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Automatic Patient Bed Position Control System Using Pressure Monitoring

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Abstract: This paper presents the design and implementation of an Automatic Patient Bed Position Control System using pressure monitoring technology. Patients who remain in the same position for extended periods are at risk of developing pressure ulcers and discomfort. The proposed system uses pressure sensors to monitor the distribution of pressure on the patient's body. The sensed data is processed using a microcontroller to determine whether the patient has been in the same position for a prolonged duration. If abnormal pressure patterns are detected, the system automatically adjusts the bed position using motorized control mechanisms. The system also provides alerts to caregivers and enables remote monitoring using IoT technology. This solution improves patient comfort, reduces the workload of healthcare staff, and enhances hospital automation.
Keywords: Smart Healthcare, Pressure Sensor, Arduino, Automatic Hospital Bed, IoT Monitoring

1. INTRODUCTION

Modern healthcare systems increasingly rely on automation and intelligent monitoring technologies to improve patient safety and quality of care. One major issue in hospitals and homecare environments is the development of pressure ulcers caused by patients remaining in the same position for long periods of time. Pressure ulcers not only cause discomfort but may also lead to severe medical complications if not addressed in time. The Automatic Patient Bed Position Control System using Pressure Monitoring is designed to address this issue. The system uses pressure sensors placed on the bed surface to continuously monitor the pressure exerted by the patient's body. The sensor data is analyzed by a microcontroller, which determines whether the patient needs repositioning. When necessary, motors automatically adjust the bed position to redistribute pressure and improve patient comfort. Additionally, the system integrates Internet of Things (IoT) technology to allow remote monitoring of patient conditions by healthcare professionals. This approach not only improves patient safety but also reduces manual workload for caregivers.

2. LITERATURE REVIEW

[1] A smart bed system for pressure ulcer prevention was proposed by Brush et al., which integrates sensors and automated control mechanisms to adjust bed posture based on patient conditions. Their work highlights the importance of continuous pressure monitoring and adaptive positioning to reduce prolonged stress on specific body areas.

[2] Sivanantham developed a smart bed system capable of measuring physiological parameters such as heartbeat, respiration, and body movement. The study demonstrated that integrating multiple sensors into hospital beds can enhance patient monitoring and provide real-time health insights.

[3] Silva et al. introduced an intelligent sensor-based system for pressure ulcer prevention. Their research emphasized continuous pressure monitoring and early detection of risk conditions, significantly improving patient safety in clinical environments.

[4] Ajami and Khaleghi explored wireless sensor-based monitoring systems where hospital beds are integrated with sensors to detect patient movement and pressure distribution. This approach enables timely intervention and reduces the occurrence of pressure-related injuries.

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[5] Dash et al. proposed an IoT-based health monitoring system that continuously collects and transmits patient data, allowing healthcare professionals to monitor patients remotely and make timely decisions.
[6] Advanced smart mattress systems have been developed to monitor body pressure distribution using embedded sensors, helping in posture detection and effective prevention of pressure ulcers.
[7] IoT-based smart healthcare frameworks have also been explored to integrate multiple patient monitoring devices into a unified system. These systems enable real-time data sharing, remote access, and improved coordination between caregivers and medical professionals.
[8] Research on smart healthcare monitoring using IoT platforms has shown that continuous tracking of patient parameters such as temperature, heart rate, and oxygen saturation can significantly improve early diagnosis and emergency response in hospitals.
[9] Systematic studies on in-bed monitoring technologies highlight the use of multiple sensors, including pressure, motion, and physiological sensors, to provide a comprehensive understanding of patient conditions and ensure better clinical outcomes.
[10] Recent developments in intelligent healthcare systems focus on combining automation with sensor-based monitoring to reduce the workload of caregivers while maintaining high-quality patient care and safety.

3. PROPOSED SYSTEM

The proposed system focuses on developing an intelligent patient bed that can automatically adjust its position while continuously monitoring important health parameters. The system integrates pressure sensing technology, vital parameter monitoring, motorized bed control, and wireless communication into a single platform. The primary objective of this system is to improve patient comfort and reduce the workload of healthcare providers. The central control unit of the system is the Arduino Uno microcontroller, which processes the data received from various sensors. Sensors such as temperature, heart rate, and oxygen saturation (SpO) are used to monitor the patient's health condition. These sensors continuously collect physiological data and send the information to the microcontroller for analysis. A pressure sensing device, specifically a Force Sensing Resistor, is placed beneath the patient or on the bed surface to measure the pressure exerted by the patient's body. By analyzing the pressure distribution, the system can identify the patient's posture and detect any imbalance or improper positioning on the bed. When the system detects uneven pressure or an uncomfortable posture, the microcontroller sends signals to the motor driver circuit. The motor driver then activates DC gear motors that adjust the position of different sections of the bed, such as the head or leg section. This automated movement helps maintain a comfortable and safe position for the patient without requiring manual intervention. To enable remote monitoring, a Wi-Fi communication module such as the NodeMCU is integrated into the system. The module allows the collected health data to be transmitted to an external monitoring platform or mobile application. This feature enables caregivers or medical professionals to monitor the patient's condition from a remote location. Additionally, the system includes a display unit that shows the patient's vital parameters in real time. An alert mechanism using a buzzer is also incorporated to notify caregivers if abnormal health conditions are detected. Overall, the proposed system combines automated bed control and patient monitoring to enhance patient care and hospital efficiency.

Fig 3.1. Framework of the model

3.1 IDEA OF THE SYSTEM

The main idea of the proposed system is to design a smart patient bed that can automatically adjust its position while monitoring important health parameters. Patients who remain in bed for long periods often require frequent adjustments for comfort and proper body support. patients who stayed in one position for extended periods were at risk of developing pressure ulcers. Manual adjustment by caregivers can be time-consuming, especially in hospitals with many patients. To address this issue, the system uses sensors to monitor vital parameters such as temperature, heart rate, oxygen saturation, and body pressure on the bed. A microcontroller processes these readings and determines whether the bed position needs adjustment. By combining sensing technology, automated control, and wireless communication, the system aims to improve patient comfort and assist healthcare providers in monitoring patient conditions.

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3.2 SYSTEM EXPLANATION

The system operates by collecting data from different sensors placed near the patient and on the bed surface. The sensor readings are processed by the Arduino Uno, which acts as the main control unit. A pressure sensor such as a Force Sensing Resistor detects the pressure distribution on the bed and helps identify the patient's posture. If the system detects uneven pressure or an uncomfortable position, the microcontroller activates the motor driver to control the bed movement through DC motors. At the same time, the patient's vital parameters are displayed on an LCD screen. A Wi-Fi module like the NodeMCU transmits the data for remote monitoring, while a buzzer alerts caregivers when abnormal conditions occur.

4. COMPONENTS OF THE SYSTEM

The proposed automatic patient bed control system consists of both hardware and software components that work together to monitor patient health parameters and control the bed position automatically. The hardware components are responsible for sensing, processing, and performing mechanical actions, while the software components manage data processing, communication, and system control. The integration of these elements enables the system to function as an intelligent healthcare support device.

4.1 HARDWARE COMPONENTS

Hardware components are the physical electronic devices used to build the system. These devices collect information from the patient, process the signals, and perform actions such as adjusting the bed position or displaying data.

1.Microcontroller Unit

Fig 4.1 Arduino UNO

The Arduino Uno serves as the central controller of the system. It receives signals from various sensors, processes the data according to the programmed logic, and controls output devices such as motors, displays, and alarms.

2. Wireless Communication Module

The NodeMCU provides wireless connectivity for the system. It allows the collected health data to be transmitted to a remote monitoring platform so that healthcare professionals can observe the patient's condition from another location.

Fig 4.2 NodeMCU

3. Health Monitoring Sensors

Sensors are used to measure the patient's vital parameters. A temperature sensor measures body temperature, the heart rate sensor detects the patient's pulse, and the SpO_2 sensor monitors the oxygen saturation level in the blood. These measurements help determine the patient's overall health condition.

A. Temperature sensor

Fig 4.3.1 Temperature Sensor

B. SpO Sensor

The SpO sensor measures the oxygen saturation level in the blood. It uses a light-based sensing technique to detect how much oxygen is carried by the blood and sends the measured value to the Arduino Uno for processing and display.

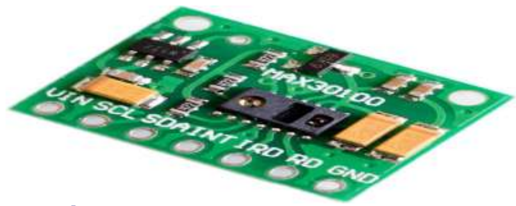

Fig 4.3.2 SpO and Heart Rate Sensor

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C. Heart Rate Sensor

The heart rate sensor detects the patient's pulse and calculates the number of heart beats per minute (BPM). The sensed pulse signal is processed by the Arduino Uno and the result is displayed on the LCD screen.

4. Pressure Detection Sensor

A Force Sensing Resistor is used to detect the pressure applied by the patient on the bed surface. By analyzing pressure distribution, the system can identify the patient's posture and determine whether a change in bed position is required.

Fig 4.4 Pressure Sensor

5. Display Unit

An LCD display is used to present important system information such as body temperature, heart rate, oxygen level, and system status. This display allows caregivers to quickly understand the patient's condition.

Fig 4.5 LCD Display

6.Motor Driver Circuit

The L293D acts as an interface between the microcontroller and the motors. It enables the microcontroller to control the direction and operation of the motors used for adjusting the bed.

Fig 4.6 Motor Driver Circuit

7. Actuator Mechanism

DC gear motors are used to move the bed sections such as the head or leg portion. The gear mechanism provides sufficient torque to lift and lower the bed smoothly.

08. Alert System

A buzzer is included to provide an audible warning when abnormal conditions are detected, such as high temperature or improper pressure distribution on the bed.

4.2 SOFTWARE COMPONENTS

Software components control the operation of the hardware devices and ensure proper communication between different parts of the system. The software is responsible for collecting sensor data, processing the information, and controlling the automated bed movement.

1. Embedded Programming

The system is programmed using embedded software that runs on the microcontroller. This program continuously reads the sensor values, compares them with predefined thresholds, and determines whether an action is required.

2. Control Algorithm

The software includes a control algorithm that analyzes the pressure sensor readings and vital parameter data. Based on these values, the algorithm decides whether the bed position needs adjustment and activates the motors accordingly.

3. Communication Software

Communication protocols are used to send the patient's health data from the microcontroller to the Wi-Fi module. The Wi-Fi module then transfers the data to a remote monitoring platform or cloud server.

4. Monitoring Interface

The system software also manages the display interface that shows patient parameters on the LCD screen. This allows caregivers to easily monitor the system without additional devices. Overall, the combination of hardware and software components enables the proposed system to monitor patient health parameters, detect pressure distribution on the bed, and automatically adjust the bed position when necessary. This integrated approach improves patient comfort, enhances safety, and reduces the workload of healthcare providers.

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5. METHODOLOGY

The methodology describes how the proposed system monitors the patient's health parameters, detects pressure on the bed, processes the collected data, and automatically adjusts the bed position. The system operates through a sequence of sensing, data processing, decision making, and mechanical actuation. Each stage plays an important role in ensuring that the patient's comfort and safety are maintained.

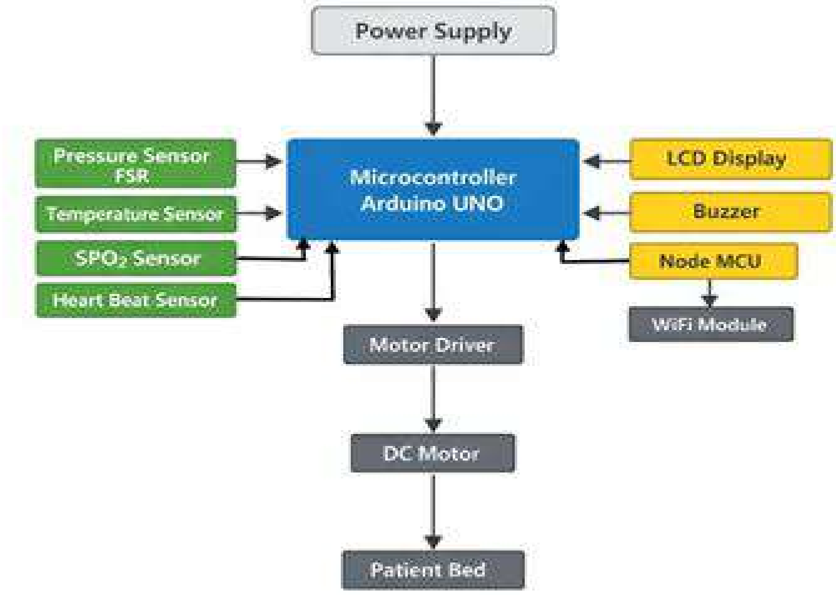

Fig 5.1 Block Diagram

A. Sensor Data Acquisition

The first stage of the system involves collecting data from different sensors placed on or near the patient. Sensors are responsible for measuring physiological parameters and physical pressure applied on the bed surface. The temperature sensor measures the body temperature of the patient. It converts thermal energy into an electrical signal that can be interpreted by the microcontroller. Continuous monitoring of body temperature helps in identifying abnormal conditions such as fever. The heart rate sensor measures the pulse rate of the patient. It typically works by detecting variations in blood flow through optical sensing. When the heart pumps blood, small changes in light absorption occur in the blood vessels, and these changes are detected by the sensor to calculate the pulse rate. The SpO sensor measures the oxygen saturation level in the patient's blood. It uses light-based sensing methods to determine the percentage of oxygen present in the bloodstream. Monitoring oxygen saturation helps detect respiratory issues or insufficient oxygen supply. A pressure sensing device such as a Force Sensing Resistor is placed on the bed to measure the pressure exerted by the patient's body. When pressure is applied to the sensor, its electrical resistance changes. This variation in resistance is converted into a voltage signal that indicates the amount of force applied. By analyzing this pressure distribution, the system can determine whether the patient's position is balanced or needs adjustment.

B. Data Processing by the Microcontroller

All sensor signals are sent to the main controller, which in this system is the Arduino Uno. The microcontroller reads the analog or digital signals generated by the sensors and converts them into numerical data. The Arduino processes the received data using programmed instructions stored in its memory.

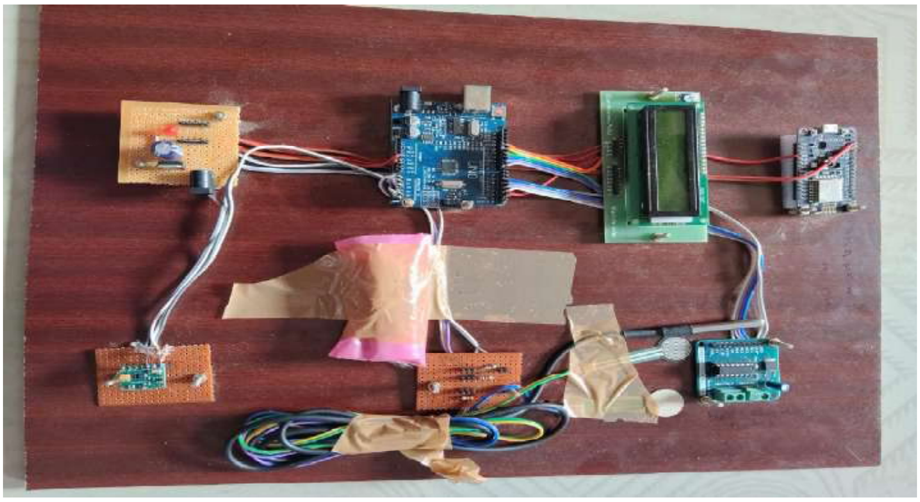

Fig 5.2 Circuit Kit

The sensor values are continuously compared with predefined threshold values to determine whether the patient's condition is normal or abnormal. For example, if the temperature exceeds a safe limit or if pressure distribution indicates an uncomfortable posture, the system identifies the need for corrective action. The microcontroller also coordinates communication between different components of the system. It sends processed data to the display unit and transmits information to the wireless communication module for remote monitoring.

C. Decision-Making Process

After analyzing the sensor data, the microcontroller decides whether the bed position needs to be changed. The decision-making process is based on pressure readings and the patient's health parameters. If the pressure sensor detects uneven pressure distribution or prolonged pressure on a specific area of the bed, the system assumes that the patient's posture may cause discomfort or lead to health complications such as pressure sores. In such cases, the microcontroller generates control signals to activate the motor driver circuit. Similarly, if abnormal health parameters are detected, the system can trigger an alert through a buzzer so that caregivers are notified immediately.

D. Motor Control and Bed Adjustment

The bed adjustment mechanism is controlled using DC gear motors connected through a motor driver. The motor driver acts as an interface between the microcontroller and the motors. The microcontroller sends control signals to the motor driver, which then supplies the required current to operate the motors. Depending on the control signal, the motors rotate in different directions to raise or lower sections of the bed. This allows the head or leg portion of the bed to move until a comfortable position is achieved.

The motors continue to operate until the desired adjustment is completed. Once the pressure distribution becomes balanced, the system stops the motor movement automatically.

E. Data Display and Remote Monitoring

The processed sensor data are displayed on an LCD screen so that caregivers can observe the patient's condition directly. Parameters such as temperature, heart rate, and oxygensaturation are shown in real time.

Fig 5.3 Data Display

For remote monitoring, the system uses a wireless communication module such as the NodeMCU. The module transmits the collected data to an online monitoring platform or server. This allows healthcare providers to monitor patient information from a remote location.

F. Alert Mechanism

To improve patient safety, the system includes an alert mechanism using a buzzer. When abnormal conditions are detected, such as high temperature, low oxygen levels, or excessive pressure on the bed, the buzzer produces an audible warning signal. This ensures that caregivers can quickly respond to emergency situations. Overall, the methodology integrates sensor data collection, microcontroller-based processing, automated motor control, and wireless communication. Through this process, the system can monitor patient health conditions, detect posture-related issues, and automatically adjust the bed position to improve patient comfort and safety.

6. ALGORITHM

The algorithm describes the logical sequence followed by the system to monitor patient parameters and automatically adjust the bed position. The microcontroller reads the sensor values, processes the data, and controls the motor movement whenever required.

Step1: Start the system and initialize all hardware components including sensors, display, and communication modules.
Step2: Activate the sensors and begin collecting data such as body temperature, heart rate, oxygen saturation level, and pressure on the bed.
Step3: Send the sensor signals to the Arduino Uno for processing.
Step4: Convert the incoming sensor signals into digital values and display the measured parameters on the LCD screen.
Step5: Compare the obtained values with predefined threshold limits to determine whether the patient's condition is normal.
Step6: Read the pressure values from the Force Sensing Resistor to evaluate the patient's posture and pressure distribution on the bed.
Step7: If uneven pressure or an uncomfortable position is detected, send a control signal to the motor driver to activate the DC motors and adjust the bed position.
Step8: If abnormal health parameters such as high temperature or low oxygen level are detected, activate the buzzer to generate an alert for caregivers.
Step9: Transmit the patient's health data to the monitoring system through the NodeMCU for remote observation.
Step10: Repeat the monitoring and adjustment process continuously to ensure patient comfort and safety.
Step11: Stop the system when it is manually turned off.

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7. RESULT

The proposed patient bed monitoring system was tested to observe the performance of the sensors and the bed adjustment mechanism. During testing, the sensors successfully measured the patient's vital parameters such as body temperature, heart rate, and oxygen saturation level. The collected data were processed by the Arduino Uno and displayed on the LCD screen. The temperature readings obtained during testing were within the normal human body range of approximately 36°C to 37.5°C. The heart rate values were observed between 70 and 90 beats per minute, which is considered a normal resting pulse rate for most individuals. Similarly, the oxygen saturation (SpO) readings were between 95% and 99%, indicating a healthy oxygen level in the blood. The pressure sensor, implemented using a Force Sensing Resistor, detected whether the patient remained in the same position for a certain period. When the predefined time limit was reached, the system automatically activated the motor mechanism to slightly adjust the bed position. This helps reduce continuous pressure on the same body area and improves patient comfort. The system also transmitted sensor data through the Wi-Fi communication module using the NodeMCU, allowing remote monitoring of patient parameters. The experimental results show that all the monitored parameters remained within acceptable ranges during testing, and the bed adjustment mechanism responded correctly when the time limit for a fixed position was reached. Therefore, the system demonstrates reliable performance in monitoring patient conditions and assisting in automatic bed positioning.

Table 7.1 (For our experimental testing we have set the timing in seconds.)

Test No	Temp(°C)	Heart Rate (BPM)	SpO_2	Time in same position in sec	Bed Position
1	36.9	79	97	10	Center
2	36.7	74	97	25	Left
3	37.5	82	98	50	Right

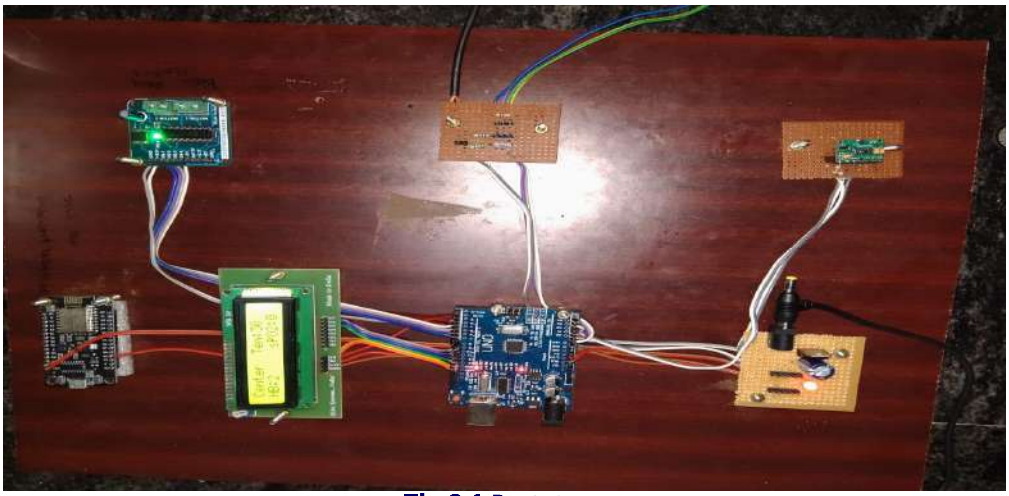

Fig 8.1 Prototype

Fig 8.2 Right Side Bed Position

In future: The system can be improved by integrating a mobile application for remote monitoring of patient health parameters. Advanced sensors and artificial intelligence techniques can be included to analyze patient conditions more accurately and provide early warnings. Cloud storage can also be used to maintain patient data for long-term medical analysis. Additionally, the system can be enhanced with an emergency alert feature to notify caregivers during abnormal conditions and a battery backup to ensure continuous operation during power failures.

9. CONCLUSION

This paper presented the design and implementation of an Automatic Patient Bed Position Control System using pressure monitoring technology. The system provides continuous monitoring of patient pressure distribution and automatically adjusts the bed position when necessary. The integration of IoT allows caregivers to monitor patient conditions remotely. The proposed system can help prevent pressure ulcers, improve patient comfort, and reduce the workload of healthcare staff.

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