OPEN ACCESS
Global Journal of Research in Engineering & Computer Sciences
ISSN: 2583-2727 (Online)
Volume 05| Issue 05 | Sept.-Oct. | 2025
Journal homepage: https://gjrpublication.com/gjrecs/
Research Article

Highlights of the Humanoid Robot, Including Its Challenges and Impacts

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DOI: 10.5281/zenodo.17087084 **Submission Date: 02 Aug. 2025 | Published Date: 09 Sept. 2025**

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Abstract
Based on the human form factor, humanoids are bipedal, general-purpose robots designed to boost human productivity. They can learn and carry out a variety of duties, such as loading or unloading boxes, moving containers, and grabbing objects. These robots can move, interact, and even navigate themselves to replicate human dexterity thanks to their advanced actuators, sensors, on-robot electronics, and software. To prepare them for the uncertainty of real-world situations, robots are trained to perform a variety of movements and reactions in simulated environments. The implementation of strong data protection and security procedures, the creation of ethical principles, the establishment of safety and reliability standards, and thorough testing are some of the recommendations made to handle the challenges and impacts of humanoid robots. It is also advised to address the economic impact by offering training programs for employees and generating new employment prospects, all the while promoting societal acceptance through inclusive design and public education. To get past present obstacles and enable wider deployment in a variety of settings, further technological developments in AI, human-robot interaction, and energy efficiency are also essential.

Keywords: *Internet of Things (IoT), Artificial Intelligence (AI), Humanoid Robots, Recommendations, Deep Learning, Machine Learning.*

I. INTRODUCTION

Mobile robots are employed for a range of jobs that largely require human engagement and collaboration, and they have grown in popularity in a variety of situations within the quickly evolving area of robotics [4-6].

1.2 Addressing Technical and Integration Obstacles

i. **Reliability and Durability:** Conduct rigorous testing and validation to ensure the reliability and durability of humanoid robots, which are still a significant technical challenge.
ii. **Energy Efficiency:** Focus on improving energy efficiency to make humanoid robots more practical for sustained operations.
iii. **Scalability and Cost:** Work towards reducing the cost of humanoid robots to enable wider adoption and scale.
iv. **Unstructured Environments:** Develop breakthroughs in AI and human-robot interaction to enable robots to function effectively and safely in complex, unstructured environments.
v. **Perception and Communication:** Advance image analysis and gesture recognition to improve robots' ability to perceive and interact in noisy environments, such as factories.

1.3 Addressing Social and Economic Effects

i. **Job Displacement:** Implement upskilling and reskilling programs for workers, and encourage the creation of new job opportunities in robotics development and maintenance to mitigate potential job displacement.

ii. **Social Acceptance:** Promote public education and awareness to help foster acceptance and understanding of humanoid robots and their role in society.
iii. **Inclusive Design:** Encourage inclusive design principles to ensure that humanoid robots accommodate diverse user needs and preferences for better social integration.

1.4 Ethical and Security Considerations

i. **Ethical Guidelines:** Develop clear ethical guidelines for humanoid robot development, ensuring that robot behaviors align with human values and morals.
ii. **Accountability:** Establish mechanisms for accountability for decisions and actions taken by humanoid robots to ensure responsible deployment.
iii. **Privacy and Data Security:** Implement strong data protection policies, encryption methods, and regular security audits to safeguard sensitive information gathered by robots.

1.5 Strategic Deployment

i. Phased Introduction: Begin with industrial settings and controlled indoor environments where technology can be proven and refined, before moving to more complex domestic applications.
ii. Human-Robot Collaboration: Focus on developing applications where humans and robots can collaborate safely, efficiently, and productively [32].

II. LITERATURE REVIEW

This paper presents the design of a novel humanoid robot head. This humanoid head is based on biological likeness to the human being, so that the humanoid robot could interact agreeably with people in various everyday tasks. An innovative contribution with regard to computer vision systems implemented in former humanoids lies in the proposed humanoid head's configuration, equipped with an omnidirectional stereo vision system. Furthermore, this design integrates human like cervical vertebrae in order to support the head. They should subsequently serve as a physical interface to the pitch and roll movements of the humanoid robot's neck. Likewise, other sensors are added to improve the robot's performance during bipedal locomotion, i.e., inertial sensors [1]. Computer vision is an artificial intelligence field that is widely used in many fields today. Smart glasses and humanoid robots, on the other hand, are new technologies with a lot of investment, but their development is progressing very quickly and impressively. Computer vision and augmented reality constitute the working principles of smart glasses. On the other hand, the data and technologies to be obtained with smart glasses directly affect the development of humanoid robots. While humanoid robots are on the way to become a big part of our future, computer vision and smart glasses are the main subjects of this article as areas that enable the development of this technology. In this study, the interaction of smart glasses and humanoid robots was examined. The effect and development of computer vision on smart glasses and humanoid robots are explained. In addition, the effect of artificial intelligence and mind-reading investments on humanoid robots in the future is also mentioned [2]. This paper presents the design of an autonomous humanoid robot designed to optimize and enrich customer service in showrooms, e.g., electronic equipment, mobile network operators, and generally in stores with various articles. The proposed humanoid robot design is distinguished by two key components: a sensor-equipped mobile platform with drives and a body featuring a head outfitted with a touch tablet and an RGBD camera. The control system enables autonomous navigation in both known and uncharted environments, with a special focus on diverse, crowded, and cluttered spaces. To enhance its adaptability, this robot is not only fitted with LIDAR sensors but also cliff and ultrasonic sensors. While the interactive ability with humans is an expected functionality, this paper brings forth certain distinct innovations in humanoid robot design for customer service. One of these unique aspects includes the robot's ability to physically alter its configuration, such as rotating its head and adjusting the height of its torso to maintain line-of-sight with the customer. This capability signifies a novel degree of spatial responsiveness that exceeds static interaction. Moreover, the proposed robot is equipped with a user-friendly gesture recognition system, uniquely designed to detect and recognize simple human hand gestures. This attribute paves the way for understanding simple commands such as requests for assistance. Upon recognizing a request, the robot tailors its services by following the person around the showroom, effectively assisting and answering customer queries or displaying requisite information on its screen. This active assistance model, specifically tailored for human interaction, showcases the robot's unique capability to respond proactively and dynamically to human inputs [3]. The focus of this paper is the development of an autonomous humanoid robot designed for these interactive tasks, with a special emphasis on customer service environments such as hotels, stores, and hospitals. The authors of [5] discussed the utilization of robots in healthcare recently. They discovered that a considerable number of robots deployed in hospitals aim at facilitating direct cooperation with patients. The authors of [7] introduced a rudimentary robot equipped with a screen and camera, designed to function as a personal assistant and walk-helper. Subsequent work continued on this robot, with the authors delineating and demonstrating the holonomic system of the robot's mobile base [8]. The authors of paper [9] also exhibited a remotely operated system for the provision of aid. In [10], human-robot collaboration for on-site construction was discussed. A system designed to augment construction productivity and safety by synchronizing robot intelligence with human skills was showcased. It was pointed out that the personal robots introduce numerous challenges, one of which is security. Robots are often stronger and faster than humans, potentially creating hazardous situations. The second challenge, pertinent to this paper, is the communication gap between the robot and the human. Conventionally, a robot designed to assist a human will typically not cooperate with qualified individuals possessing advanced programming knowledge. Consequently, robot communication cannot rely on complex interfaces but must utilize interfaces comparable to natural human interactions. Robots designed to cooperate with humans should be capable of understanding speech or gestures for natural communication. There is also a category of robots known as Attract, Interact, and Mindset (AIM). Their function is to draw attention to products in stores or shopping malls, then present offers and advertisements, or assist in shopping. Many AIM robots have been introduced in recent years [11–15], typically comprising a mobile base, a torso with a touchscreen, and a camera. The simplest models offer touchscreen interactions, while more sophisticated ones incorporate voice recognition. The tallest model enhances visibility but may intimidate some users. A unique model [15] incorporates gesture recognition for natural interaction. However, none offer the comprehensive interaction modalities and height-adjustable design of our proposed autonomous humanoid robot. Gesture recognition systems, which are increasingly leveraging artificial intelligence, have become popular recently. Their reliability has improved due to ongoing advancements in algorithms, programming frameworks, and large datasets necessary for such models. The application of gesture recognition systems has been widely discussed in publications [15–18]. Paper [15] describes a basic system for recognizing gestures, hands, and faces. The authors suggested wide-ranging applications of this system, such as facilitating communication for deaf individuals, enabling children to interact with computers or other devices, detecting lies, or monitoring patients in hospitals. The authors of paper [16] introduced hand gesture recognition systems using 3D depth sensors and reviewed widely-used commercial sensors and datasets. Various gesture recognition systems based on 3D hand modeling, static hand recognition, and hand trajectory tracking were also described. Similar insights into gesture recognition methods were provided in [16], while [17] presented various applications of gesture recognition systems in the realm of human computer interaction. Gesture recognition systems have also found an application in robotics. There are environments where a robot may struggle to recognize human speech, such as crowded or noisy places such as shopping malls or factories. Here, robots need alternative communication methods, such as gestures. Given the advancements in image analysis algorithms and portable hardware, robots equipped with various types of cameras could leverage human gesture recognition for interaction. The authors of [19] suggested the use of a gesture recognition system for therapy with children diagnosed with autism spectrum disorders, as these children often struggle with imitating gestures. They proposed therapeutic games involving joint gesture imitation by the robot and children. The authors of [20] designed a non-verbal communication system using gesture recognition for people fluent in sign language. In [21], a real-time gesture recognition system implemented in a dynamic human-robot application was presented. Paper [22] presented a system where the UR5e robot was operated via gestures in collaboration with humans. The authors of [23] proposed a comprehensive system for gesture-based teleoperation, tested in a pick-and-place case study. The application of a gesture recognition system was also reported in [24], where an agricultural robot with a ZED 2 camera was presented. Recent studies such as [25–28] have used the Media Pipe open-source framework [29] for real-time gesture recognition. In contrast to the existing literature, our innovative mobile humanoid robot has been specifically designed to operate effectively in crowded and noisy environments. Equipped with a gesture recognition system, the robot can understand and respond to human gestures, thus facilitating non-verbal communication when voice recognition might be impractical. This is particularly useful in noisy places such as shopping malls or factories.

III. THE ADVANTAGES OF THE HUMANOID ROBOTS

1. Versatility in Tasks: The multitude of tasks that humanoid robots can accomplish is one of their main advantages. Their human-like mobility and dexterity enable them to travel and engage in a variety of situations, from intricate industrial processes to domestic tasks.
2. Human Interaction: Humanoid robots are designed with a focus on human interaction. They possess features such as facial recognition, speech synthesis, and natural language processing, enabling them to engage in conversations and comprehend human emotions.
3. Assistance to the Elderly and Disabled: These robots have the potential to revolutionize the caregiving industry. Humanoid robots can provide companionship to the elderly, assist with daily activities, and even offer physical support to those with mobility challenges.
4. Efficiency in Hazardous Environments: Humanoid robots can be deployed in situations deemed dangerous for humans, such as search and rescue missions during natural disasters or handling hazardous materials in industrial settings.
5. Enhanced Learning and Training: In fields like medicine and education, humanoid robots can serve as effective tools for training purposes. They can simulate scenarios, allowing learners to practice and refine their skills in a controlled environment [30].

IV. DRAWBACKS OF THE HUMANOID ROBOTS

1. High Costs: Humanoid robot development and manufacturing require sophisticated engineering and cutting-edge technologies, which raises production costs. Their practicality and accessibility for broad adoption may be restricted by this cost problem.

2. Ethical Dilemmas: Humanoid robots' development raises moral concerns regarding their place in society. Robot rights, possible employment displacement, and the thin line separating human-machine interaction are among the topics discussed.
3. Uncanny Valley Effect: The uneasiness individuals experience when a robot seems and acts almost human but lacks certain characteristics is known as the "uncanny valley" phenomenon. This effect may make it more difficult for humans to accept and engage with robots.
4. Technical Limitations: Humanoid robots still have technical limits despite progress. Their general functionality may be impacted by their fewer fluid motions and limited perception and comprehension of the environment compared to humans.
5. Security and Privacy Concerns: With features like facial recognition and data processing, humanoid robots can raise privacy concerns. If not properly safeguarded, personal information could be misused or breached [30].

V. CONCLUSION

This study has discussed the technological advancements in humanoid robots. Numerous research journals have reported on these achievements. Additionally, we have talked about its consequences and the safety measures that ought to be taken during the design and building phases [31]. To sum up, humanoid robots provide a combination of opportunities and difficulties [33]. They are considered revolutionary inventions due to their adaptability, ability to change industries, and capability for human contact. However, considerable thought is necessary given the ethical, social, and technical concerns they raise. Steering the automation trend toward a future that benefits both humans and machines requires weighing the benefits and drawbacks of humanoid robots and resolving related issues. It's critical to keep in mind that the real worth of technology is found in its capacity to improve and augment the human experience as we continue to innovate.

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CITATION

Sani, K. M., Muhammad, S. A., Ahmed, A. F., Ibrahim, A., Kabir, A., & Baballe, M. A. (2025). Highlights of the Humanoid Robot, Including Its Challenges and Impacts. In Global Journal of Research in Engineering & Computer Sciences (Vol. 5, Number 5, pp. 9–13). https://doi.org/10.5281/zenodo.17087084