storage, and mobile application integration for remote healthcare management. The CPR mechanism can also be improved using advanced actuators capable of providing more precise compression control.

The integration of smart healthcare technologies and wearable medical devices has the potential to transform emergency cardiac care by making life-saving treatment more accessible and efficient.

DEPLOYMENT AND MAINTAINANCE DEPLOYMENT:

Hardware Assembly and Calibration: Securely integrate the biosensors into the wearable casing to ensure stable skin contact, and calibrate the actuator/motor system to consistently deliver chest compressions at a depth of 5–6 cm and a rate of 100–120 compressions per minute.

Power and IC Configuration: Connect and fully charge the rechargeable Li-ion battery, verifying that the power management IC correctly balances and regulates voltage to prevent high-torque motor demands from disrupting the ESP32/Arduino micro controller.

Software Flashing and Backend Setup: Flash the final Embedded C/Arduino code onto the microcontroller, deploy the Python data handling scripts to the cloud, and initialize the database to receive live vitals and system logs.

Application and Network Rollout: Launch the mobile/web interface, ensuring its live vitals display functions correctly and that the push, SMS, or call protocols are properly routed to trigger immediate alerts to emergency contacts and hospitals.

Manikin and Safety Validation: Mount the assembled prototype onto standard CPR manikins to rigorously validate compression accuracy, device stability, and to ensure the hardware emergency stop and overload protection mechanisms work flawlessly.

MAINTAINANCE:

1. Mechanical and Gear Inspection: Conduct monthly physical inspections of the actuator, motor driver circuit, and gear mechanisms to look for wear, strain fractures, or lubrication breakdown caused by repeating high-torque compressions.

2. Casing and Strap Upkeep: Quarterly check the structural integrity of the wearable casing, fastening straps, and buckles to make sure the device can be secured tightly to a patient without slipping during active operation.

3. Sensor Calibration and Cleaning: Perform bi-weekly cleaning and diagnostic tests on the sensors using base simulators to prevent data drift and ensure accurate cardiac arrest detection.

4. Battery Lifecycle Management: Execute monthly discharge and recharge cycles on the Li-ion battery to prevent capacity degradation, verifying that it retains enough power to run automated compressions continuously for at least 30 minutes.

5. Software Updates and Connectivity Audits: Deploy periodic over-the-air firmware updates to optimize the decision algorithm, and conduct weekly network "ping" tests to confirm the IoT modules can transmit emergency logs and alerts without latency.

5. CONCLUSIONS

The ResQ project presents an affordable, portable, and automated solution for managing sudden cardiac arrest emergencies outside hospital environments. The system is designed to deliver immediate and consistent chest compressions using a servo motor mechanism that follows medical standards of 100–120 compressions per minute with a compression depth of 5–6 cm, helping maintain blood circulation and improving the patient's survival chances until professional medical assistance arrives. By reducing human dependency, fatigue, and errors associated with manual CPR, the device provides a more reliable emergency response system. The integration of IoT technology through ESP32 and Blynk enables real-time monitoring of patient health parameters such as pulse rate, ECG readings, and oxygen levels while also sending emergency alerts to caregivers or medical services during critical situations. In addition, the project demonstrates that effective automated CPR and health monitoring can be achieved using cost-effective and easily available components, making the system suitable for homes, workplaces, ambulances, and public areas. Overall, the project successfully combines automation, wearable technology, and IoT-based healthcare monitoring to create a practical and accessible life-saving solution for society.

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