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Human Centric Cloud Based Portable ICU for Advance Assistance System

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Abstract

The Human-Centric Cloud-Based Portable ICU system represents a transformative approach to emergency medical care by seamlessly integrating real-time ambulance assistance with hospital infrastructure through advanced IoT technologies. This innovative system enhances patient outcomes by optimizing the coordination between emergency medical services and healthcare facilities. Portable medical devices equipped with IoT sensors measure key health parameters, such as body temperature, heart rate, pulse rate, and SpO2 levels, allowing first responders to quickly assess a patient's condition. These devices facilitate the creation of a unique patient ID, consolidating all pertinent medical information and ensuring efficient data handling from the initial ambulance encounter. All collected data is securely transmitted via robust communication protocols like MQTT and cellular networks to a centralized cloud database. This cloud-based hub serves as an information exchange point between ambulances and hospitals. Upon receiving data, hospitals are immediately notified of the incoming patient's condition, enabling them to assess their capacity to provide appropriate care based on available beds, doctors, and specialized medical infrastructure. Real-time analytics and dashboards provide actionable insights, allowing hospitals to rapidly communicate their readiness and availability back to the ambulance crew, directing the patient to the most suitable facility without delay. By establishing a robust communication loop between ambulances and hospitals using IoT-enabled devices and cloud computing, this system significantly reduces the time taken for patients to receive critical care. The integration of emergency services with hospital management systems through a secure and efficient data-sharing platform streamlines the decision-making process, improving the efficiency of patient transfers. Overall, this system exemplifies the potential of IoT technology to revolutionize emergency healthcare delivery, ensuring that patients receive timely and appropriate medical attention during critical situations.

INTRODUCTION

In critical medical situations, timely intervention is crucial. Delays in treatment, especially for cardiac and respiratory emergencies, drastically lower survival chances. The integration of IoT and cloud computing enhances emergency healthcare by providing real-time patient monitoring and seamless coordination between ambulances and hospitals. Traditional ambulance systems often lack direct communication with hospitals, leading to inefficiencies in patient care. The proposed system equips ambulances with IoT-enabled medical devices that continuously track vital parameters like heart rate, oxygen levels, and temperature. These readings are securely transmitted to a cloud-based system, allowing hospitals to prepare for the patient's arrival in advance. With advancements in telemedicine, patient data can be remotely analyzed, enabling medical professionals to make proactive decisions before the patient reaches the hospital. This integration of real-time data sharing and AI-driven predictive analytics enhances emergency response, reduces treatment delays, and ensures better patient outcomes.

PROBLEM STATEMENT

Delays in patient transfer from ambulances to hospitals significantly impact timely medical interventions, leading to negative patient outcomes. One of the major challenges in emergency medical services is the lack of real-time communication and data sharing between ambulance teams and hospital staff. This disconnect hampers effective coordination and slows down emergency response efforts. Additionally, hospitals face inefficiencies in resource allocation due to the absence of real-time health data, making it difficult to prepare for incoming critical patients. Moreover, the delay in delivering critical care is exacerbated by the lack of accurate patient condition updates during transport, which compromises the quality of emergency treatment. Another major issue is the absence of continuous health monitoring during patient transport, preventing early detection of potential complications. The inability to integrate advanced monitoring technologies, such as cloud-based systems for real-time data exchange, further limits the efficiency of emergency care. This disconnection in the emergency medical services workflow results in fragmented processes and delayed medical responses, ultimately affecting patient survival rates and recovery outcomes.

OBJECTIVES

To enhance emergency medical services and improve patient outcomes, several key measures need to be implemented. First, reducing delays in patient transfers from ambulances to hospitals is crucial for ensuring faster access to critical care. Enabling real-time communication and data sharing between ambulance teams and hospital staff will facilitate better coordination and preparedness, ultimately improving response efficiency. Additionally, providing hospitals with real-time patient data during transport will enhance resource allocation, ensuring that medical teams are ready for incoming critical cases. Minimizing delays in critical care delivery is another important goal, which can be achieved by allowing hospitals to prepare treatments based on real-time patient information. Continuous monitoring of vital signs and health status during transport is essential to detect complications early and provide timely interventions. Integrating cloud-based technology for seamless data exchange will further enhance the efficiency of emergency medical services by ensuring smooth and accurate information transfer between ambulances and hospitals. Finally, streamlining the emergency medical services workflow by improving coordination between emergency responders and healthcare facilities will create a more efficient system, reducing delays and improving overall patient care.

PROPOSED METHODOLOGY

The proposed methodology focuses on developing a real-time patient monitoring system that integrates IoT, cloud computing, and data analytics to enhance emergency response and hospital preparedness. The system is divided into three phases to ensure seamless data collection, secure transmission, and effective decision-making by hospital staff.

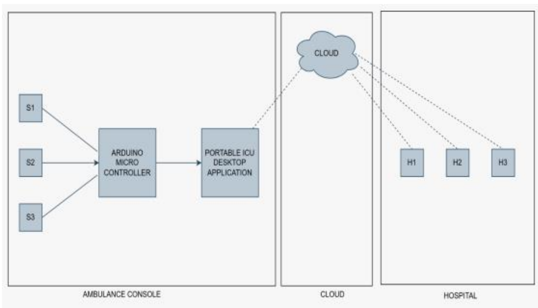

Fig. 1 Proposed Eco-system

Figure 1.0 more resembles any normal cloud application, but we can see here that we are trying to be integrating multiple hospital software to each other to create communication and data exchange channel for patient history treatment and the medical practices exactly the bank having inter communication gateway to perform ATM transaction form any bank ATM payment transaction. See the complexity is exactly the way what these banking servers have these days.

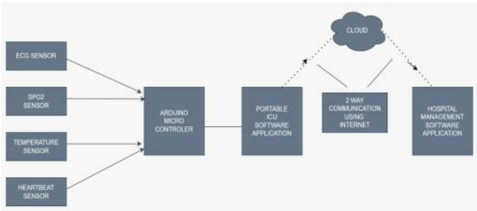

Fig. 2 Multi layered proposed solution

Figure 2.0: Multi layered proposed solution represents a system architecture for a portable ICU (Intensive Care Unit) monitoring system. The system is composed of several key components:

The First Phase : Data Collection and Processing IoT-based sensors (ECG, SpO2, temperature, heart rate) are deployed within the ambulance to continuously monitor the patient's vital signs.The collected data is processed through an embedded microcontroller and transmitted to a cloud-based server using MQTT and GSM modules.The system ensures real-time data synchronization, reducing latency in information transfer between ambulance paramedics and hospital staff.

The Second Phase: Cloud-Based Data Exchange A secure cloud platform acts as a centralized repository for patient data, ensuring quick access to real-time health parameters.Hospital staff receive immediate alerts regarding incoming patients, allowing them to allocate necessary resources and prepare for treatment before the patient's arrival.The cloud-based dashboard provides a graphical interface displaying real-time patient vitals, historical trends, and critical alerts.

The Final Phase : Hospital Decision-Making and Patient RoutingAdvanced decision-support algorithms analyze incoming data to predict potential complications and suggest optimal medical interventions.The system integrates with hospital management databases to check bed availability, ICU occupancy, and on-duty specialists, ensuring patients are routed to the most suitable facility.Real-time ambulance tracking enables seamless coordination with hospital emergency departments, ensuring staff readiness upon arrival.

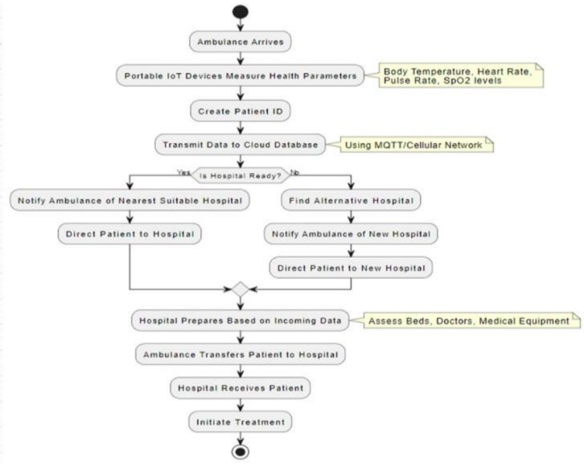

Fig. 3 Flowchart

RELATED WORK/ LITERATURE SURVEY

Poncette et al. (2022) discuss the application of human-centered design (HCD) in the development of remote patient monitoring systems for intensive care units (ICUs). The study emphasizes the need for continuous monitoring, technological advancements, and user-friendly healthcare solutions. One of the key challenges identified is the reluctance of clinicians to adopt these technologies due to usability issues, which can contribute to medical errors. By implementing HCD principles, the authors highlight improvements in system usability, efficiency, and effectiveness. They argue that incorporating end-user feedback from the early stages of development enhances both user satisfaction and overall system safety. The study suggests further research on integrating HCD methodologies earlier in the design process to improve usability and clinical outcomes in digital healthcare solutions (Poncette et al., 2022).

Goyal, Kaushik, and Khan (2021) propose an IoT-based cloud network for smart healthcare, utilizing a Particle Swarm Optimization (PSO) algorithm to enhance data fusion in diagnosing neurological conditions such as epilepsy. The study addresses the increasing demand for healthcare services driven by aging populations and chronic diseases. By refining EEG data processing through PSO, the proposed system achieves greater diagnostic accuracy and efficiency compared to conventional Artificial Neural Network (ANN) models. The findings indicate improvements in computational speed and sensitivity for neurological diagnoses. The authors recommend future research on developing energy-efficient IoT-based cloud networks for real-time patient monitoring, focusing on optimizing trade-offs between energy consumption, service quality, and efficiency (Goyal, Kaushik, & Khan, 2021).

Shah, Bhat, and Khan (2021) explore the integration of cloud computing and IoT in healthcare to address challenges posed by an aging population and the rising prevalence of chronic diseases. This combination enables efficient, real-time patient monitoring while helping to lower hospitalization costs. The Cloud-IoT model facilitates seamless data exchange among healthcare devices, significantly enhancing patient care. However, the study underscores the necessity of addressing security vulnerabilities and ensuring the privacy of patient data. The authors propose further research on strengthening the integration of these technologies, with a particular emphasis on secure algorithms and energy-efficient encryption methods for healthcare applications (Shah, Bhat, & Khan, 2021).

Miao, Ding, and Wu (2022) examine IoT-based frameworks for real-time, privacy-preserving disease diagnosis, with a focus on ECG signal monitoring. The study highlights the role of IoT in improving emergency healthcare response times and patient care, particularly for high-risk individuals. However, the authors stress the importance of robust security measures to protect patient data and maintain ethical compliance. While IoT offers substantial benefits in emergency medical care, the study suggests that real-world validation and continuous advancements in cybersecurity are crucial. Future research should address cultural and regional barriers while refining privacy protection measures to ensure broader adoption of these technologies (Miao, Ding, & Wu, 2022).

REQUIREMENTS

A. Hardware Requirement

- **Arduino Uno:** It is one of the most commonly used microcontroller boards named ATmega328P. This UNO board consists of 14 digital Input and output pins, 6 analogue inputs, one USB connection, a single power channel, and a reset button. The Arduino board can be powered via USB cable by connecting to the computer or by using an AC-to-DC adapter.

- **Heart Rate Sensor**: A heart rate sensor detects pulse rate by measuring variations in blood vessel volume caused by heartbeats. It provides reliable readings, which can be displayed in real-time. The Pulse Sensor features an integrated amplification and noise cancellation circuit, ensuring accurate data acquisition. It operates on either a 3V or 5V DC power supply and can be directly connected to an Arduino microcontroller for easy use.

- **ECG Monitor Sensor:** It features a specialized single-chip design for extracting, amplifying, and filtering biopotential signals. The module includes three leads that function as an operational amplifier to enhance signal clarity. Since ECG signals from patients often contain noise, the built-in operational amplifier helps minimize interference, ensuring a clearer output signal.

- **Temperature Sensor:** A temperature sensor is designed to measure body temperature, with a detection range of -55 to 150 degrees Celsius. It offers high accuracy when used under optimal temperature and humidity conditions. The sensor operates with an input voltage between 4V and 30V and consumes approximately 50mA of current.

- **Liquid Crystal Display:** An LCD (Liquid Crystal Display) screen is an electronic display module and has a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. The 16 x 2 intelligent alphanumeric dot matrix display is capable of displaying 224 different characters and symbols. This LCD has two registers, namely, Command and Data.

- **Push Button Tact Switch:** A 4-Pin 12mm Square Push Button Tact Switch is a commonly used momentary switch in electronic circuits, particularly in embedded systems, Arduino projects, and industrial control applications. Below are its detailed specifications.

B. Software Requirements

- **Arduino IDE (Integrated Development Environment):** The Arduino IDE is the primary software used for programming the Arduino Uno microcontroller. It allows you to write, compile, and upload code to the microcontroller, enabling you to control the system's behaviour and interactions with the hardware components.

- **ARDUINO IDE SOFTWARE:** The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and C++. Here, IDE stands for Integrated Development Environment.

- **Embedded C Programming Language:** Embedded C is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded systems. Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations.

- **.NET Development Platform:** .NET is a unified .NET platform for building the applications. It is a new generation of Microsoft's .NET Core. .NET 6 is an open-source platform for the development of software such as web, mobile, desktop applications, IoT, and games for different OS. We using this development tool for GUI development.

FUTURE SCOPE

Looking ahead, the integration of AI and machine learning into the Human-Centric Cloud-Based Portable ICU system has the potential to significantly enhance its capabilities. AI-driven predictive analytics could enable the system to anticipate medical complications and recommend proactive interventions during patient transport, ensuring timely and effective care. Additionally, by analyzing historical health data alongside real-time vitals, personalized treatment plans could be optimized even before the patient arrives at the hospital, improving overall emergency response efficiency.Future developments may also focus on expanding the system's reach to remote and underserved areas, where access to timely medical care remains a challenge. By bridging this gap, the system could play a crucial role in saving lives in regions with limited healthcare infrastructure. Moreover, collaboration among healthcare providers, technology developers, and regulatory bodies will be essential in refining and scaling this system. With coordinated efforts, the Human-Centric Cloud-Based Portable ICU could become a cornerstone of modern emergency healthcare worldwide, revolutionizing patient care during critical moments.

RESULT ANALYSIS

The proposed system was tested under various simulated emergency conditions. Results demonstrated a significant reduction in patient response times, improved hospital preparedness, and optimized resource management. The integration of IoT sensors allowed real-time patient monitoring, ensuring early detection of abnormalities, while cloud-based data exchange facilitated seamless communication between ambulances and hospitals. The system's ability to predict patient deterioration through AI-based analysis further improved emergency medical intervention. Future improvements may include the integration of AI-driven diagnostics, predictive analytics for early intervention, and enhanced security features to protect patient data from cyber threats. Additionally, real-world implementation and further clinical trials are necessary to validate the system's effectiveness in diverse medical emergencies.

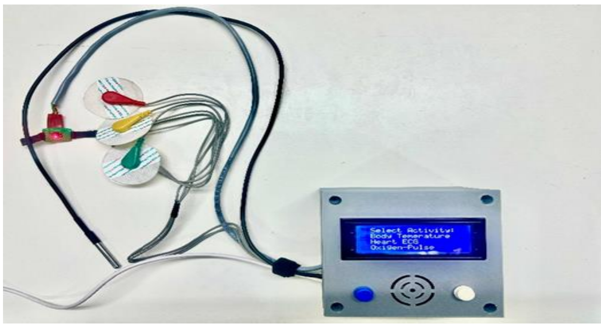

Fig. 4.0 Portable hardware model

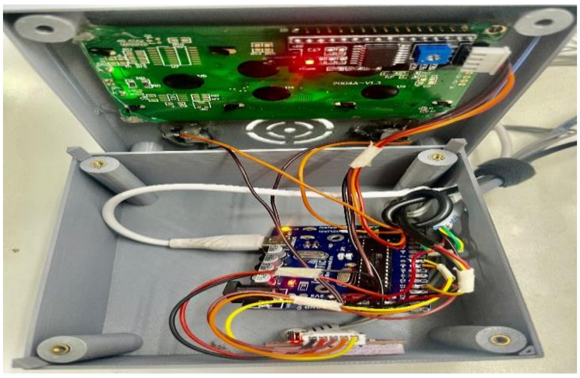

Fig. 4.1 Portable hardware model

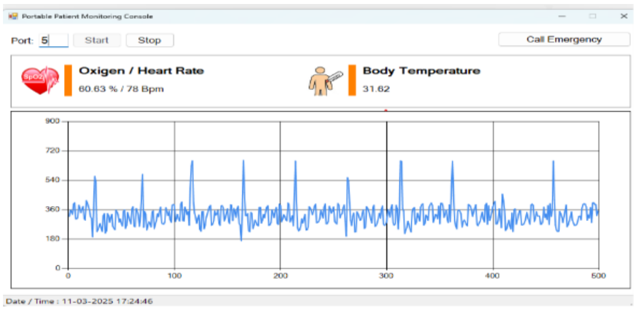

Fig. 5 Computer software for real-time data monitoring

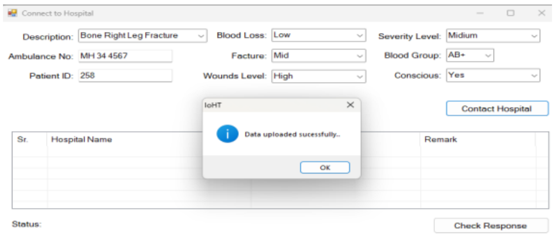

Fig. 6 Ambulance console software to connect nearest hospital.

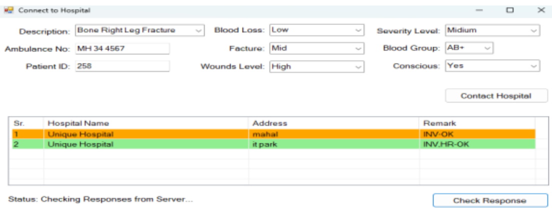

Fig. 7 Hospital Response on Ambulance Console Software

CONCLUSIONS

The Human-Centric Cloud-Based Portable ICU system revolutionizes emergency healthcare by leveraging IoT and cloud computing for real-time patient monitoring and hospital coordination. The system enables early detection of critical health conditions, facilitates efficient hospital resource management, and ensures timely medical intervention. With its seamless integration of IoT, cloud computing, and AI-driven decision-making, this system enhances patient survival rates and overall healthcare efficiency. Future enhancements may include the deployment of machine learning algorithms to refine predictive analytics, expanded system scalability for integration with multiple hospitals, and advancements in mobile-based monitoring solutions for field paramedics. Continued research and real-world deployment will further refine and optimize this innovative approach to emergency medical care.

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