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Respiration Based Emergency Alert System

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Abstract: A In modern healthcare environments, continuous patient monitoring is important for the early detection of medical emergencies and timely medical assistance. However, in many hospitals, a limited number of medical staff must monitor multiple patients, which may lead to delayed responses when patients experience sudden health problems. To overcome this issue, this project proposes a Smart Patient Call System based on breathing pattern detection, which helps patients communicate emergency situations through automatic physiological monitoring.The system uses a wearable breathing sensor to continuously monitor the patient's respiration rate and detect changes in breathing patterns. Since breathing is a critical vital sign, abnormal patterns such as rapid breathing, slow breathing, heavy breathing, or interruptions in respiration can indicate possible medical problems. The breathing signals are processed by an embedded processing unit, which analyzes the data and compares it with predefined threshold values.When abnormal breathing patterns are detected, the system automatically generates an alert and sends it wirelessly to a central monitoring station, such as a nurse station. The alert is indicated using LED indicators and buzzer alarms, allowing caregivers to quickly identify patients who require attention.The system also includes an automatic escalation feature, which sends additional notifications through SMS or mobile alerts if the initial warning is not acknowledged within a certain time. This ensures that critical emergencies are not ignored.Overall, the proposed system improves communication between patients and healthcare providers, reduces response time during emergencies, and enhances patient safety by integrating breathing sensors, embedded processing, and wireless communication technologies.
Keyword: Respiratory Monitoring, IoT Healthcare, ESP32, MPX5010DP, ADS1115, Blynk IoT, ESP-NOW, Emergency Alert System, Breathing Pattern Detection, Embedded Systems.

I. INTRODUCTION

Respiration rate is an important vital sign that helps in identifying a person's health condition. Continuous monitoring of breathing is especially important for patients with respiratory diseases, elderly individuals, and patients in critical care units. Early detection of abnormal breathing patterns can help prevent serious health complications and improve patient safety. The proposed Respiration-Based Emergency Alert System using IoT continuously monitors a patient's breathing using a respiration sensor that detects airflow during inhalation and exhalation. These signals are processed by a microcontroller, and the data is transmitted through an IoT platform for remote monitoring. If the system detects abnormal respiration rates, it automatically sends alerts through mobile notifications, SMS, or internet-based alerts to caregivers. By combining sensor technology, embedded systems, and IoT communication, the system helps provide quick medical response, improve patient monitoring, and enhance safety in hospitals and home-care environments.

II. LITREATURE REVEW

[1] Early hospital communication systems were mainly based on manual nurse call buttons placed near the patient's bed. In 2010, J. G. Webster explained the working principle of traditional nurse call systems used in hospitals. In this system, patients can request help by pressing a push button, which sends a signal to the nurse station through wired communication. Although this system improves communication between patients and caregivers, it requires the patient to physically press the button.

Patients who are unconscious, paralyzed, or severely immobile may not be able to use this system effectively.[2]Biomedical monitoring technologies were later developed to measure important physiological parameters of the human body. In 2014, R. S. Khandpur studied various biomedical sensors used to monitor vital signs such as respiration rate, heart rate, and body temperature. Respiration sensors can detect airflow changes and breathing patterns accurately. These monitoring systems help doctors observe respiratory conditions, but they mainly focus on data monitoring and do not include automatic emergency alert mechanisms.[3] Wearable health monitoring devices were introduced to enable continuous patient monitoring. In 2018, a research study published by IEEE presented a wearable respiration monitoring system using pressure sensors. This system continuously tracks breathing patterns and provides real-time physiological data. Although the wearable design improves patient mobility and comfort, the system mainly focuses on monitoring and does not include a direct emergency alert system for caregivers.[4] With the advancement of communication technologies, voice-based assistance systems were developed to improve patient–caregiver interaction. In 2020, S. Kumar introduced a voice-based patient assistance system using speech recognition technology. Patients can request help using voice commands instead of pressing buttons. While this method provides hands-free communication, it cannot be used by patients who are unable to speak clearly or who are connected to ventilators.[5] Internet of Things (IoT) technology has also been applied in healthcare monitoring systems. In 2020, K. Singh proposed an IoT-based smart healthcare system that allows doctors to monitor patient health remotely through mobile devices. Sensors collect physiological data and transmit it to a cloud platform for analysis. Although this system improves remote monitoring, it does not specifically focus on respiration-based emergency alerts.[6] Modern healthcare technologies emphasize the importance of continuous monitoring of vital signs to improve patient safety. Many smart monitoring systems now integrate sensors, microcontrollers, and wireless communication modules to observe patient health conditions in real time. These systems provide valuable medical data but may not always include automatic emergency detection mechanisms.[7] Research studies also highlight the importance of respiration monitoring in detecting early signs of medical emergencies. Abnormal breathing patterns such as rapid breathing, slow breathing, or irregular respiration may indicate respiratory distress or other serious health problems. Continuous monitoring of breathing patterns can help healthcare providers respond quickly to critical situations.[8] Recent developments in smart healthcare technologies have introduced wearable and non-invasive sensors that can monitor physiological signals without causing discomfort to patients. These systems improve the convenience of patient monitoring, especially for elderly individuals and patients in critical care units.[9] However, many existing monitoring systems only collect and display physiological data without providing automatic alert mechanisms. As a result, caregivers must manually observe monitoring systems, which may delay response time during emergencies.[10] Therefore, there is a growing need for an intelligent healthcare monitoring system that can automatically detect abnormal respiration patterns and send alerts to caregivers. A respiration-based emergency alert system can help improve patient safety, reduce response time during medical emergencies, and provide efficient monitoring in hospitals and home-care environments.

III. METHODOLOGY

The proposed Respiration-Based Emergency Alert System monitors a patient's breathing continuously and detects abnormal respiratory conditions. A nasal cannula tube placed near the patient's nostrils captures airflow during inhalation and exhalation. The airflow creates small pressure changes that are detected by the MPX5010DP differential pressure sensor, which converts them into analogy electrical signals. These analogy signals are converted into digital data using the ADS1115 Analog-to-Digital Converter (ADC). The digital breathing data is then processed by the ESP32 microcontroller, which analyses the respiration pattern using threshold comparison and a time-window detection method to identify abnormal breathing conditions. When abnormal breathing such as slow, irregular, or stopped respiration is detected, the system activates local alerts through LEDs, a buzzer, and a 16×2 LCD display. At the same time, the ESP32 sends real-time notifications to caregivers' smartphones through the Blynk IoT platform using Wi-Fi. This methodology ensures continuous monitoring, accurate detection of respiratory emergencies, and quick medical response, improving patient safety in hospitals and healthcare environments.

A. System Design and Architecture

The proposed Respiration-Based Emergency Alert System is designed to monitor a patient's breathing continuously and detect abnormal respiration conditions. The system consists of a respiration sensing unit, signal processing unit, alert unit, and IoT communication unit. The nasal cannula and MPX5010DP pressure sensor detect airflow during breathing and convert it into analogy signals. These signals are converted into digital data using the ADS1115 ADC and processed by the ESP32 microcontroller to analyse the respiration pattern. When abnormal breathing is detected, the system activates alerts through LEDs, a buzzer, and an LCD display. At the same time, the ESP32 sends real-time data and notifications to the Blynk IoT platform via Wi-Fi, allowing caregivers to monitor the patient remotely and respond quickly to emergencies.

B. Hardware Components

The hardware components used in the proposed system include the nasal cannula tube, MPX5010DP differential pressure sensor, ADS1115 Analog-to-Digital Converter (ADC), ESP32 microcontroller, 16×2 LCD display, LEDs, buzzer, power supply, and IoT communication module. These components work together to monitor the patient's breathing and generate alerts during abnormal respiratory conditions. The nasal cannula and pressure sensor detect airflow changes during breathing and convert them into analogy signals. The ADS1115 ADC converts these signals into digital data, which is processed by the ESP32 microcontroller to analyse the respiration pattern.

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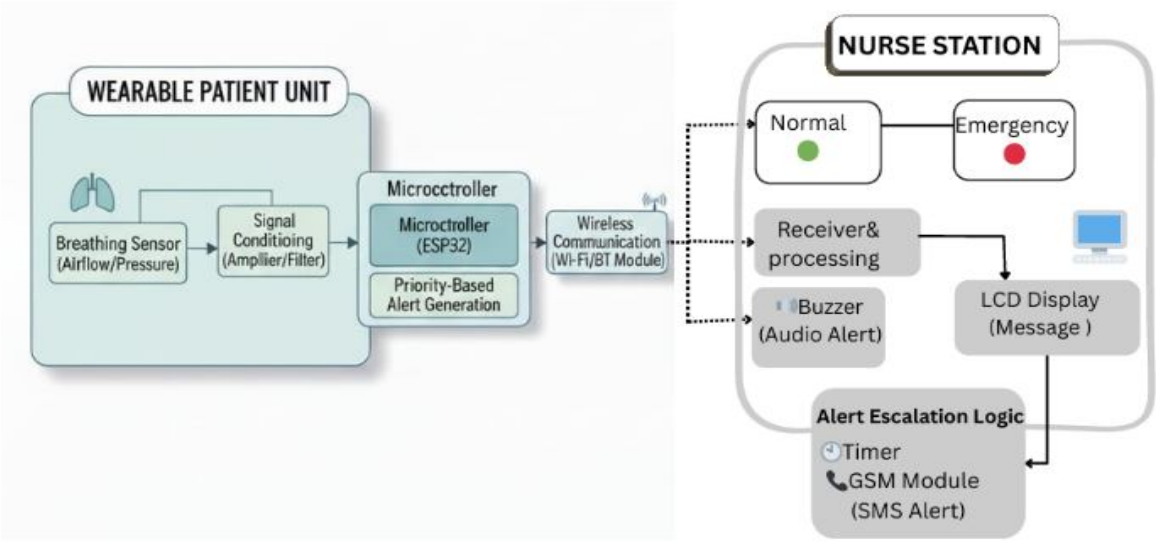

Fig1.1 Block Diagram

When abnormal breathing is detected, the system activates alerts through LEDs, a buzzer, and an LCD display. The ESP32 also sends real-time breathing data and notifications to the Blynk IoT platform via Wi-Fi, enabling remote monitoring by caregivers.

B. Data Acquisition and Processing

The system continuously collects breathing data from the patient using a nasal cannula tube placed near the nostrils. As the patient inhales and exhales, airflow through the tube creates small pressure variations that represent the breathing pattern. The MPX5010DP differential pressure sensor detects these pressure changes and converts them into analogy electrical signals. These analogy signals are then transmitted to the ADS1115 Analog-to-Digital Converter (ADC), which converts them into digital data for accurate processing. The ESP32 microcontroller receives the digital breathing data and analyses the respiration rate and pattern using predefined threshold values and a time-window detection method. Signal processing within the microcontroller ensures that breathing data is interpreted accurately and abnormal conditions such as slow, rapid, irregular, or stopped breathing are detected quickly.

C. Bluetooth-Based Control System

The system enables wireless communication between the monitoring device and the caregiver through an IoT-based mobile application. Caregivers can monitor the patient's breathing status and receive alerts through the mobile interface in real time. The ESP32 microcontroller uses its built-in Wi-Fi module to transmit breathing data to the IoT cloud platform. The mobile application receives this data and displays the patient's respiration status, allowing caregivers to observe the breathing pattern remotely. The communication system ensures that any abnormal breathing condition detected by the system is immediately reported through notifications. This wireless communication enables quick response from caregivers and improves patient monitoring even when medical staffs are not physically near the patient.

D. Motor Control Mechanism

The system controls the operation of output devices to generate alerts when abnormal breathing conditions are detected. The ESP32 microcontroller processes the respiration data and determines whether the breathing pattern is normal or abnormal. Based on the analysis, the microcontroller activates the alert devices such as LEDs, buzzer, and LCD display. The green LED indicates normal breathing, while the red LED and buzzer are activated during abnormal or emergency conditions. The LCD display shows the patient's breathing status for easy monitoring. This control mechanism ensures that alerts are generated quickly and accurately, enabling caregivers to respond immediately to potential respiratory emergencies.

E. System Operation and Testing

The system operates by continuously monitoring the patient's breathing using the nasal cannula and pressure sensor. The airflow changes during inhalation and exhalation are detected by the MPX5010DP sensor and converted into analogy signals. These signals are then digitized using the ADS1115 ADC and processed by the ESP32 microcontroller to analyse the respiration pattern. The system was tested under different breathing conditions to verify its performance. During testing, the device successfully detected normal and abnormal breathing patterns and activated the alert mechanisms accordingly. Local alerts such as LEDs, buzzer, and LCD display functioned properly, and notifications were also sent to the mobile application through the IoT platform.

The testing results confirm that the system operates reliably and can effectively detect respiratory abnormalities, ensuring timely alerts and improved patient safety.

F. User Control Interface

The system provides a user control interface through a mobile application for monitoring the patient's breathing status. Caregivers and doctors can access the interface using a smartphone to view real-time respiration data and system alerts.

The ESP32 microcontroller sends breathing data to the IoT cloud platform through Wi-Fi. The mobile application receives this information and displays the patient's breathing condition with clear status messages such as normal breathing or emergency alert. This user interface allows caregivers to monitor patients remotely and receive instant notifications during abnormal breathing conditions. It ensures quick response to emergencies and improves overall patient monitoring efficiency.

G. Testing and Evaluation

The developed system is tested to evaluate its performance and reliability in monitoring the patient's breathing. Different breathing conditions such as normal breathing, slow breathing, and irregular breathing are tested to verify the proper functioning of the respiration sensing unit and data processing system. The pressure sensor and ADC conversion process are also tested to ensure accurate detection and transmission of breathing signals to the ESP32 microcontroller. The microcontroller processing and alert mechanisms such as LEDs, buzzer, and LCD display are observed to confirm that the system responds quickly when abnormal breathing is detected. Multiple test trials are conducted to verify continuous monitoring, accurate respiration detection, and system stability. The IoT communication is also tested to ensure that breathing data and emergency alerts are successfully sent to the mobile application. The testing results confirm that the system reliably detects abnormal breathing and provides timely alerts to caregivers.

H. Expected Outcome

The expected outcome of the proposed system is to provide continuous and reliable monitoring of a patient's breathing. The system should be able to accurately detect airflow changes during inhalation and exhalation and determine the patient's respiration rate and breathing pattern. When abnormal breathing conditions such as slow, irregular, or stopped respiration occur, the system is expected to immediately activate alert mechanisms including LEDs, buzzer, and LCD display. At the same time, notifications should be sent to caregivers through the IoT-based mobile application. The system is expected to improve patient safety by enabling early detection of respiratory emergencies and ensuring timely medical assistance. It also aims to reduce the need for constant manual monitoring by healthcare staff while providing reliable remote monitoring capabilities

G. Result

The proposed Respiration-Based Emergency Alert System was developed and tested to evaluate its performance in monitoring a patient's breathing and detecting abnormal respiratory conditions. The system was tested under different breathing scenarios to analyze sensing accuracy, response time, and reliability of the alert and IoT communication system. Experimental results show that the system effectively monitors respiration using the integrated nasal cannula tube, MPX5010DP pressure sensor, ADS1115 ADC, and ESP32 microcontroller.

Fig1.2 Respiration Based Emergency Alert System

During testing, the respiration sensing unit successfully detected airflow changes during inhalation and exhalation. The pressure variations captured by the sensor were accurately converted into electrical signals and processed by the ESP32 microcontroller after ADC conversion. The system was able to identify normal breathing as well as abnormal conditions such as slow, irregular, or stopped respiration. When abnormal breathing was detected, the alert mechanisms including LEDs, buzzer, and LCD display were activated immediately to notify nearby caregivers. At the same time, the ESP32 transmitted real-time breathing data and alert notifications to the mobile application through the IoT platform, ensuring remote monitoring and quick medical response. The response time of the system from abnormal respiration detection to alert activation was observed to be very fast, allowing caregivers to take immediate action. The experimental results confirm that the system operates reliably and provides continuous respiration monitoring with real-time alerts. Overall, the developed system demonstrates effective respiratory monitoring, early detection of breathing abnormalities, and timely emergency notifications. This system can improve patient safety, support healthcare staff in monitoring multiple patients, and provide a practical solution for continuous respiration monitoring in hospitals and healthcare environments.

IV. CONCLUSION & FUTURE SCOPE

The Respiration-Based Emergency Alert System was successfully developed to monitor a patient's breathing and provide immediate alerts during abnormal respiratory conditions. The system uses components such as a nasal cannula tube, MPX5010DP differential pressure sensor, ADS1115 Analog-to-Digital Converter, and ESP32 microcontroller to detect airflow changes and analyze breathing patterns. The system also includes LEDs, a buzzer, and an LCD display to provide local alerts, while IoT communication enables remote monitoring through a mobile application. The testing results show that the system accurately detects breathing patterns and quickly identifies abnormal conditions, which helps improve patient safety and reduces the need for continuous manual monitoring by healthcare staff. The system also offers a reliable and cost-effective solution for respiration monitoring in hospital and healthcare environments. In the future, the system can be improved by integrating additional medical sensors such as heart rate and oxygen saturation sensors to provide more comprehensive patient monitoring. Advanced data processing techniques can be implemented to improve the accuracy of abnormal breathing detection. Further improvements may include cloud-based data storage, integration with hospital monitoring systems, and enhanced IoT connectivity for real-time healthcare management. These developments can transform the system into a smart patient monitoring platform, improving patient care and supporting healthcare staff in managing critical patients more efficiently.

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