+Enhancing Patient Comfort: A Smart Ward Room Temperature Monitoring System

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ABSTRACT. The Smart Ward Room Temperature Monitoring System is designed to enhance temperature regulation and patient comfort in hospital wards by addressing inefficient ventilation, excessive heat, and power outages. This system maintains optimal temperature conditions by adjusting fan and cooling appliance speeds using IoT-based temperature sensors and smart control algorithms. The required hardware components include a desktop computer, Arduino board, Wi-Fi module, exhaust cooling fan, LCD display, resistors, jumper wires, backup battery, Diode N1007, and an Android mobile device. The software used consists of Arduino IDE and Blynk IoT for remote monitoring and also the programming language used is C++. Following the ISO/IEC 25010 quality model, the system achieved an average rating of 4.70 in functionality, usability, and reliability. Key features include automated fan control, real-time temperature tracking, and remote access via mobile devices, reducing energy consumption and manual adjustments. System testing demonstrated improved energy efficiency, enhanced patient comfort, and stabilized room temperatures. Iterative development and testing helped refine data accuracy. To further enhance the system, researchers recommend adding alert notifications for temperature fluctuations, integrating a humidity sensor for improved precision, and implementing data logging for trend analysis. They also suggest utilizing solar power to improve reliability and developing a custom program to strengthen security and privacy. These improvements will make the system more efficient, sustainable, and secure, ensuring patient comfort in extreme conditions and serving as a model for intelligent monitoring in medical facilities.

Keywords: Smart Ward Temperature Monitoring System

1. Introduction

Maintaining patient comfort in hospital wards during severe weather is crucial since heat waves may complicate temperature control and become hazardous to human health, particularly for susceptible populations like children and the elderly [1]. Power outages exacerbate this issue by incapacitating temperature control systems, resulting in hazardous indoor environments [2].

On April 22, 2024, Iligan City registered a heat index of 45°C, which puts into perspective the gravity of the situation. Notwithstanding occasional rain, the blistering heat immediately came back and impacted comfort even indoors [3]. Ineffective air circulation from the absence of exhaust fans enhances discomfort and ailments, especially in patients with breathing ailments [4].

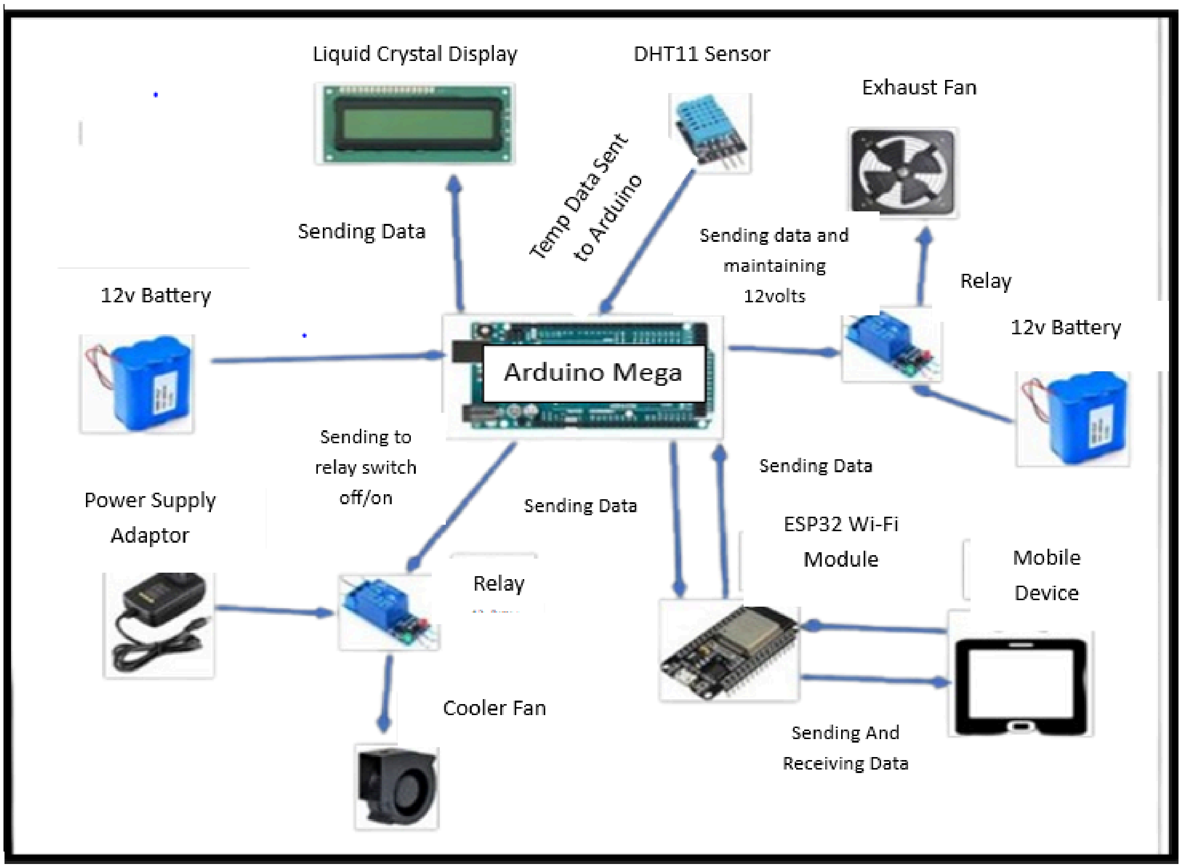
An intelligent ward room temperature monitoring system, driven by IoT sensors, assists in controlling indoor climate by monitoring indoor/outdoor and body temperatures. It enables smart control of heating, ventilation, and air-conditioning systems, decreasing dependence on huge HVAC units and increasing energy efficiency [5], [6].

The system also manages fan and exhaust fan speed, tracks body temperature, provides remote access using Wi-Fi, and has a backup battery to ensure operation during power loss, enhancing patient comfort and system reliability [7].

2. Addressing the Challenge

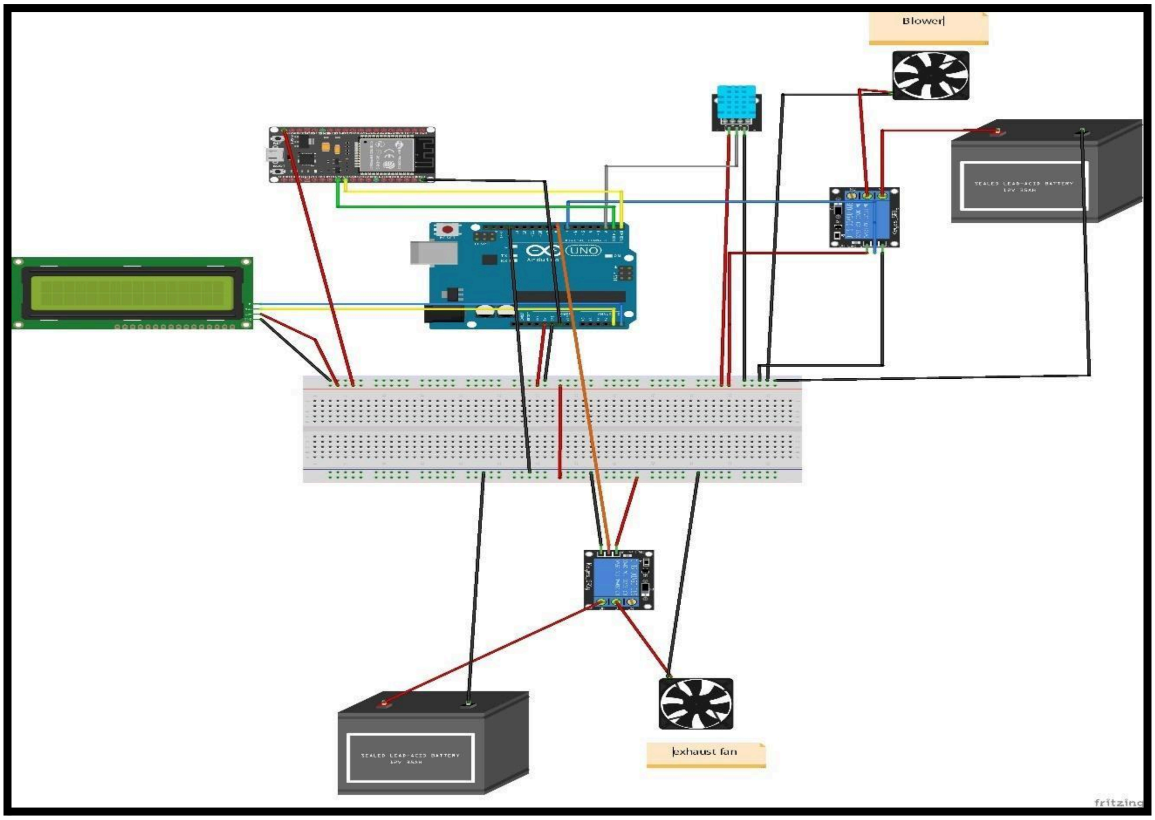
According to the Iligan City Disaster Risk Reduction and Management Office, the city recorded a heat index of 45°C on April 22, 2024. Such extreme heat exacerbates the need for effective hospital temperature control systems. Poor air circulation in hospital wards can lead to high humidity and stagnant air, further affecting patients' health, especially those with respiratory conditions.
To tackle these challenges, a smart ward room temperature monitoring system has been developed. This system integrates sensors and Internet of Things (IoT) devices to monitor and regulate temperature and air circulation dynamically. By automating fan and exhaust speed based on real-time temperature data, the system enhances patient comfort and reduces dependence on conventional HVAC systems, promoting energy efficiency.

3. System Design and Functionality



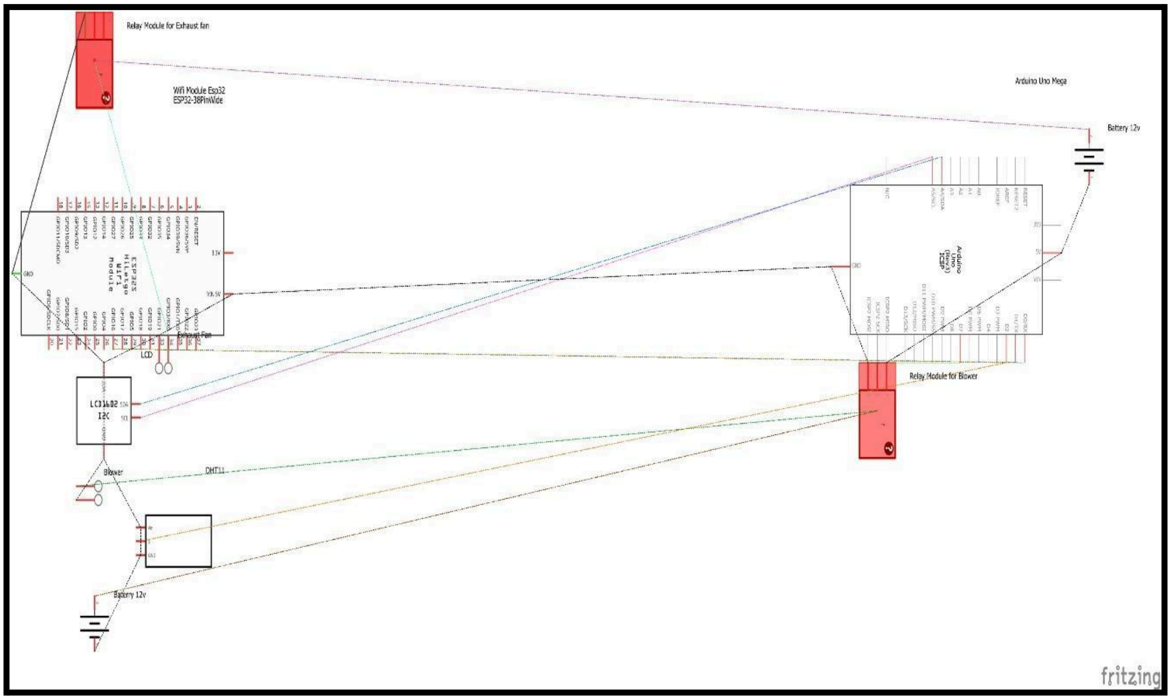
The smart ward temperature monitoring system employs a DHT11 sensor to measure temperature and humidity levels, while an Arduino microcontroller processes this data. An ESP32 Wi-Fi module allows real-time monitoring and control via a smartphone application. The system also features an exhaust fan and cooling fan that adjust their speeds dynamically based on environmental conditions. To address power outage concerns, the system includes a backup battery that ensures continued operation of the exhaust fan, preventing excessive heat buildup even during blackouts. The smart system also provides real-time temperature updates on an LCD display, ensuring nurses and caregivers can easily monitor and adjust settings as needed.

4. Circuit Diagram



The system uses a DHT11 sensor, relay-controlled fans, a 12V battery, an ESP8266 Wi-Fi module, and an LCD, with an Arduino Uno as the main controller. It continuously monitors temperature and humidity, displaying results on a 16x2 LCD. Fans activate when the temperature exceeds 28-30°C, with an exhaust fan turning on above 30°C, and they turn off below 27.5°C. The system enables automatic fan control and remote monitoring via ESP8266, potentially using Blynk IoT. It offers an affordable, energy-efficient cooling solution for hospital wards, smart homes, and remote monitoring applications.

5. Schematic Diagram



The smart temperature monitoring system is designed using an Arduino Uno and Arduino Mega as controllers. It integrates a DHT11 sensor, ESP8266 Wi-Fi module, and relay modules to manage blower and exhaust fans powered by 12V batteries. The Arduino Mega controls the relay modules, switching fans ON or OFF based on temperature thresholds, while the Arduino Uno reads temperature data and displays it on an LCD screen. Remote monitoring and control are enabled via the Blynk IoT App. This system is highly beneficial for hospital wards, smart home automation, and remote temperature management.

6. Testing and Performance

Extensive testing was conducted to evaluate the system's effectiveness in maintaining optimal ward temperatures. Various scenarios were tested, including:

- Without Cooling Mechanisms: Maximum temperature reached 32.6°C.
- With a Cooling Fan: Reduced temperature to a range of 28.0°C to 31.8°C.
- With an Exhaust Fan: Improved air circulation, achieving a lower minimum temperature of 27.3°C.
- Combination of Cooling and Exhaust Fan: Provided the most efficient cooling, maintaining a temperature range of 26.6°C to 32.5°C.
- The results highlight the effectiveness of integrating both a cooling fan and an exhaust fan to ensure optimal ward temperatures, making the system ideal for hospital settings.

Summary, Conclusion, and Recommendations

7. Summary of Findings

The objective of this research was to evaluate the performance and purpose of the newly developed Automated Real-Time Temperature Monitoring System for Hospital Wards, which integrates DHT11 sensors, an exhaust fan, and a cooler fan, under real-world applications. The major findings of the study are summarized as follows:

1. The temperature fluctuations in hospital wards could be accurately sensed with DHT11 temperature sensors, enabling real-time monitoring and adjustment of cooling systems.
2. The cooling fan and exhaust fan significantly improved system performance by maintaining optimal temperature levels, ensuring patient comfort and equipment functionality.
3. The prototype demonstrated effective cooling, temperature adaptability, and suitable airflow management under various environmental conditions.
4. IoT controls enhanced user experience by allowing remote monitoring and real-time adjustments to cooling settings.
5. The tests demonstrated the system's ability to maintain ideal conditions for extended periods, proving its effectiveness in healthcare facilities.

8. Conclusion

The Automated Real-Time Temperature Monitoring System for Hospital Wards is a significant advancement in addressing thermal issues in healthcare settings. By integrating advanced cooling solutions, such as an exhaust fan and cooling fan, the system ensures patient comfort and equipment reliability. Its adaptability to varying temperature conditions, combined with IoT-enabled remote monitoring and control, enhances usability and convenience for healthcare personnel. The system's efficient integration of energy-saving technologies ensures optimal performance while minimizing power consumption, making it ideal for medical environments requiring precise and continuous thermal management.

9. Recommendation

Based on the study's findings and conclusions, the following recommendations are proposed:

1. Alert Notifications: Implement a real-time alert system to notify medical staff if room temperature deviates from the ideal range, ensuring timely interventions.
2. Humidity Monitoring: Incorporate a humidity sensor alongside the DHT11 temperature sensor to enhance environmental control.
3. Data Logging and Reporting: Develop a feature to record temperature and humidity data over time, aiding in trend analysis and informed decision-making for hospital management.
4. Renewable Energy Support: Integrate solar power or other renewable energy sources to ensure continuous operation during power outages and promote energy sustainability.
5. Custom Software Development: Create a dedicated application for managing system

controls instead of relying solely on third-party apps, ensuring better security, privacy, and data management.

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