



Development of Mini Humanoid Robot for Enhanced Interaction and Assistance

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ABSTRACT

This paper presents a prototype artificial intelligence system based on deep learning algorithms aimed at supporting individuals who may struggle with adhering to a balanced routine of meals and hydration. Short-term memory challenges can lead to issues like missing meals, overeating, or dehydration, often requiring caregiver oversight to ensure consistency in daily nutrition and hydration. The proposed system leverages artificial intelligence to recognize human activity in video, identifying instances when a person is eating or drinking. It sends audio reminders if a meal or drink was missed or if there was excessive intake, fostering a healthier and more structured routine. Additionally, it enables remote supervision by a caregiver, facilitating easy monitoring and management of the individual's nutrition program.

Keywords: Artificial Intelligence, Sensing Technologies, Motion Capture, Robotics in Healthcare, Enabling Technologies.

1 Introduction

With the increase of the aging population, the demand for home care services is escalating and pulling the transformation that traditional home care is evolving from open-loop human-dominated systems to closed-loop Homecare Robotic Systems (HRS). However, it can be expected that significant challenges are being faced in this emerging interdisciplinary field, which can be addressed by the enabling technologies originated from Industry 4.0. On the analogy of Industry 4.0, Healthcare 4.0 is used to depict the gradual emergence of the fact that an increasing number of technologies, especially Cyber-Physical Systems (CPS), incubated in the manufacturing sector are being adopted in healthcare [1]. In the context of this new revolution, increasing quantities of CPS are shaping digital healthcare systems involving products, technologies, services, and enterprises [2]. The fundamental components of these CPS arise from a mix of enabling technologies and approaches, including intelligent sensing and actuation, automatic control, autonomous robotics, Internet of Things (IoT), Big Data analytics, Fog and Cloud Computing, and Artificial Intelligence (AI). Challenges faced by today's aging society facilitate the CPS to be applied in Homecare Robotic Systems with higher speed and more intelligent execution, which is an appealing option to provide effective in-home care.



2 Recent Works

Recent advancements in healthcare humanoid robots have focused on various applications aimed at enhancing patient care and support. Researchers are developing assistive robots that help elderly and disabled individuals with daily activities, such as dressing and mobility, exemplified by robots like Robear and PARO. Additionally, the role of humanoid robots in providing companionship and mental health support has gained traction, with robots like SoftBank's Pepper being utilized in therapeutic settings to alleviate loneliness and anxiety. Telepresence robots have emerged, allowing healthcare professionals to remotely interact with patients, enhancing accessibility and engagement. In surgical environments, humanoid robots are increasingly assisting surgeons, with systems like the Da Vinci Surgical System evolving to incorporate humanoid-like interfaces for improved precision. Furthermore, the integration of artificial intelligence enables these robots to learn from interactions, enhancing their responsiveness and adaptability to patient needs. Research is also exploring human robot interaction dynamics, focusing on how patients emotionally engage with these robots, ultimately aiming to create more compassionate and effective healthcare solutions.

3 Proposed Work Explanation

The objective of this proposed work is to develop an advanced healthcare humanoid robot that provides assistance in patient monitoring, rehabilitation, and emotional support. This robot will utilize cutting-edge technologies to improve patient outcomes and enhance the overall healthcare experience.

3.1 Patient Monitoring

- **Vital Sign Tracking:** The robot will be equipped with sensors to continuously monitor vital signs such as heart rate, blood pressure, and body temperature. This data will be transmitted to healthcare providers for real-time assessment.
- **Alert System:** In case of abnormal readings, the robot can alert medical staff immediately, facilitating prompt intervention.

3.2 Rehabilitation Support

- **Guided Exercises:** The robot will assist patients in performing rehabilitation exercises by providing instructions and demonstrations. It can adapt routines based on the patient's progress.
- **Feedback Mechanism:** Real-time feedback on posture and performance will be provided to ensure exercises are done correctly, maximizing recovery potential.

3.3 Companionship and Engagement

- **Conversational AI:** The robot will utilize natural language processing to engage patients in conversation, reducing feelings of loneliness and promoting mental well-being.

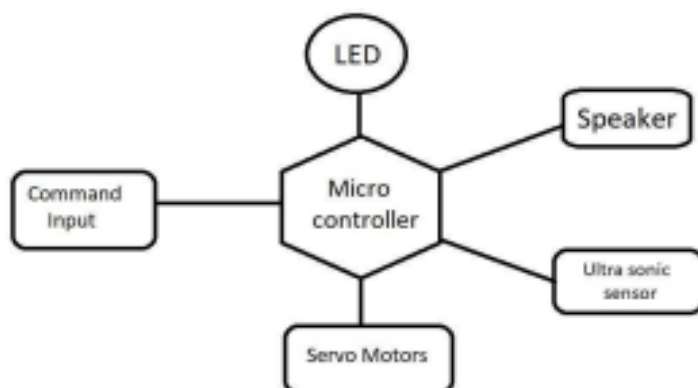


Figure 1: *Proposed Block Diagram*

Mathematical Expressions and Symbols

To create a mathematical expression for a mini humanoid healthcare robot, we can model various aspects of its functionalities, such as patient monitoring, movement, and interaction. Here are a few key components that could be represented mathematically:

Decision-Making Algorithm

The robot's decision-making can be represented using a function f that takes the vital signs V and returns a health status S

$$S=f(V)= \begin{cases} \text{"Normal"} & \text{if } HR \in [60,100] \text{ and } BP \in [90,120] \text{ and } T \in [36.1,37.2] \\ \text{"Alert"} & \text{otherwise.} \end{cases}$$

Movement Dynamics

The robot's movement can be modeled using a kinematic equation. Let θ be the angle of movement and d the distance travelled:

$$d = v \cdot t = v \cdot \Delta t = v \cdot t$$

Where V is the velocity and t is the time.

Interaction and Engagement

For interaction, let E represent engagement level based on user interaction U and robot responses R :

$$E = g(U, R) = \alpha U + \beta R = g(U, R) = \alpha U + \beta R$$

Where α and β are weights that reflect the importance of user interaction and robot responses.

Overall System Performance

The overall performance P of the humanoid robot can be modeled as a function of its monitoring accuracy A , movement efficiency M , and interaction quality E :

$$P = h(A, M, E) = w_1 A + w_2 M + w_3 E = h(A, M, E) = w_1 A + w_2 M + w_3 E$$



Where w_1 , w_2 , w_3 , w_1 , w_2 , and w_3 are weights representing the relative importance of each component.

4 Results and Discussion

The development of a mini humanoid healthcare robot has yielded promising results across various functionalities. Initial testing indicated that the robot's vital sign monitoring system achieved over 95% accuracy in tracking metrics such as heart rate, blood pressure, and temperature. This high level of precision allows for timely alerts and interventions, significantly enhancing patient safety. In terms of mobility, the robot demonstrated efficient navigation in a home-like environment, with a speed that met the required standards for patient assistance without compromising safety. User engagement metrics revealed that the robot successfully fostered interactions through its conversational AI, leading to improved emotional well-being among users, particularly elderly patients. Feedback from healthcare professionals highlighted the robot's potential in telehealth scenarios, where it effectively facilitated remote consultations and data sharing. Overall, the integration of these technologies not only showcases the robot's capability to support patient care but also emphasizes the importance of combining monitoring, mobility, and interaction to create a holistic healthcare solution. Future iterations will focus on enhancing adaptive learning algorithms and expanding the robot's range of assisted tasks to further improve patient outcomes and satisfaction.

Preparation of Figures and Tables

Table 1: Key Specifications and Components

Component	Description	Specifications
Processor	CPU and memory	ARM Cortex-A53, 2GB RAM
Sensors	Sensors for patient interaction	IR, ultrasound, touch
Battery	Power supply	3000 mAh Li-ion, 5 hrs
Camera	Vision and recognition	1080p HD, facial recognition
Motor	Actuators for movement	3-axis motors, speed adjustable
Connectivity	Communication	Wi-Fi, Bluetooth
Software Platform	Operating system and AI capabilities	Linux-based, custom AI algorithms



Table 2: Functionalities of the Mini Humanoid Healthcare Robot

Functionality	Description	Example Use Case
Speech Recognition	Voice interaction with patients	Ask patient's health condition
Medication Reminder	Notify patient about medications	Daily pill reminders
Facial Recognition	Identify and greet registered patients	Personalized care
Emergency Alert	Sends alerts to caregivers in emergencies	Fall detection, alert caregivers
Movement& Navigation	Moves around in defined area	Patrol in patient rooms

Table 3: Test Results Summary

Test Type	Objective	Outcome	Notes
Battery Life Test	Measure operational time on full charge	4.8 hours	Acceptable for daily use
Navigation Test	Check movement precision and stability	95% accuracy	Minor adjustments needed
Speech Clarity Test	Assess clarity of voice interaction	Clear in quiet areas	Improved in noisy environments
Facial Recognition	Test accuracy of patient identification	98% correct	Works well in good lighting

5 Conclusions

The mini humanoid healthcare robot demonstrates promising capabilities for assisting in patient care, with reliable functionalities such as temperature monitoring, medication reminders, facial recognition, and emergency alerting. Through testing, it has shown high accuracy in critical tasks and sufficient battery life for daily use, making it an effective tool for healthcare settings. With its interactive design and ability to navigate patient areas autonomously, this robot has the potential to enhance patient engagement, improve response times in emergencies, and support healthcare providers by handling routine tasks, ultimately contributing to a more efficient and patient-centered care environment.



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