

A BRIEF REVIEW OF RECENT ADVANCEMENT IN HUMANOID ROBOTICS RESEARCH

I Pavan Raju

*Research Scholar, CSE Department, Amity University Haryana
pavanraju997@gmail.com*

Dr. Sunil Sikka

*Associate Professor, CSE Department, Amity University Haryana
ssikka@ggn.amity.edu*

Mr. Ankit Garg

*Assistant Professor, CSE Department, Amity University Haryana
agarg1@ggn.amity.edu*

Mr. Manoj Pandey

*Assistant Professor, ECE Department, Amity University Haryana
mkpandey@ggn.amity.edu*

ABSTRACT

Robotics is an interdisciplinary research field with a combination of computer science and engineering. Humanoid robotics is a branch of research in robotics where it deals with human-shaped robots capable of mimicking human actions and intelligence. This paper reviews the recent advancement in the field of humanoid robotics research and the comparison of wide versions of humanoid robots available. This paper also briefly discusses the problems and scope of Artificial Intelligence to solve complex problems in humanoid robots

Keywords: Humanoids, gait, Artificial intelligence, Research, Reinforcement learning

1. INTRODUCTION

A humanoid robot can be defined as the programmable machine which can imitate the tasks of humans as well as their appearance. Humanoid research helps researchers to understand more about human structure and behavior. After years of research and development in this field, humanoids are now available in different shapes, sizes, and capabilities based on their application area. Most of the humanoid comes with one torso, two legs, two hands, and head. But in some applications, partial body parts are designed to perform specific work or research, such as only the lower part of the body to perform research operations on the gait of the robot. These have the complex structure and design when compared with other robots, so more and more attention is drawn in this area to improve the design and control parameters of humanoids. The humanoid robot can mimic the human expressions with eyes and mouth either by using mechanisms or display screen to express the gestures. Apart from the research in this field, humanoids are being developed to use as an assistant robot and also to perform dirty and dangerous tasks. Applications of humanoid robots are well established in the field of Health care, Defence, Education, and Entertainment. Even in education sector humanoid are introduced in order to assist the faculty to teach the students. This encourages the student to learn the subject in more practical way and enhance their learning capabilities.[1]

This paper presents the recent advancements in the field of humanoid robotics and explores the technical details of each robot followed by the development that took place from the origin to the latest version of humanoid available till date. This paper is divided into three major sections. Section II presents the major research and development of humanoid robots to date. Followed by the comparison

of best humanoid robots in terms of their design, performance and advancements happened in the section III and finally some of the major problems faced in this field and scope of AI to tackle those problems in section IV.

2. RECENT RESEARCH AND DEVELOPMENT

The research in the humanoid robotics is started since 1945. In the early stages only, mechanical designs were used to develop a humanoid robot. Later on, with the advancements in computer science and electronics, the development in this field has become more sophisticated. Let us explore the recent developments in humanoid robotics in different application areas.

- a) **ASIMO** (Advanced Step in Innovative Mobility) is one of the greatest achievements by HONDA in the field of Humanoid robots. Honda started the development of this robot in the year 1980 and launched ASIMO in 2000. The name was chosen in honour of Isaac Asimov.[2] The evolution of the robot from the beginning to till date can be seen in the Figure 1. ASIMO has a height of 130cm and weighs about 54kg. It can recognize moving objects, surrounding environment, sounds, and faces. It can also understand the gestures and postures portrayed by others. The latest model of this robot achieved the ability to climb stairs and also to run which was a critical task of humanoid research.[3]. The recent advancements in the latest model includes the ability to walk, run, run backward, hop on single or two legs continuously. With the implementation of AI, it is capable of having a coordination between visual and auditory sensors to simultaneously recognise a face and voice of a person. It can also predict the walking direction of person in next few seconds and plan its locomotion accordingly to avoid collisions.



Figure 1 Evolution of ASIMO Robot

- b) **NAO** was launched in the year 2004 by Aldebaran robotics, a French-based company under the Softbank group.[4] This robot was initially developed for soccer competition at RoboCup Standard Platform League (SPL). NAO is widely used for research and educational purpose in educational institutions and research laboratories all over the globe. Nao was used to teach english to the students of age 3 and 4 whose native language is dutch[1] Different versions of NAO come with 14, 21, and 25 Degrees of Freedom with a height of 22.6 in and 10.8-inch width.[5] NAO is integrated with a wide range of sensors for its perfect balance and positioning within space. The advancements in the latest model includes the optimization of its hardware with stronger metal gears in joints, soles which help to dampen the noise and friction of footsteps. It also comes with the advanced features of shape and face detection with optimized algorithms with improved distance estimation. More powerful battery system is integrated which is 30% more efficient than the previous generation model. It is packed with a Linux based operating system platform which helps the researches to understand and further develop the robot.

- c) **iCub** is an Open-source humanoid robot initially developed by RobotCub Consortium and manufactured by the Italian Institute of technology, Italy in 2010.[6] iCub is a 1-meter tall robot developed to enable the cognitive skills in the human-like robot. It is an open-source robot with hardware design, software, and documentation all released under the General Public License. iCub is designed with dimensions similar to a 3.5-year child. It is integrated with 53 degrees of freedom with 7 in each arm, 9 in each hand, 6 in the head, 3 in the torso, and 6 in each leg. As the robot is being open-sourced several researchers around the globe helped to improve the capabilities of this robot. It performs several complex tasks like crawling using visual guidance, solving complex 3D mazes, grasping small objects, shooting arrows with a bow, and learning to hit the centre of the target. It has unique eyeballs which enable it to express its face emotions just like human beings. Still, dedicated research is going on to further improve the possibilities of this robot.
- d) **REEM** is the prototype of a humanoid robot developed by PAL Robotics in Spain. REEM-A[7] and REEM-B[8] are the initial prototypes developed. These robots are capable of recognizing, grasping, and lifting objects. REEM-C is the latest advanced humanoid robot by PAL robotics. It is a 1.7m high robot with 22 degrees of freedom and moves at a speed of 4 km/hr. REEM-C is the recent prototype with advanced gait algorithms with an average speed of 1.4km/h and can lift to 10kg of the weight of payload to transport from one place to another.



Figure 2 Evolution of REEM series robots

(a) REEM-A (b) REEM-B (c) REEM-C

- e) **Sophia** is a social humanoid robot developed by Hanson Robotics.[9] It was created in the year 2016 and integrated with advanced AI algorithms to behave more like humans. She is capable of displaying more than 60 facial expressions and can make active conversations on predefined topics. In October 2017, Sophia became a Saudi Arabian citizen, the first robot to receive citizenship. It has advanced features to follow faces, maintain eye contact, recognize and capable to process speech and have conversations using natural language processing (NLP)[10]. It has AI algorithms that help it to learn constantly to improve the efficiency of its conversations. In all the humanoid robots, Sophia had become a public figure addressing various competitions and news channels like CNBC, Forbes, the New York Times, etc.

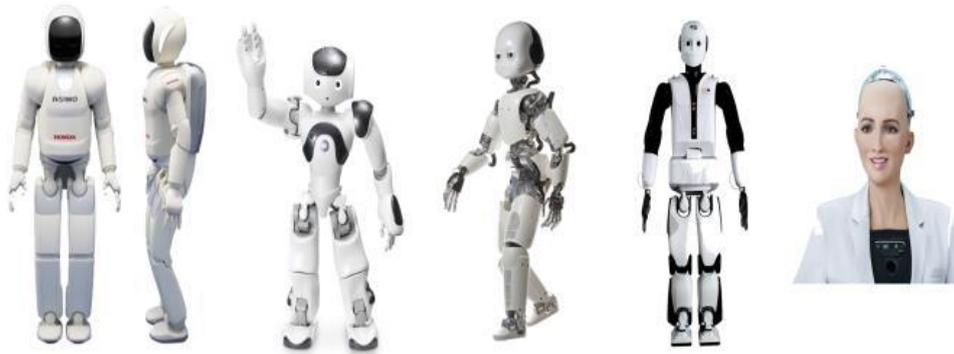


Figure 3 Humanoid described in the paper.
From left to right: (a) ASIMO (b) NAO (c) iCub (d) REEM (e) Sophia

3. COMPARISON OF HUMANOID ROBOTS

In the previous section, origin and development of these robots had been viewed. This section represents the fundamental differences between some of the top humanoid robots [11] in Table 1

TABLE 1 COMPARISON OF 5 TOP HUMANOID ROBOTS

Name	ASIMO	NAO	iCub	REEM	SOPHIA
Height(cm)	130	57	100	170	182
Weight(kg)	54	27	36.5	60	40
Degrees of Freedom	34	25	53	22	22
Speed	9 km/hr	1.2km/ hr	N/A	1.4 km/hr	N/A
Processor Unit	Mobile Pentium III-M 1.2 GHz	ATOM Z530 1.6 GHz CPU 1/2/4/8 GB RAM	PC104 Motherboard PB-945+, with Intel Core 2Duo 2,16 MHz	NVIDIA Jetson™ TX2	N/A
Power Supply	Lithium ion 51.8 V	lithium ion 62.5 Wh at 21.6V	Xantrex Power supply, 1,2 Kw, 0-35V	Lithium-Ion Battery 48 V 1225 Wh	Lithium-Ion Battery
Sensors	Camera, touch sensor, tactile sensor, rangefinder	Four microphones, sonar rangefinder, two infrared emitters and receivers, inertial board, nine tactile sensors, eight pressure sensors	Tactile sensor, tendons, torque sensors, hall effect sensor, capacitive sensor	Camera, IMU sensor, Accelerometer	Camera, tactile sensors, accelerometer microphone.

Each humanoid robot is implemented in different application areas in order to server the purpose. ASIMO robot is used for the research and also to assist the people at corporate companies. NAO is spread across wide range of educational institutes over the globe helping researchers and students to understand and explore the possibilities of humanoid robotics. iCub being an open-sourced robot, still a dedicated research is going on to improve the capabilities. Sophia is the first humanoid to become a public figure. Advancements in this robot is going on to improve its efficiency in conversational skills and also to improve the ways of expressing its emotions.

4. PROBLEM FACED AND SCOPE OF AI IN HUMANOID ROBOTICS

Even after decades of research and development, still there are plenty of challenges that are to be tackled in this field. The main challenge in humanoid robotics will be developing a combination of physical structure and software program to make humanoid walk efficiently. The current robots are able to walk at very slower speed and finds difficult to adapt to new environmental conditions. Latest simulation software's help to tackle this challenge by designing a virtual model and integrating with AI algorithms such as Reinforcement learning [10] to improve the efficiency of gait over time.

Reinforcement learning is a biologically supported learning paradigm that helps humanoid to learn the pattern of gait from experience over time. Just like kids learn to walk by learning from mistakes, algorithms in reinforcement learning also tends to train the humanoid robot to learn and understand best suitable patterns for effective travel.

Deep Neural Networks has a great application in Humanoids that enables the robot with the ability to see, listen and understand the surroundings. Number of AI algorithms in Neural networks and Natural Language Processing [9] are implemented till date to make robot understand visual data [12] and audio data. Research in optimization of these algorithms are going on to improve the speed and accuracy of the output.

5. CONCLUSION

Humanoid robotics is always an interesting and challenging field in robotics. This paper reviewed some of the top humanoid robots where major breakthrough happened in the research over years. This paper presented the comparison of various technical features between different humanoid robots. Artificial Intelligence and Robotics are powerful combination that overcome the current drawbacks or finds new possibilities to improve the efficiency of robot's performance. With the increase in the open source society in this research field, developers all over the globe are coming up with best possible algorithms to solve and improve the performance of the humanoids. Still advanced research is going on to solve some of the problems mainly to improve the human-computer interaction, ability to handle any kind of terrain to travel and bring them cost effective.

REFERENCES

1. G. Tuna, A. Tuna, E. Ahmetoglu, and H. Kuscu, "A survey on the use of humanoid robots in primary education: Prospects, research challenges and future research directions," *Cypriot Journal of Educational Sciences*. 2019.
2. J. Clute, "Isaac Asimov," in *A Companion to Science Fiction*, 2007.
3. M. Hirose and K. Ogawa, "Honda humanoid robots development," *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, 2007.

4. S. Shamsuddin *et al.*, "Humanoid robot NAO: Review of control and motion exploration," in *Proceedings - 2011 IEEE International Conference on Control System, Computing and Engineering, ICCSCE 2011*, 2011.
5. D. Gouaillier *et al.*, "Mechatronic design of NAO humanoid," 2009.
6. G. Metta, G. Sandini, D. Vernon, L. Natale, and F. Nori, "The iCub humanoid robot: An open platform for research in embodied cognition," in *Performance Metrics for Intelligent Systems (PerMIS) Workshop*, 2008.
7. F. Ferro and L. Marchionni, "REEM: A humanoid service robot," in *Advances in Intelligent Systems and Computing*, 2014.
8. R. Tellez *et al.*, "Reem-B: An autonomous lightweight human-size humanoid robot," in *2008 8th IEEE-RAS International Conference on Humanoid Robots, Humanoids 2008*, 2008.
9. H. Robotics, "Sophia - Hanson Robotics," *Webside*, 2019. .
10. P. M. Nadkarni, L. Ohno-Machado, and W. W. Chapman, "Natural language processing: An introduction," *Journal of the American Medical Informatics Association*. 2011.
11. S. Saeedvand, M. Jafari, H. S. Aghdasi, and J. Baltes, "A comprehensive survey on humanoid robot development," *Knowledge Engineering Review*. 2019.
12. T. H. S. Li, P. H. Kuo, T. N. Tsai, and P. C. Luan, "CNN and LSTM Based Facial Expression Analysis Model for a Humanoid Robot," *IEEE Access*, 2019.