WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

IoT Enabled Patient Health Monitoring System

Er. S. Senthazhai[2], H. Aashik[1], P. Mahesh[1], A. Venkatachalapathy[1], S. Vishva[1]

[1]Department of Electronics and Communication Engineering, Krishnasamy College of Engineering & Technology, Cuddalore, India
[2]Associate Professor, Department of Electronics and Communication Engineering, Krishnasamy College of Engineering & Technology,Cuddalore, India

ABSTRACT :

In hospitals, continuous monitoring of patient health is critical to ensuring timely intervention in case of emergencies. This paper presents an IoT-based real-time Patient Health Monitoring System that allows nurses to monitor multiple patients from a central nurse station.The system utilizes an ESP32 microcontroller connected to various health sensors, including blood glucose monitors, temperature sensors, heart rate and SpO2 sensors, respiratory rate sensors, and blood pressure monitors. All measured parameters are transmitted to a cloud-based Firebase database, where a real-time dashboard is accessible via a web application at the nurse station. Additionally, the system integrates with a smartwatch worn by nurses, which receives instant emergency alerts when critical health conditions are detected. The proposed system enhances patient care efficiency, reduces response time in emergencies, and ensures continuous health monitoring for improved medical management.

Keywords: IoT, Patient Monitoring, ESP32, Healthcare, Smartwatch Alerts, Firebase, Real-time Data

I.INTRODUCTION :

In modern healthcare environments,continuous and efficient monitoring of patient vitals is essential to ensure timely medical intervention and improve patient outcomes. In hospitals, especially in critical care units and general wards,healthcare professionals must constantly track parameters such as heart rate,blood pressure, oxygen saturation, and
body temperature. Traditional patient monitoring systems rely on periodic manual assessments, which can lead to delays in detecting life-threatening conditions. Moreover, human intervention introduces the risk of oversight, especially in cases where multiple patients require simultaneous attention. This limitation necessitates the development of an advanced system that enables real-time, automated patient monitoring to enhance healthcare efficiency and response time. The rapid advancements in the Internet of Things (IoT) have paved the way for innovative healthcare solutions that enhance patient monitoring systems. IoT-based healthcare solutions integrate smart sensors, wireless connectivity, and cloud-based data analytics to provide continuous real-time monitoring of vital signs. These systems offer significant advantages, including reduced dependency on manual checks,improved response times to critical situations, and enhanced accuracy in detecting abnormalities in a patient’s health condition. By leveraging IoT technology, medical professionals can access real-time data remotely, allowing them to make informed decisions promptly.

This paper proposes an IoT-enabled patient health monitoring system that collects and transmits real-time health data to a centralized nurse station. The system consists of wearable sensors that continuously measure key physiological parameters and transmit the collected data to a cloud-based platform via wireless communication protocols such as Wi-Fi or Bluetooth. The centralized system processes the data and alerts healthcare providers through a smartwatch notification system when a patient's vitals indicate an emergency.

This real-time alert mechanism ensures that medical staff can respond immediately, potentially preventing complications and saving lives. The proposed system offers several benefits over conventional patient monitoring approaches. Firstly, it enables continuous monitoring, reducing the need for frequent manual assessments by nurses. Secondly, the integration of wearable devices ensures that patients experience minimal discomfort while their health metrics are being tracked.Thirdly, by utilizing a centralized data management system, the hospital staff can have an organized and accessible repository of patient information,facilitating better diagnosis and treatment plans. Additionally, the use of a smartwatch notification system allows medical personnel to receive instant alerts, ensuring that critical conditions do not go unnoticed. In addition to improving response times, IoT-based patient monitoring systems contribute to the optimization of hospital resources.

Since real-time data is available on a centralized platform, hospitals can efficiently allocate medical staff based on the severity of patient conditions, thus streamlining workflow and reducing the burden on healthcare professionals.Furthermore, these systems have the potential to be expanded for remote patient monitoring, enabling healthcare providers to track patient health even outside hospital settings, which is particularly beneficial for chronic disease management and elderly care..

II.RELATED WORKS :

The application of Artificial Intelligence (AI) and Internet of Things (IoT) technologies in healthcare and emergency response has increased tremendously, particularly in remote diagnostics and real-time patient monitoring. One such study, STEMI Recognition in Electrocardiogram (ECG) by Online AI Bot for Emergency Service and Mobile Medicine by Shi-Jim Yen, Serkan Kavak, and Jen-Yeu Chen(2021), brings to the limelight an online mobile app forearly STEMI recognition from ECG data to support remote emergency treatment.The system relies on cloud-based, deep learning models, which make instant STEMI diagnosis possible and enable pre-hospital care in patients with heartattack in remote areas. The app helps cut response times by guiding paramedics in the swift diagnosis of potentially fatal conditions, which may ultimately save lives even before reaching the hospital. Another innovative use of IoT in emergency response is seen in the Smart Car Seat Belt: Accident Detection and Emergency Services in a Smart City Environment by Majd Khaled Almohsen et al. (2021).This work aims at reducing delays in emergency services after road accidents, particularly in cities.The intelligent seatbelt, with vibration and heart rate sensors, identifies possible collisions and informs emergency contacts of the vehicle's GPS coordinates through GSM technology. By authenticating the driver through fingerprint sensors, this system tries to minimize accidental notifications. The purpose of this project is to increase emergency response time and minimize fatalities caused by road accidents, thereby promoting public safety in a smart city environment. Its potential in managing chronic illness is then discussed further by Lingzhi Hong, Xufang Cheng, and Deming Zheng (2021) in Application of Artificial Intelligence in Emergency Nursing of Patients with Chronic Obstructive Pulmonary Disease. This paper discusses the competence of AI to manage Chronic Obstructive Pulmonary Disease (COPD) in emergency care patients. In a randomized controlled trial of 447 patients, the research discovered that AI-supported interventions could enhance the quality of life for patients and lower hospitalization rates in the long term.By providing tailored, real-time support for COPD patients, the study underscores AI’s potential to revolutionize chronic illness management, improving long-term patient outcomes and alleviating healthcare burdens. Further insights into emergency medical services are provided by Jhe-Nan Lin, Wei-Zen Sun, Huei-Ming Ma, and Meng-Han Yang in their study, Data Mining in Emergency Medical Databases to Analyze Ambulance Calls and Patient Medical Histories (2016).

III.PROPOSED SYSTEM :

The proposed system consists of an ESP32 microcontroller connected to various medical sensors to monitor multiple patients in a hospital ward. The collected data is sent to a iotdata cloud , where a real-time dashboard displays patient vitals at the nurse station. Additionally, if any patient enters a critical health condition (e.g., low oxygen levels, high blood pressure), thesystem triggers an emergency alert to a smartwatch worn by the nurse. This enables rapid response and better patient care management..

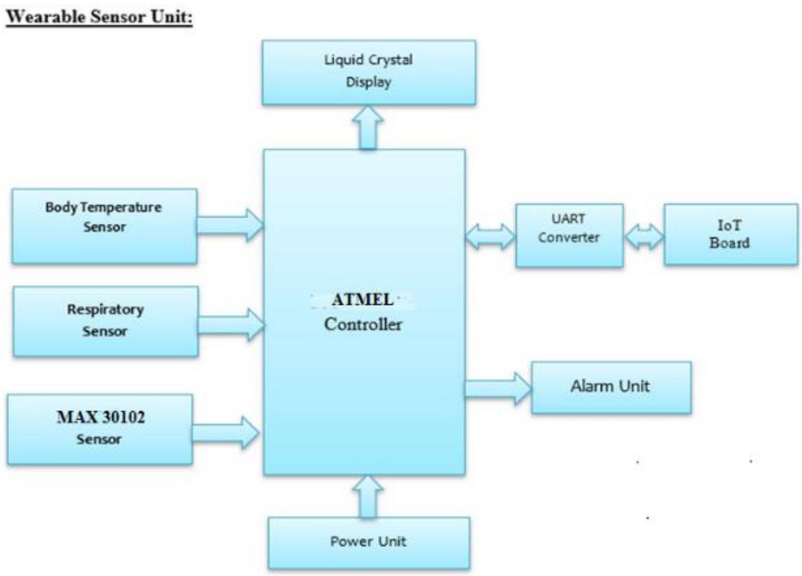


Figure 1: System Architecture of proposed system

HARDWARE COMPONENTS

LCD DISPLAY

The LCD Display provides an easy-to-remember and simple response, with a white Liquid Crystal Display that displays exceptionally clear and high-contrast white characters on a blue background or backlight..

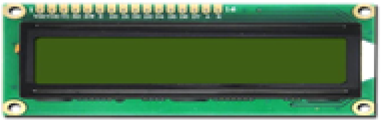


Figure 3.2 LCD

POWER SUPPLY:

Connect a 12V battery power source to the power jack of your Arduino board. Make sure the positive terminal of the battery is connected to the positive side of the power jack, and the negative terminal to the negative side. Once all connections are made, you can upload your Arduino code to the board and proceed to test the system or the working kit.

ATMEL Microcontroller

ATMEL microcontrollers are widely used in embedded systems due to their high performance, low power consumption, and ease of programming.

Figure 3.3 Atmel

ESP32 Microcontroller

The ESP32 is a versatile, low-cost microcontroller that is equipped with both Wi-Fi and Bluetooth capabilities,making it ideal for IoT applications like real-time patient monitoring systems. It acts as the brain of the system, processing data from various medical sensors and enabling wireless communication with other devices. The ESP32 is selected for its powerful processing power, low power consumption, and ease of integration with sensors and cloud platforms like Firebase. It collects sensor data,processes it in real time, and transmits the information wirelessly to the cloud database. Additionally, its built-in Wi-Fi feature ensures that the system can update the nurse station's dashboard with real-time patient data, offering seamless communication between the system's hardware and software layers

Figure 3.4 ESP32

MAX30102 Sensor

The MAX30102 is an integrated sensor module that combines a pulse oximeter and a heart rate sensor in a single package. It is used to monitor two key physiological parameters: heart rate (beats per minute) and oxygen saturation (SpO2) levels in the blood. The sensor uses red and infrared light to measure the absorption of light by the blood vessels in the skin. It detects variations in light absorption as the blood pulses, allowing it to calculate heart rate and SpO2 levels. This sensor is particularly useful in detecting oxygen deficiency,which is vital for patients with respiratory issues or heart conditions.The MAX30102 sensor ensures that the system can provide real-time updates on the patient’s cardiac and respiratory health

Figure 3.5 MAX30102

RESPIRATORY SENSOR

The Respiration Sensor is employed to track abdominal or thoracical breathing, in biofeedback uses like stress reduction and relaxation training. In addition to tracking breathing rate, this sensor also provides you with a measure of the relative depth of breathing. The Nexus Respiration Sensor can be worn on top of clothing, but for optimal performance we recommend that there are only 1 or 2 layers of clothing between the sensor and the body. The Respiration Sensor is typically worn in the abdominal region, with the middle of the sensor positioned above the belly button. The sensor should be secured tightly enough to avoid loss of tension.

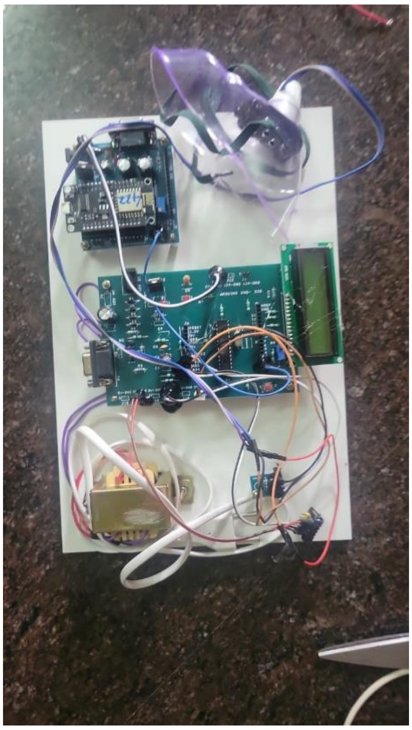
Figure 3.5 Respiratory sensor

IV. MODULES :

The performance indicators for the health system revolve around assessing the system's accuracy, efficiency, and effectiveness in real-time monitoring of patients and responding to emergencies. Some of the major indicators include the accuracy with which wearable sensor data can capture vital parameters like heart rate, oxygen saturation, and respiratory rate. These are measured against conventional diagnostic techniques to ensure validity. Moreover, response time is a key performance metric, calculated from data gathering to actionable insights creation. The system is designed to reduce latency, such that healthcare professionals are provided with real-time feedback to enable timely decision-making in emergency situations. Another key metric is the accuracy of anomaly detection by AI algorithms, which is measured by its sensitivity (true positive rate) and specificity (true negative rate). High sensitivity provides prompt detection of such conditions, while high specificity reduces false alarms, minimizing unnecessary interventions. Metrics related to usability, including smart watch visualization effectiveness and mobile app accessibility, are tracked to assess user satisfaction and medical staff adoption. These performance indicators as a whole help the system improve quality of care while streamlining resource utilization and workflow within medical centers.

V.RESULTS AND DISCUSSION :

Healthcare professionals to rapidly evaluate patient conditions and detect those in need of emergency care. The system's AI-powered analysis also issued timely warnings about declining conditions, which could be intervened upon in a timely manner. In general, the smart watch system was beneficial in enhancing the efficiency of emergency care and patient outcomes, given its potential as a cutting-edge tool in high-demand medical settings.



VI.CONCLUSION :

The IoT-enabled Patient Health Monitoring System provides an efficient solution for real-time patient tracking in hospital wards. By leveraging ESP32, Firebase, and smartwatch notifications, the system ensures continuous monitoring, rapid emergency response, and improved healthcare management. Future enhancements may include AI-based predictive analysis for early disease detection.

FUTURE ENHANCEMENTS :

By integrating machine learning algorithms that had been trained with large datasets, the system was able to forecast possible complications and send preemptive warnings to health professionals. This would enable doctors not only to react to current situations but also to foresee and prevent future danger, greatly enhancing patient outcomes.

ACKNOWLEDGEMENTS

We extend our sincere gratitude to Er. S.Senthazhai, Assistant Professor, Department of ECE, Krishnasamy College of Engineering & Technology, for their guidance and support throughout this project.

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