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Humanoid AI Robot: A Member of Our Next-generation Family

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Abstract

Humanoid robots represent a swiftly advancing area of study and innovation, seeking to produce robots with traits and abilities resembling those of humans. These robots have diverse uses, such as aiding humans in different activities or exploring dangerous or inaccessible areas. Advancing humanoid robots entails combining cutting-edge technologies, including robotics, natural language processing, computer vision, and artificial intelligence. Combining computer science and engineering, robotics is an interdisciplinary subject of study. A subfield of robotics research known as "humanoid robotics" studies robots with human features that can imitate human behavior and intelligence. This study compares various humanoid robot versions that are already on the market and discusses recent developments in the field of humanoid robotics research. The problems and potential applications of artificial intelligence to complicated problem solving in humanoid robots are also briefly covered in this paper.

Keywords: Humanoid, robots, automated machinery, jumping pad, autism spectrum, dynamic moment primitives, gait, artificial intelligence, research, reinforcement learning

INTRODUCTION

Humans rely heavily on machines for survival, performing everyday tasks and manufacturing labor. Automatic machines, such as drills and belt conveyers, were designed to perform tasks automatically. An upgraded version of automated machinery, the humanoid robot, was developed, consisting of five figures in each hand and foot: two legs, two arms, two feet, and one head and neck. Humanoid robots can perform domestic duties, amuse humans through dancing, singing, making amusing faces, and music, and provide health-related guidance. In hospitals, robots assist surgeons. As engagement with humanoid robots grows, they may become cherished family members. The review study covers balancing, fall avoidance, collision detection, and walking mechanisms of humanoid robots [1].

The creation of humanoid robots stands as one of the most ambitious and thrilling endeavors within the realm of technology. Presently, numerous robots with human-like qualities have been developed. These humanoids undertake various tasks to aid humans in diverse activities, including space missions, operating, and monitoring high-speed vehicles, and more. They earn the name "humanoids" due to their resemblance to humans, equipped with sensors and actuators responsible for motion. Sensors detect environmental changes such as movement, heat, and shifts in direction, while actuators, predominantly rotary actuators, execute human-like movements. Achieving the desired motion from humanoids requires a meticulous study of the human body and its movements, a discipline known as biomechanics. This aspect sets humanoids apart from other types of robots. Several technology

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companies like Honda, Sony, and Sansui have taken the lead in developing humanoids capable of mimicking human motion. The fascination with humanoid robots dates back to ancient times, with designs and concepts for humanoids originating as far back as the 14th century. While still in its infancy, the advancement of sophisticated humanoids represents a field with a promising future.

RECENT RESEARCH AND DEVELOPMENT

Humanoid robots research has been underway since 1945. A humanoid robot was developed using solely mechanical designs in the early phases. Subsequently, as computer science and electronics have advanced, this subject has seen more complex growth. Let us examine the most current advancements in several application domains of humanoid robotics. In the domain of humanoid robotics, one of Honda's notable achievements is ASIMO (Advanced Step in Innovative Mobility). Honda began working on this robot in 1980 and introduced ASIMO in 2000. Isaac Asimov was honored by the choice of name [2]. The most recent model boasts new features that allow it to continually hop on one or both legs, walk, run, and sprint backward. Artificial intelligence (AI) has made it possible to coordinate optical and aural sensors so that a person's voice and face may be recognized at the same time. Additionally, it has the ability to anticipate a person's walking direction for the next few seconds and adjust its movement to prevent collisions.

Aldebaran Robotics, a French firm under the Softbank group, introduced NAO in 2004 [3]. Originally, this robot was created for the RoboCup Standard Platform League (SPL), a soccer competition. Around the world, research labs and educational institutions employ NAO extensively for both instructional and research purposes. Dutch-speaking children in the age range of 3 and years were taught English using NAO [1]. NAO is available in various versions with 14, 21, and 25 degrees of freedom, measuring 22.6 inches in height and 10.8 inches in breadth [4]. For ideal balance and location in space, NAO is equipped with a multitude of sensors. The most recent model boasts improvements to its hardware, such as stronger metal gears in joints and soles that reduce friction and noise from footfall. Together with enhanced distance estimates and refined algorithms for form and face detection, it also has sophisticated features. An integrated battery system with 30% greater efficiency than the previous generation model is more powerful. It comes with a Linux-based operating system platform that aids in the comprehension and advancement of the robot by researchers.

The year 2010 saw the development of the open-source iCub humanoid robot by the RobotCub Consortium and its production by the Italian Institute of Technology [5]. The goal of creating the 1-meter-tall iCub robot is to enable cognitive abilities in a robot that resembles a human. The General Public License is used to release the hardware design, software, and documentation of this open-source robot. iCub's dimensions are based on those of a youngster who is 3.5 years old. In all, 53 degrees of freedom are combined, with 7 in each arm, 9 in each hand, 6 in the head, 6 in each leg, and 3 in the chest. The robot's capabilities have been enhanced by numerous researchers worldwide as it is made available for public use. It is capable of carrying out a number of intricate activities, such as crawling with the use of visual cues, navigating intricate 3D mazes, holding small objects, firing arrows with a bow, and learning to strike the target's center. It can convey its feelings in the same way that humans do, thanks to its special eyes. However, intensive research is ongoing to expand this robot's potential.

The humanoid robot prototype known as REEM was created in Spain by PAL Robotics. The first prototypes that were created were REEM-A [6] and REEM-B [7]. These robots have the ability to lift, grab, and identify items. PAL robotics' most recent sophisticated humanoid robot is called REEM-C. With 22 degrees of freedom, this 1.7-meter-tall robot can move at a speed of 4 km/h. The most recent version, known as REEM-C, has sophisticated gait algorithms, can move cargo up to 10 kg, and has an average speed of 1.4 km/h.

Hanson Robotics has created Sophia, a sociable humanoid robot [8]. In order to behave more like humans, it was developed in 2016 and merged with cutting-edge AI algorithms. She can make active chats on preset subjects and exhibit over 60 different facial emotions. In October 2017, Sophia made history by becoming the first robot to be granted citizenship in Saudi Arabia. Its sophisticated features include the ability to recognize faces, follow them, keep eye contact, process speech, and engage in natural language processing (NLP) conversations [9]. Its AI algorithms enable it to continuously learn and enhance the effectiveness of its dialogues. Sophia has become well-known among all the humanoid robots, appearing on news programs and contests such as CNBC, Forbes, and the New York Times.

BALANCE

Researchers have been working on a robot that can maintain a balanced posture in both static and dynamic positions. The robot's stability and complexity increase as its degree of freedom [2] increases. Katsu Yamane proposed a reduced model of an inverted pendulum robot with one joint in 2012, which was easier to balance and had fewer degrees of freedom. The upper limb moment is crucial for the robot's equilibrium, and a motion controller was proposed to control the top half of the body while the lower half is stabilized. The center of gravity is another important factor in stability, and the dynamic moment primitives approach helps maintain the initial posture when standing or walking [10].

FALL AVOIDANCE

The introduction of motion controllers allowed remote control of upper body and lower body stability. Center of gravity is crucial for stability but finding it for the entire body weight is less effective. The lower body half's stability is boosted by 50% in static positions. Dynamic moment primitives [3] help maintain balance when standing or moving, preventing unexpected pushes from the environment. Scientists have developed a support leg to keep a humanoid's body stable when another leg swings. A humanoid robot must overcome obstacles and use its hands to grab onto barriers to prevent falling. A safe landing is crucial, and piezoelectric sensors can determine the contact force between the robot's body and the floor. A jumping pad with force sensors can be used for safe experiments. To minimize impact intensity, impact-absorbing materials like rubber or foam can be used, especially for heavy humanoids. This not only saves the robot from harm but also saves the labor and effort of the study team. The human body uses muscles in various areas, and a humanoid robot should be able to move around based on surface conditions.

A humanoid robot is designed to walk at a constant speed on a predetermined width and travel left and right with the same step width. However, it needs a changeable step size due to different surfaces and environments. The swing leg concept allows for step length and angle adjustments. A key component of a robot's ability to walk is its camera, which initially used a 2D [4] camera for plane floor walking but was replaced with a 3D camera for stair climbing. Humanoid robots face challenges in climbing vertical ladders, which require careful and firm grip on handrails. Various methods have been developed, including catwalk, crawl gait, and pace gait, to overcome these dangers and effectively navigate a 3D world [5].

MODEL

The SFB 588 lab in Karlsruhe has developed a humanoid robot, the Tae-Mu, powered by an external hydraulic pump, capable of performing various tasks in the kitchen. The robot also has a 72.3 kg lightweight carbon fiber HR Tae-Mu, supported by a three-axis [6] active torso. A child-sized robot, made of aluminum beam, can walk on 3 cm artificial grass. The robot also has an 8 degrees-of-freedom arm with an HR (humanoid robot) of 11 kg.

APPLICATIONS

Humanoid robots are becoming increasingly popular for their fitness benefits, saving time and money. They can perform five isometric exercise types, such as push-ups, raised leg push-ups, and side holds. They also play soccer, identify targets, and using their feet to kick the ball. Additionally, these robots find applications in the field of medicine, offering advantages such as cost and time savings. People enjoy having these robots coach them and improve their fitness levels. Humanoid robots provide comfort and independence [7] to elders, aiding in detecting autism spectrum disorder in children through simple questions and recording communication skills. They can also control car steering and velocity, and are helpful in emergency situations, such as switching off valves, switches, and plugs, and working in earthquakes. These robots help elderly individuals with various tasks at home. Humanoid robot also helps more ageing people in daily house chores like carrying tray, sweeping floor and putting clothes in washing machines [8, 9]. In comparison with the human tutor, students showed more positive attitude towards humanoid robot tutor. The humanoid robot tutor is more successful in engagement of class than a human being [11–14].

CONCLUSION

The researchers' primary goal is not to use humanoid robots to replace people, but to produce the best results from it that people can utilize in their daily lives or in an emergency. People of all ages are drawn to humanoid robots, regardless of their age. In addition to being made to perform any kind of task in every circumstance, human robots also significantly lessen stress and anxiety. Given the growing number of applications for humanoid robots, it is important to note that one day these machines may become cherished family members that will attend to all of our likes and dislikes.

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