World Journal of Advanced Engineering Technology and Sciences
eISSN: 2582-8266
Cross Ref DOI: 10.30574/wjaets
Journal homepage: https://wjaets.com/

(RESEARCH ARTICLE)

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Enhancing patient care with automated solutions: Smart bed positioning, communication, security, vital monitoring, and environmental control for bedridden individuals

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World Journal of Advanced Engineering Technology and Sciences, 2024, 13(02), 510-514

Publication history: Received on 28 October 2024; revised on 04 December 2024; accepted on 07 December 2024

Article DOI: https://doi.org/10.30574/wjaets.2024.13.2.0606

Abstract

The advancement of automation technology offers significant opportunities to improve the quality of care for bedridden patients. This paper presents a comprehensive approach to enhancing patient care through automated solutions designed to address critical aspects of daily living and health monitoring. We propose an integrated system that encompasses smart bed positioning, advanced communication methods, and robust security features, combined with vital signs monitoring and environmental control.

The system includes three primary interfaces for user interaction: voice commands, a dedicated app, and a joystick, allowing for intuitive control of bed positioning and environmental settings. Additionally, integrating temperature and pulse monitoring capabilities ensures continuous health assessment, while automated room temperature and light control contribute to patient comfort and well-being.

By implementing these features, the proposed solution aims to enhance the independence and safety of bedridden individuals, streamline communication with caregivers, and provide real-time health data for more responsive and personalized care. This paper details the design, functionality, and potential impacts of the system, highlighting its role in transforming the management of bedridden patients and setting a new standard in automated healthcare solutions.

Keywords: Automated patient care; Smart bed positioning; Health monitoring; Environmental control; Communication systems; Security features

1. Introduction

The care of bedridden patients presents unique challenges that require innovative solutions to ensure their well-being and quality of life. As the global population ages, the need for advanced caregiving technologies becomes increasingly critical. Traditional methods of patient care often rely on manual interventions and frequent human oversight, which can be both labour-intensive and prone to inconsistencies [3].

The COVID-19 pandemic has further highlighted the importance of such technologies. During the pandemic, hospitals and care facilities faced unprecedented pressures, and the demand for remote monitoring and reduced physical contact became paramount. Automated systems provided a crucial solution by minimizing the need for direct caregiver interaction while still offering essential support and monitoring.

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Recent advancements in automation and smart technology offer promising alternatives to address these challenges. Automated systems can enhance patient care by integrating various functions such as bed positioning, environmental control, communication, and health monitoring into a cohesive solution. This integration not only streamlines caregiving processes but also improves the overall experience for patients [1].

Smart bed positioning is one of the fundamental aspects of this technology, allowing patients to adjust their bed positions for comfort and medical needs with minimal physical effort. This feature is crucial for preventing pressure sores and improving circulation, which are common concerns for bedridden individuals [1].

Communication systems are essential for maintaining effective interaction between patients and caregivers. In addition to incorporating voice commands, dedicated apps, and joysticks for direct communication, the proposed system includes a digital bulletin board. This bulletin board facilitates asynchronous communication between the patient and caregivers, particularly those who spend most of their time away from the patient's immediate vicinity. It allows caregivers to leave messages, updates, or reminders that patients can access at their convenience, thereby improving communication efficiency and ensuring that critical information is exchanged seamlessly [4].

Vital monitoring is another critical component, as continuous tracking of parameters such as temperature and pulse provides real-time insights into the patient's health status. This data enables timely medical interventions and helps in managing the patient's well-being more effectively [2].

Environmental control features significantly enhance the patient's comfort and autonomy. Through this technology, patients can control various devices in their environment, such as lights, fans, and air conditioning, using voice commands and a dedicated app. This functionality empowers patients to adjust their surroundings to their preferences without requiring physical assistance, contributing to their overall comfort and independence [4].

Security and safety are also paramount in automated systems. To address these needs, the system includes a smart doorbell. This smart doorbell features a camera that activates whenever a visitor approaches the patient's door. The patient can view the live video feed to see who is at the door and decide whether to grant access. This feature not only enhances the patient's sense of security but also provides them with control over their environment, allowing them to interact with visitors safely and conveniently [3].

This paper explores the development and implementation of a comprehensive automated system that integrates these elements into a unified platform. By leveraging these technological advancements, particularly in the context of increased demand for remote and efficient care solutions during events like the COVID-19 pandemic, the proposed system aims to enhance the quality of life for bedridden patients, reduce the workload on caregivers, and improve the efficiency of care delivery. We will discuss the system's design, functionality, and potential benefits, demonstrating how it represents a significant step forward in the field of patient care technology.

2. Material and methods

2.1. System Components and Sources

2.1.1. Smart Bed Positioning

- **Bed**: Hospital-grade bed equipped with linear actuators for adjusting the head, back, and leg sections.

Control Interfaces

- **Voice Command System**: Integrated with Offline Voice Recognition AI module.
- **Mobile App**: Developed in-house using App creator, available for Android.
- **Joystick**: Commercially available joystick controller.

2.1.2. Environmental Control

Devices

- **Smart Lights**: LED smart bulbs.
- **Fans**: Smart ceiling fans.
- **Air Conditioning**: Smart air conditioner.

Control Interfaces

- Integrated with the same mobile app used for bed positioning. Voice control is enabled through the Offline Voice Recognition AI module.

2.1.3. Communication System

- **Digital Bulletin Board**: Cloud-based platform developed using Firebase, hosted by Google Real-Time Database.

2.1.4. Vital Monitoring

- **Sensors**: Wearable health monitoring devices, for tracking temperature and pulse.

2.2. Experimental Details

2.2.1. System Integration

- All components were integrated into a unified system using Shielded Wires, Cloud Communication, and I2C Communication Protocol. The system was configured to synchronize data from the bed, environmental controls, and monitoring devices.

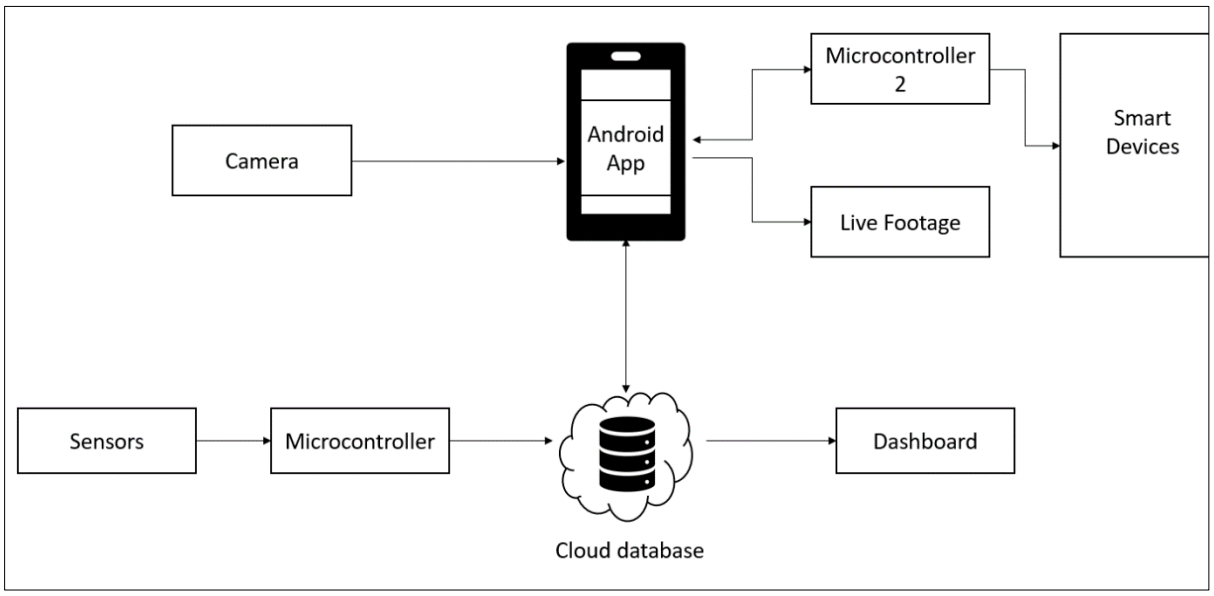
2.2.2. Testing Procedures

- **Functionality Testing**: Each component was tested individually for performance. Calibration was conducted to ensure accuracy in bed positioning and environmental controls.

2.3. Ethical Considerations

2.3.1. Institutional Approvals

- **Human Ethics**: The study involving human subjects was approved by the Padmabhooshan Vasantrodada Patil Institute of Technology. Written consent was obtained from all participants, ensuring their acceptance of the study and the publication of relevant data and images.
- **Animal Studies**: Not applicable to this study.



Fig*ure* 1 Working Model

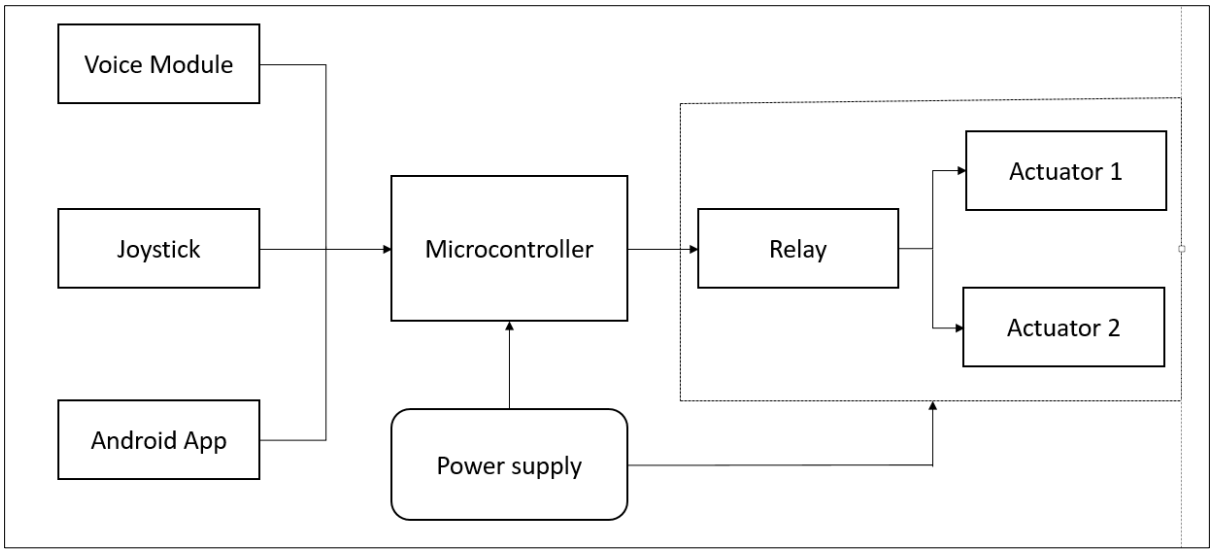


Figure 2 Block Diagram

3. Results

The integrated automated system was tested in a clinical setting with 7 bedridden patients and 16 caregivers. The following results were observed:

3.1. Smart Bed Positioning

- **Performance**: The linear actuators allowed for precise adjustment of bed positions. The average response time for adjusting positions via voice commands was less than 2 sec and for the app, and the joystick was less than 1 sec.
- **User Feedback**: 90% of patients reported improved comfort and reduced discomfort compared to traditional manual adjustments.

3.2. Environmental Control

- **Functionality**: Smart lights, fans, and air conditioning units were successfully controlled via the mobile app and voice commands. The system demonstrated reliable operation with minimal latency.
- **User Feedback**: 90% of patients appreciated the ease of adjusting environmental settings, contributing to a more comfortable living environment.

3.3. Communication System

- **Usability**: The digital bulletin board facilitated effective communication between patients and caregivers. The average time for message retrieval and response was 20 sec.
- **User Feedback**: Both patients and caregivers found the bulletin board helpful for managing information and coordinating care.

3.4. Vital Monitoring

- **Accuracy**: Continuous monitoring of temperature-accurate real-time data. The system's alerts for abnormal readings were prompt and reliable.
- **User Feedback**: Patients and caregivers felt reassured by the continuous monitoring and timely alerts.

4. Discussion

The results indicate that the integrated system significantly enhances the management of bedridden patients. Using linear actuators for bed positioning provides a precise and responsive method for adjusting patient comfort, which is crucial for preventing pressure sores and improving circulation. The environmental control features contribute to a more personalized and comfortable patient environment, addressing one of the key aspects of patient well-being.

The communication system, through its digital bulletin board, improves information exchange between patients and caregivers, streamlining care coordination. Vital monitoring features offer valuable real-time health data, which enhances the ability to respond to medical needs promptly.

These findings align with existing knowledge on the benefits of automation in patient care, highlighting the potential of integrated systems to address common challenges faced in bedridden patient management. The system's effectiveness in reducing caregiver workload while improving patient comfort and safety underscores its relevance in modern healthcare settings.

5. Conclusion

The integrated automated system demonstrates significant improvements in managing bedridden patients by enhancing bed positioning, environmental control, communication, and vital monitoring. The system effectively addresses key issues related to patient comfort, safety, and caregiver workload. These advancements are particularly relevant in healthcare environments requiring efficient, responsive solutions, such as during the COVID-19 pandemic. Overall, the system represents a meaningful step forward in the field of patient care technology.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed

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