Humanoid:

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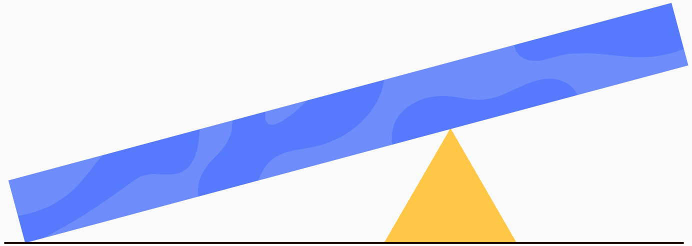
Introduction

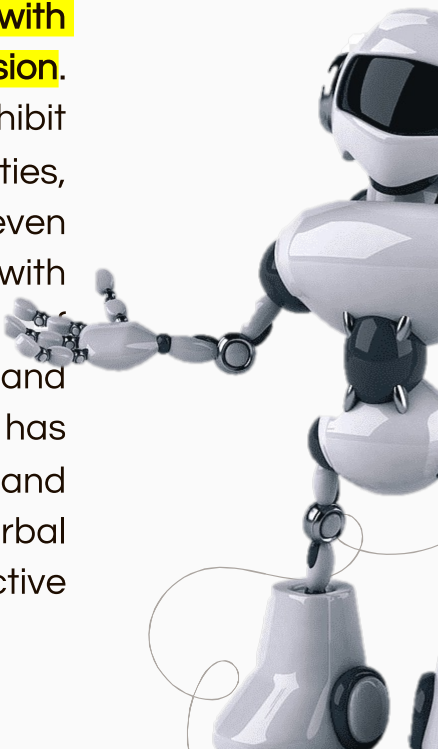
What is Humanoid?



Introduction of Humanoid

Humanoid robots are **remarkable machines designed to resemble and interact with humans,** representing a significant breakthrough in the field of robotics. Recent years have witnessed tremendous advancements in humanoid technology, pushing the boundaries of their capabilities. In the current year, cutting-edge advancements have been made, integrating state-of-the-art sensors, actuators, and algorithms into humanoids.

These advancements **enable them to perform complex tasks with exceptional efficiency and precision**. The latest humanoid robots exhibit advanced locomotion capabilities, including walking, running, and even executing acrobatic maneuvers with remarkable stability. Integration of natural language processing and computer vision technologies has enhanced their ability to understand and respond to verbal and non-verbal cues, making them more interactive and engaging.



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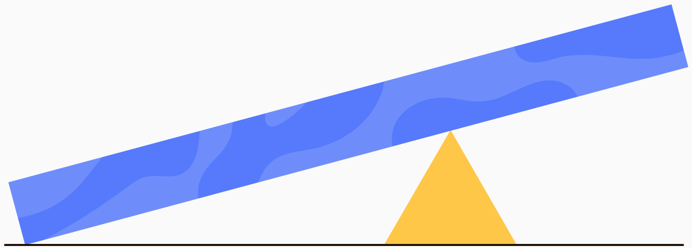
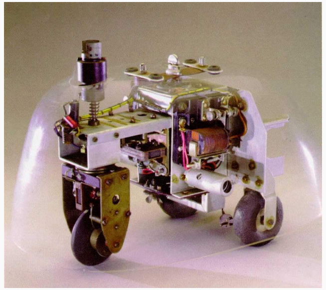
History

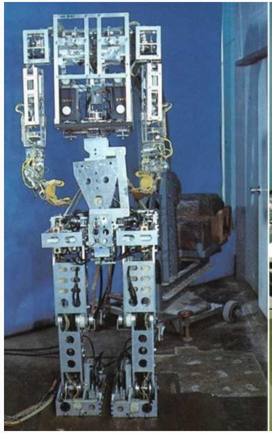
What are the humanoid developments throughout our history?



History of Humanoid

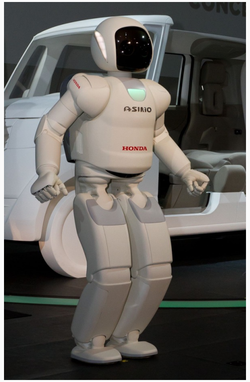
1921	Czech writer Karel Čapek introduces the term "robot" in his play "R.U.R.", depicting humanoid machines created to serve humans. This marks the first mention of humanoid robots in literature.
1948	William Grey Walter develops the first electronic autonomous humanoid robots named "Elmer" and "Elise." They can navigate their environment using photoelectric cells, representing a significant milestone in the field of robotics.
1970	WABOT-1, developed by Waseda University in Japan, becomes the first full-scale humanoid robot capable of moving its limbs and speaking. It features advanced joint control and artificial skin for tactile perception.





History of Humanoid

1997	Honda introduces ASIMO, an advanced humanoid robot designed to operate in real-world environments. ASIMO can walk, climb stairs, and recognize human faces. It showcases the potential for humanoid robots to assist humans in various tasks.
2002	Sony releases QRIO, a bipedal humanoid robot capable of dancing, recognizing faces, and interacting with humans. It demonstrates advanced motor control and coordination, pushing the boundaries of humanoid capabilities.
2010	Boston Dynamics introduces PETMAN, a humanoid robot designed for testing chemical protection clothing. It showcases exceptional balance and agility, even capable of performing push-ups and walking on a treadmill.



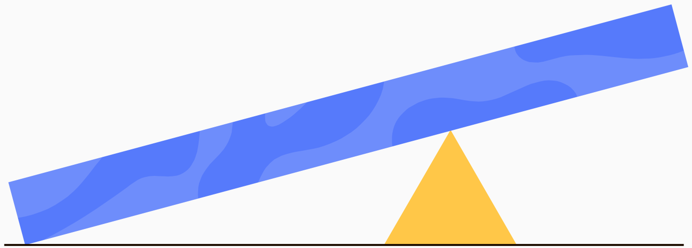
History of Humanoid

2016	Sophia, developed by Hanson Robotics, becomes the first humanoid robot to receive citizenship, granted by Saudi Arabia. Sophia showcases sophisticated facial expressions, natural language processing, and social interaction capabilities.
2019	T-HR3, developed by Toyota, showcases advanced teleoperation technology, allowing a human operator to control the robot's movements with intuitive hand and arm gestures. This development paves the way for safer human-robot collaboration.
2022	Boston Dynamics introduces Atlas, a highly agile humanoid robot capable of performing parkour-like stunts, including jumps, flips, and balancing on narrow beams. This showcases significant advancements in humanoid locomotion and agility.

03

Application

What are the impacts of humanoid in real-world applications?



Healthcare

Humanoids can assist in healthcare settings by providing companionship to patients, monitoring vital signs, assisting with physical therapy exercises, and performing simple medical procedures. They can help alleviate loneliness and provide emotional support to patients.

Education

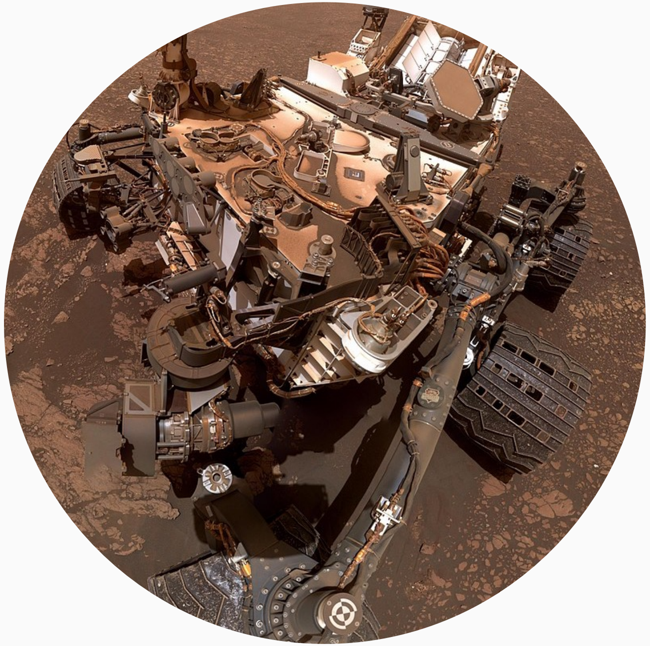
Humanoids can be used as educational tools to enhance learning experiences. They can serve as interactive tutors, teaching subjects such as language, mathematics, and science. Additionally, they can promote social skills development and encourage student engagement through interactive activities and games.

Customer Service

Humanoids can be employed as customer service representatives in various industries. They can assist customers by providing information, answering frequently asked questions, and guiding them through simple tasks. Their humanoid appearance and interactive capabilities enhance the customer experience.

Space Exploration

Humanoid robots are being developed to assist astronauts in space missions. They can perform tasks outside the spacecraft, assist with experiments, and provide support during long-duration space exploration missions.



Industrial Automation

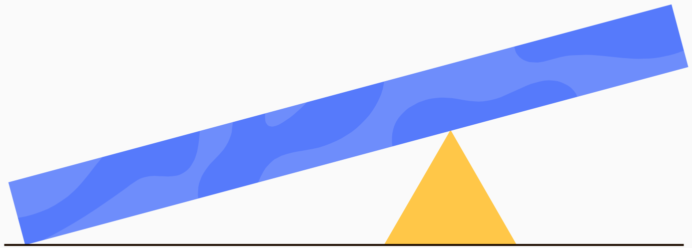
Humanoids can be employed in industrial settings to perform repetitive or physically demanding tasks. They can assist in assembly lines, handle materials, and operate machinery with precision. Their flexibility and adaptability make them valuable assets in optimizing production processes.

Disaster Response

Humanoids can be deployed in disaster-stricken areas to perform tasks such as reconnaissance, search and rescue operations, and delivering essential supplies. Their ability to navigate challenging terrains and withstand harsh conditions can aid in disaster response efforts.

04

Main Components



Six mechanical systems

Body Design

Locomotion System

Navigation & Control System

Data Collection

Data Transmission

Power Management

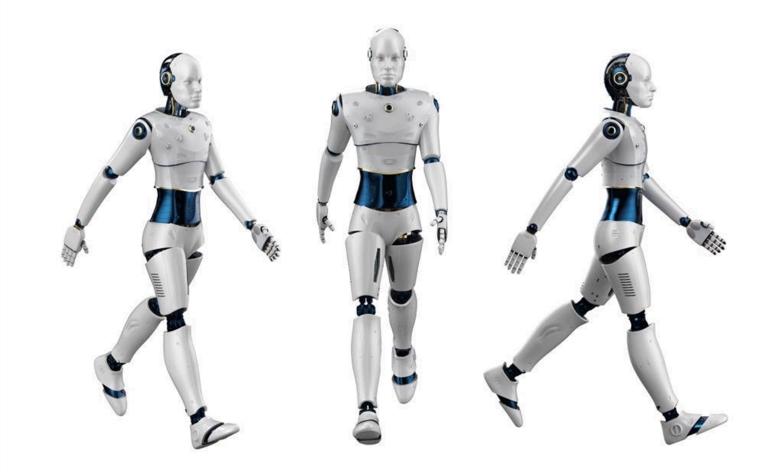
01 Body Design

The body design of humanoid robots is a critical aspect that determines their appearance, physical capabilities, and functionality.

Example of Robot Body Design

Bipedal

Bipedal humanoid robots have a body structure with two legs, resembling the human form. Bipedal design enables humanoids to walk, run, and navigate in a manner similar to humans. They often feature articulated joints in the legs, allowing for dynamic movements and balance control. Bipedal robots aim to mimic human locomotion and interact with environments designed for humans.



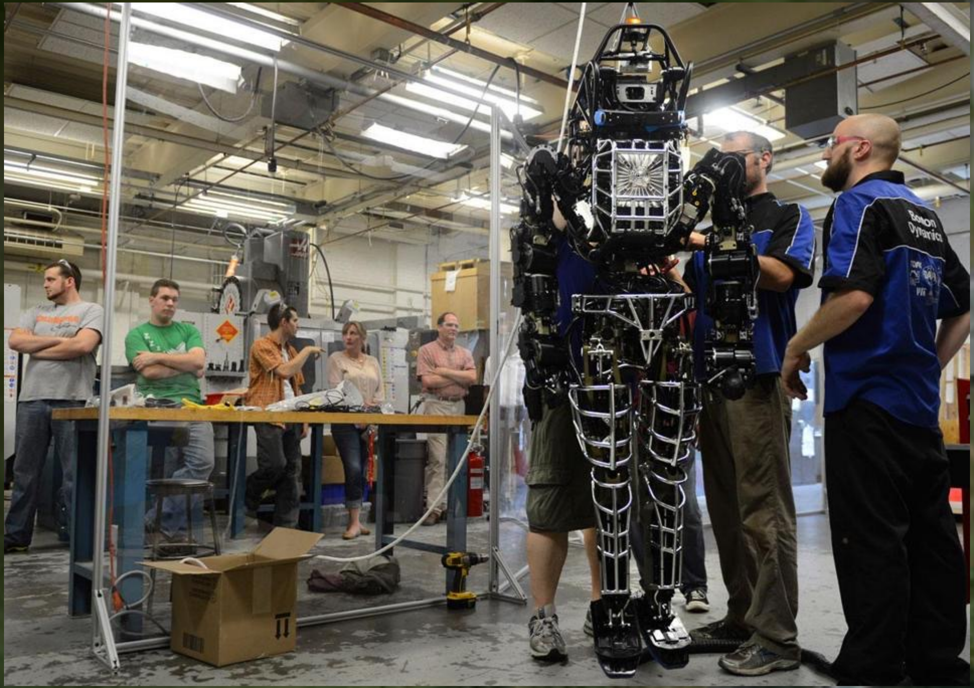
Example – Atlas (Boston Dynamics)

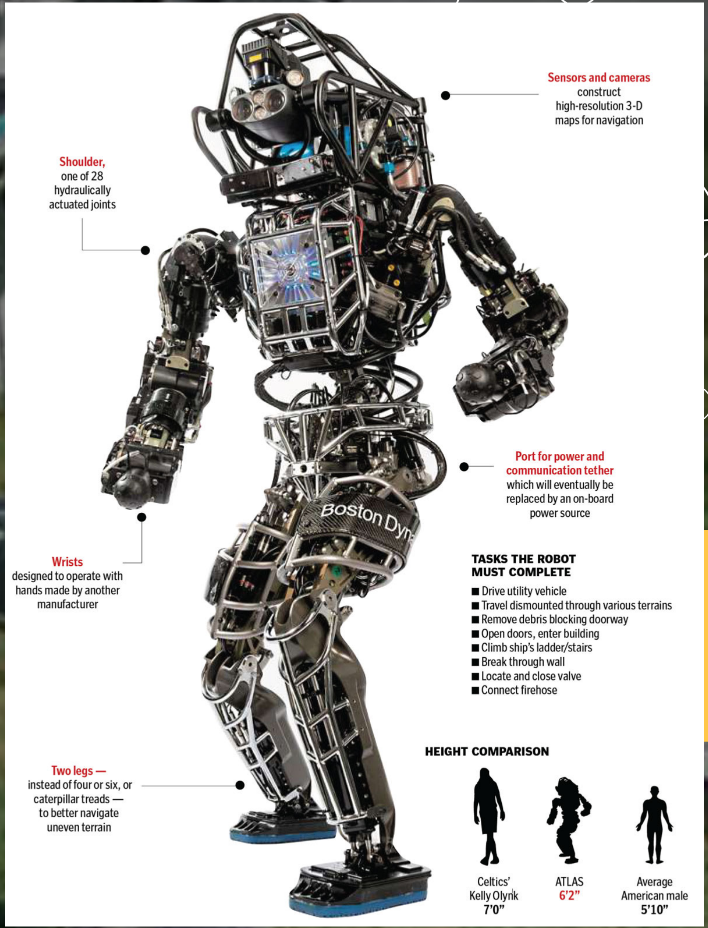
The Atlas robot is a highly versatile and capable robot that can be used for a variety of tasks. It is still under development, but it has already demonstrated the ability to perform complex tasks such as running, jumping, and climbing. As the robot continues to develop, it is likely to become even more capable and versatile.

- ✓ It is powered by a lithium-ion battery that provides up to 2 hours of runtime.
- ✓ It has a variety of sensors, including stereo vision, LiDAR, IMU, and force sensors.
- ✓ It is controlled by a software platform called ROS.
- ✓ It is designed to be used in a variety of environments, including indoors and outdoors.
- ✓ It is still under development, but it has already demonstrated the ability to perform complex tasks such as running, jumping, and climbing.

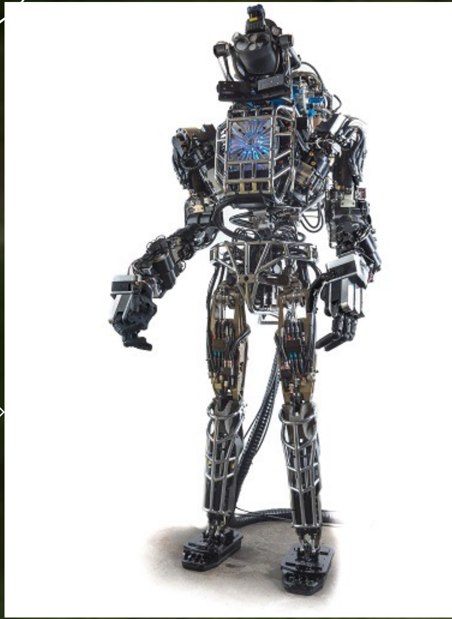
Specification	Value
Height	5'9"
Weight	180 lbs
Speed	Up to 12 mph
Strength	Able to lift up to 150 lbs
Endurance	Can walk for up to 2 hours on a single charge
Sensors	Stereo vision, LiDAR, IMU, and force sensors
Actuators	Hydraulic
Software	ROS
Applications	Search and rescue, disaster relief, and manufacturing

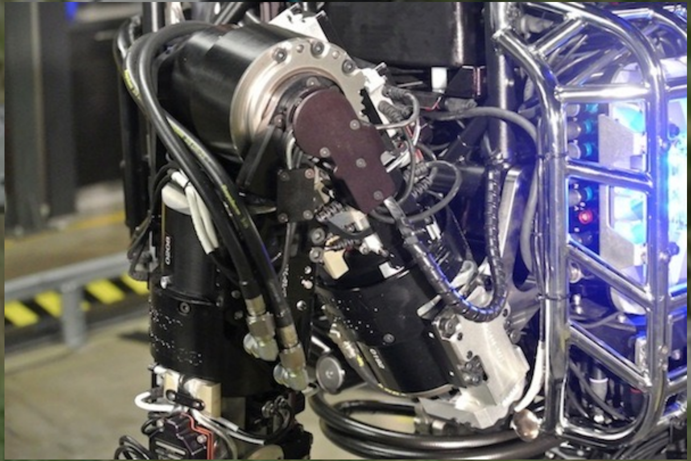
Example – Atlas (Boston Dynamics)





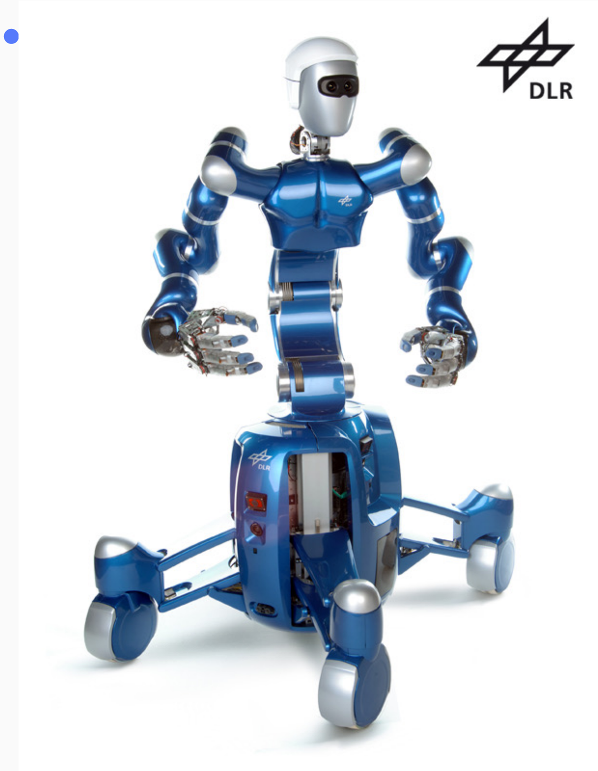
Example – Atlas (Boston Dynamics)





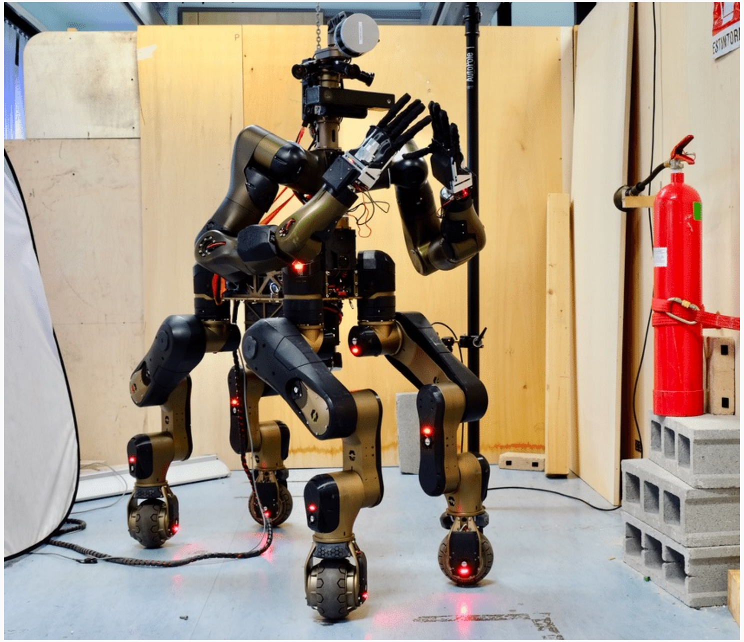
Wheeled

Some humanoid robots incorporate wheeled platforms as part of their body design. These robots use wheels for locomotion, which provides stability and efficient movement on flat surfaces. Wheeled humanoids often combine wheeled bases with an upper body structure resembling a human torso, arms, and head. This design allows them to perform tasks requiring both mobility and manipulation capabilities.



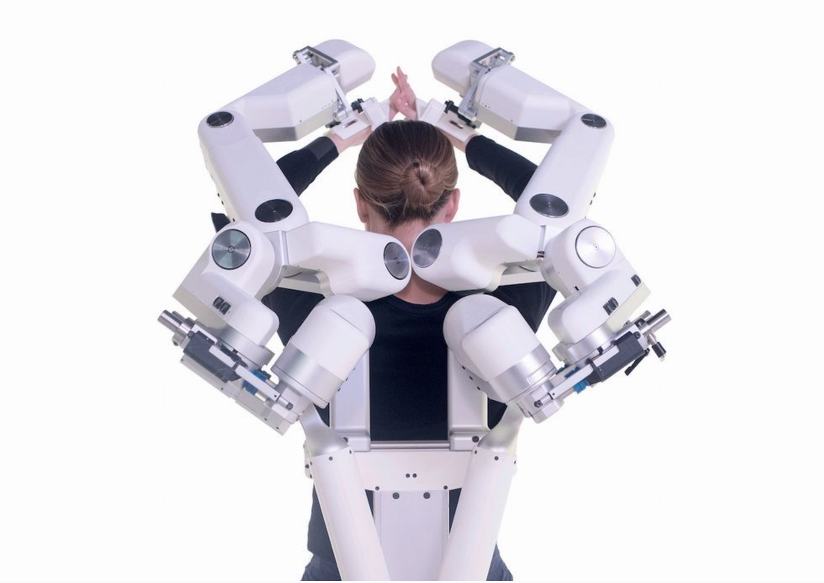
Leg-Wheeled Hybrid

Leg-wheel hybrid humanoid robots combine the advantages of bipedal and wheeled locomotion. These robots feature legs for bipedal walking and stability, along with wheels or casters integrated into their feet or base. This design allows them to switch between bipedal and wheeled locomotion modes, providing versatility in navigating different environments or terrains.



Exoskeleton

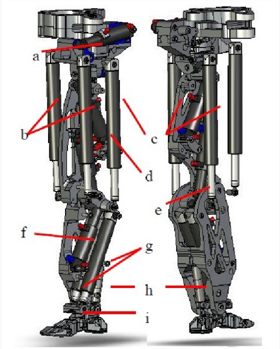
Exoskeleton humanoid robots are designed to be worn by humans, enhancing their strength and physical capabilities. These robots feature a wearable frame structure with actuators and sensors. Exoskeletons provide support, amplify human movements, and enable individuals to perform tasks that require additional strength or endurance. They find applications in fields such as rehabilitation, industrial work, or assistance for individuals with limited mobility.



02 Locomotion System

The locomotion system of humanoid robots is designed to enable them to move in a manner resembling human locomotion. It involves various components and mechanisms working together to achieve stability, balance, and efficient movement.

02 Locomotion System



3. The architecture of the entire design of humanoid robot
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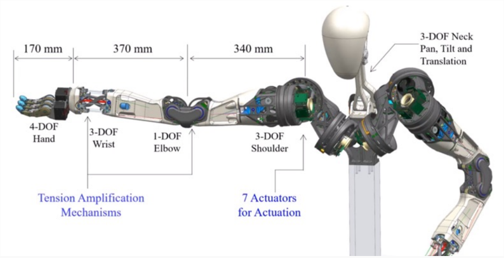
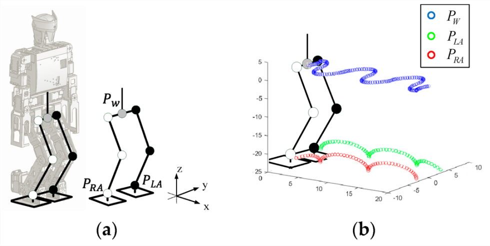




Leg Mechanism

Humanoids typically have two legs equipped with joints, including hip, knee, and ankle joints. These joints provide flexibility and allow the robot to perform walking, running, and other movements.

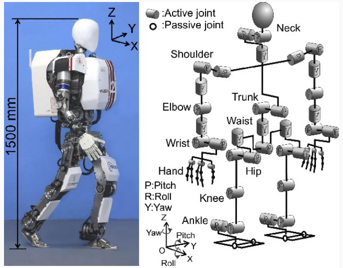
Actuators

Such as electric motors or hydraulic cylinders, are responsible for generating the forces required for leg movement. They actuate the joints, enabling the robot to perform actions like lifting, extending, and bending its legs.

Gait Generation

Determine the sequence of leg movements required for walking or running. These algorithms calculate the desired joint angles and timings based on the desired speed, stability, and other factors.

02 Locomotion System

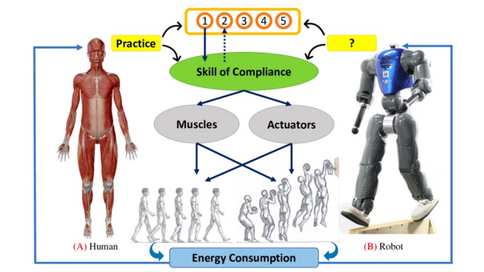


(a) Overview (b) DOF configuration

Fig. 1. WABIAN-2R (Waseda Bipedal Humanoid – No. 2 Refined).

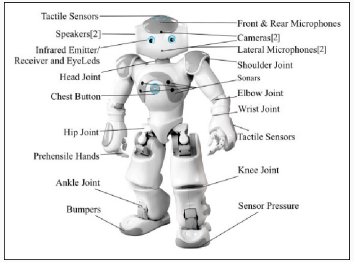
Stabilization Mechanism

Humanoid robots incorporate stabilization mechanisms to maintain balance during locomotion. These mechanisms can include additional sensors, moment sensors, or even external support, such as handrails, to prevent falls or compensate for disturbances.



Energy Efficiency

To optimize energy consumption, humanoid locomotion systems may utilize energy-efficient gait patterns, dynamic walking strategies, or even energy regeneration systems. These techniques help prolong the robot's operation time and enhance its overall efficiency.



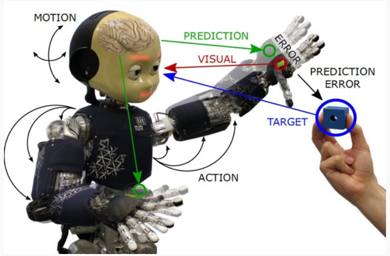
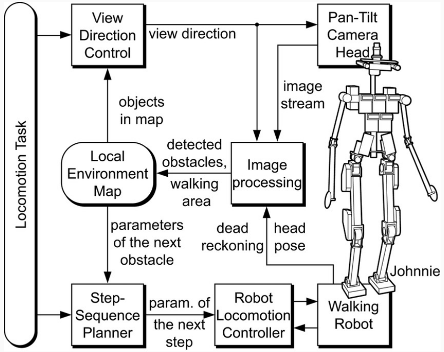
Various Sensors

Sensors play a crucial role in maintaining balance and adapting to the environment. Humanoids often incorporate sensors such as accelerometers, gyroscopes, and force sensors to measure acceleration, tilt, and ground contact forces. This information helps in adjusting the robot's posture and controlling its movements.

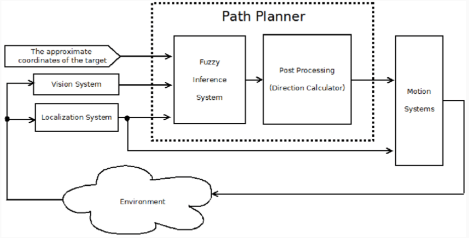
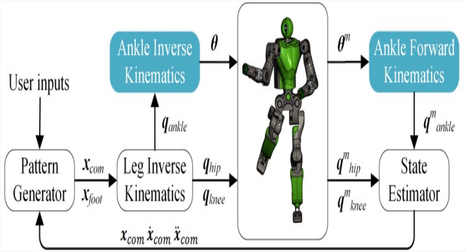
03 Navigation & Control System

Humanoid robots incorporate sophisticated navigation and control systems that enable them to navigate and interact with their environment.

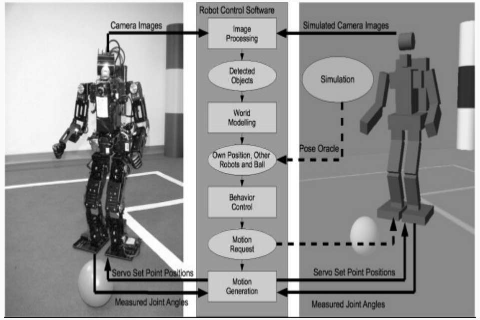
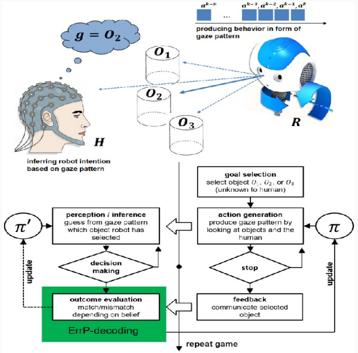
03 Navigation & Control System

Component	Advantage	Figures
Perception Sensors	These sensors provide input for environment mapping, object detection, and obstacle avoidance.	
Localization Technique	Such as simultaneous localization and mapping (SLAM), to estimate their position and create a map of the environment. This enables them to navigate autonomously and avoid obstacles.	

03 Navigation & Control System

Component	Advantage	Figures
Path Planning	To determine the optimal path for the humanoid to navigate from one location to another. It considers factors like obstacle avoidance, energy efficiency, and task-specific requirements.	
Motion Control	To generate smooth and precise movements. These algorithms take into account joint limits, dynamics, and stability constraints to ensure safe and coordinated motion.	

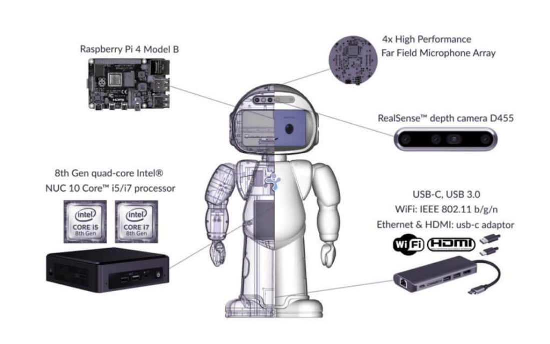
03 Navigation & Control System

Component	Advantage	Figures
Collision Detection	To prevent collisions with objects or humans in their environment. This may involve force sensors, proximity sensors, or advanced computer vision techniques to detect and avoid potential collisions.	
Autonomous Decision Making	Advanced AI algorithms & machine learning techniques enable humanoids to make autonomous decisions in real-time. Allow them to adapt to dynamic environments, respond to changing conditions, and perform tasks autonomously.	

04 Data Collection

Humanoid robots utilize various sensors to collect data from their environment, enabling them to perceive and interact with the world.

04 Data Collection



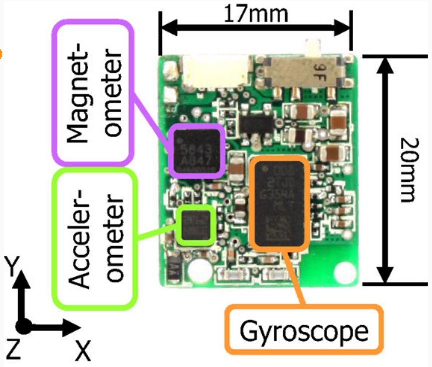
Camera

Cameras, such as RGB cameras or depth cameras (e.g., stereo cameras or Time-of-Flight cameras), capture visual information from the environment. They enable the robot to recognize objects, detect humans, and perceive depth for navigation and manipulation tasks.

LiDAR

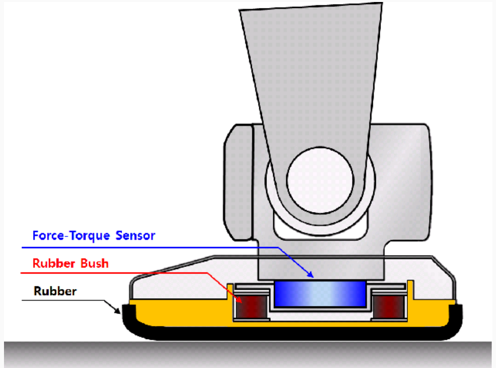
LiDAR (Light Detection and Ranging) sensors use laser beams to measure distances and create detailed 3D maps of the surroundings. Humanoids can utilize LiDAR for accurate environment mapping, obstacle detection, and localization.

04 Data Collection



Inertial Measurement Unit (IMU)

IMUs consist of accelerometers, gyroscopes, and magnetometers that measure the robot's linear acceleration, angular velocity, and orientation. IMUs are crucial for estimating the robot's pose, tracking its movements, and stabilizing its balance.



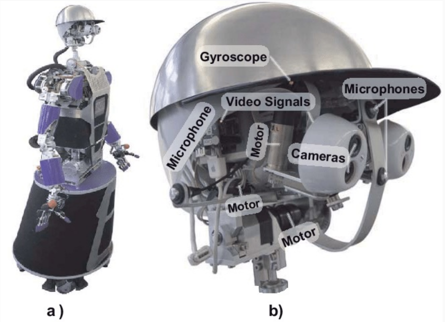
Force/Torque Sensors

Force/torque sensors are used to measure the forces and torques applied to the robot's limbs or end-effectors. They provide feedback for grasping, object manipulation, and contact interactions, enabling the robot to perceive forces exerted on it and adjust its actions accordingly.

04 Data Collection

Pressure Sensors

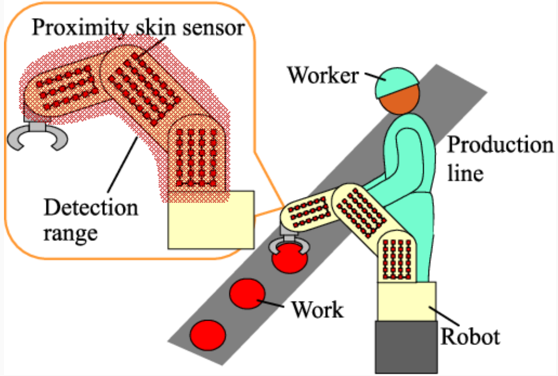
Often integrated into the feet or the contact areas of the robot. They detect changes in pressure distribution, allowing the robot to estimate its center of mass, maintain balance, and sense ground contact during locomotion.



Microphones

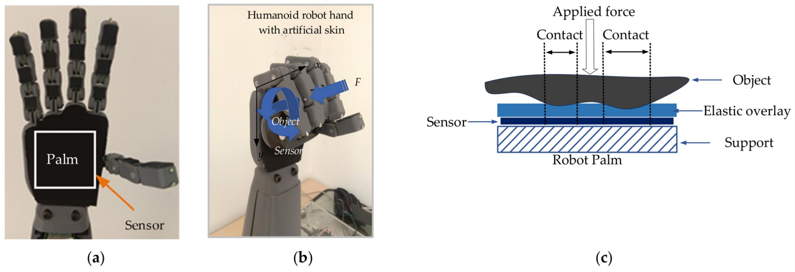
To capture audio signals, enabling humanoid robots to receive and process speech commands from humans, recognize sound patterns, and engage in voice-based interaction.

04 Data Collection



Proximity Sensors

Such as infrared or ultrasonic sensors, detect the presence or proximity of objects in the robot's vicinity. They are commonly used for obstacle avoidance and navigation in humanoid robots.



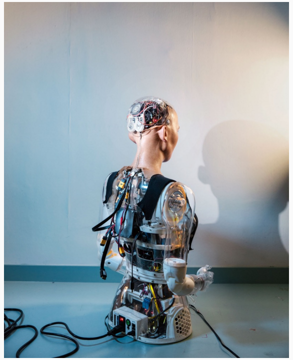
Tactile Sensors

To provide the ability to sense and interpret physical contact with objects or humans. These sensors can be integrated into the robot's fingers, palms, or other body parts, allowing it to perceive touch, pressure, and texture information.

05 Data Transmission

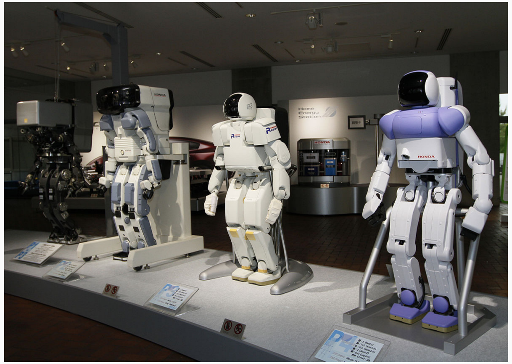
Humanoid robots require efficient and reliable data transmission systems to facilitate communication and exchange information.

05 Data Transmission



Wired

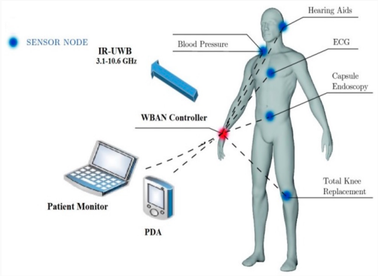
Such as Ethernet or USB connections, to transmit data between internal components and external devices. Wired connections provide fast and reliable data transfer, ensuring real-time communication and high-bandwidth data exchange.



Wireless

Including Wi-Fi, Bluetooth, or Zigbee, enable humanoids to establish wireless connections with other devices or networks. These wireless technologies allow data transmission over short distances, facilitating interactions with smartphones, tablets, or other compatible devices.

05 Data Transmission



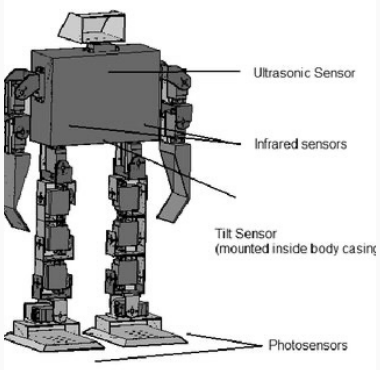
Wireless Body Area Network (WBAN)

Consist of wireless sensors placed on the humanoid's body, enabling localized data transmission for specific tasks. WBANs facilitate communication between different body parts, allowing data exchange for motion control, coordination, or monitoring purposes.

Radio Frequency (RF)

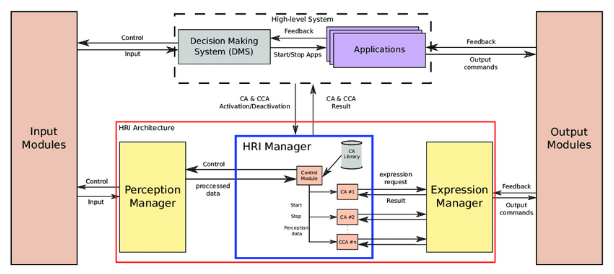
Utilizes radio waves to transmit data wirelessly. It can involve technologies such as RFID (Radio Frequency Identification) for object tracking or wireless data transmission protocols like Zigbee or LoRa for long-range communication in certain scenarios.

05 Data Transmission



Infrared

Utilizes infrared light to transmit data over short distances. IR communication can be employed for remote control purposes, allowing humanoids to receive commands or exchange data with other infrared-enabled devices.



Human-Robot Interaction (HRI) Protocols

define communication interfaces and standards specifically designed for human-robot interaction. These protocols establish guidelines for data transmission between humans and humanoids, enabling seamless and intuitive interaction through speech, gestures, or other communication modalities.

06 Power Management

Humanoid robots require efficient power management systems to ensure continuous operation and optimize energy consumption.

Power Source

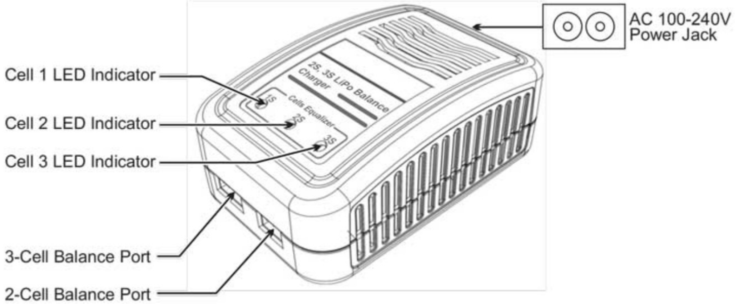
Humanoids are typically powered by batteries, fuel cells, or external power supplies. The power source provides the primary energy required for the robot's operation. Battery-powered humanoids offer mobility and portability, while external power supplies provide a continuous power source but may limit mobility. Fuel cells offer longer operation times and high energy density, but are less common due to complexity and infrastructure requirements.

Example – LiPo Batter Charger (EzRobot)

INTRODUCTION

Thank you for your choice of the ezrobot, 100-240V AC balance charger. This unit is simple to use but its operation does require some knowledge on the part of the user. Please read this entire operating manual completely and attentively before using this product, as it covers a wide range of information on operating and safety.

ezrobot Charger is an economic, high quality 100-240V AC balance charger, designed for charging LiPo batteries from 2-3 cells in balance mode. The circuit power is 11W and max charge current can reach to 1.5A.



SPECIFICATION

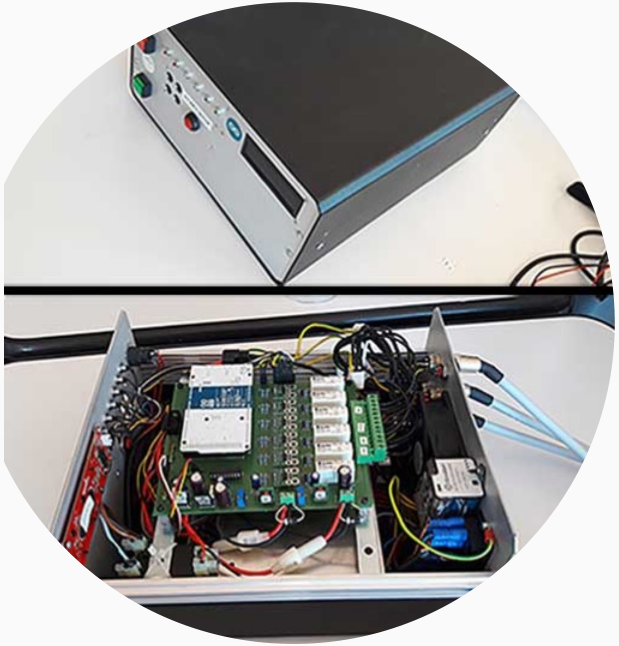
AC Input	100-240V, 50-60Hz
Battery Type	LiPo
Cell Count	2-3 cells
Charge Current	1.5A ± 10%
Cell Terminate Voltage	4.2V ± 0.02V
Circuit Power	11W ± 10%
Dimension	88x57x35mm
Weight	103g

Power Distribution

Power distribution systems manage and distribute electrical power to different components of the humanoid. They include wiring, connectors, and voltage regulation mechanisms to ensure proper power supply to motors, sensors, processors, and other subsystems.

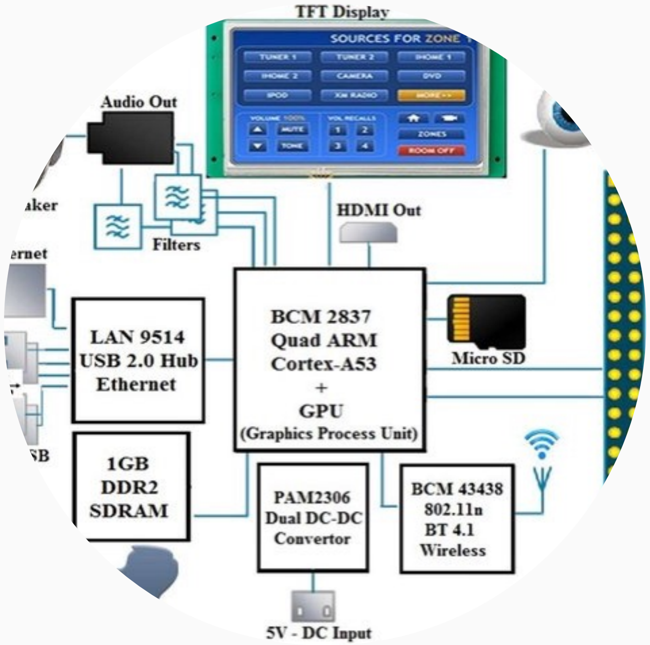
Power Monitoring

Power monitoring systems track the energy consumption of different components and subsystems in real-time. They provide information on power usage, voltage levels, and battery status. Power monitoring helps optimize energy efficiency, detect abnormalities, and estimate remaining battery life.



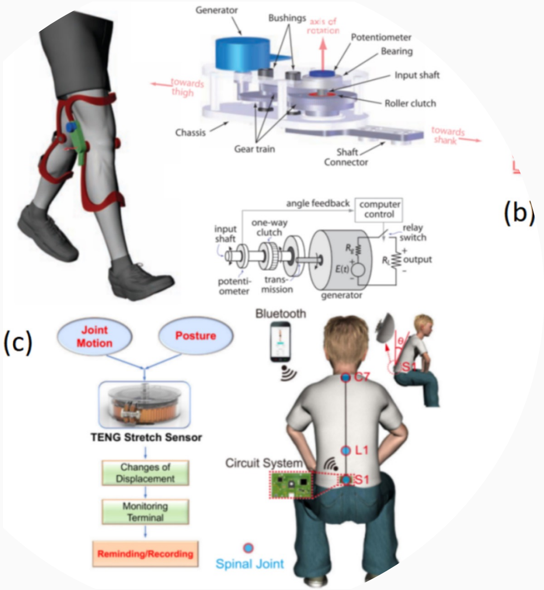
Power Management

Power management algorithms and techniques optimize power usage based on system requirements and operational conditions. These algorithms regulate power supply to individual components, activate power-saving modes, or dynamically adjust power allocation to maximize efficiency and extend operation time.



Energy Recovery

Humanoids may incorporate energy recovery systems to capture and reuse energy during certain actions or movements. Techniques such as regenerative braking or energy storage mechanisms help convert and store energy that would otherwise be wasted, improving overall energy efficiency.



Charging & Docking

Charging and docking mechanisms enable humanoid robots to replenish their energy reserves autonomously. Charging stations or docking stations with compatible connectors and interfaces provide a convenient means for recharging batteries or connecting to external power sources. Automated docking systems can initiate charging or power transfer when needed.