Humanoid

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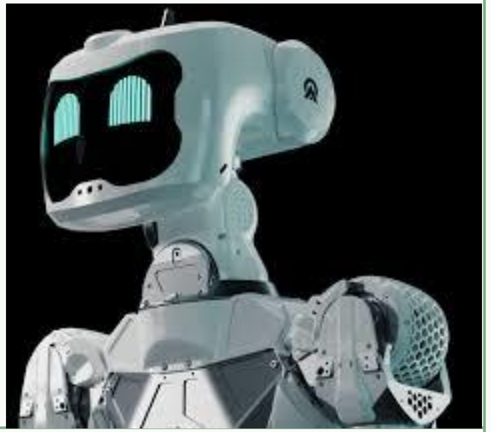
Introduction

- In terms of physical appearance, behavior, and capabilities, a humanoid robot is a type of robot that is created to resemble and communicate with people.
- The term "humanoid" denotes a robot with traits or appearances resembling those of a human.
- To sense and engage with their environment, they have a variety of sensors, actuators, and artificial intelligence technologies.



History

- **Early Concepts and Automata**: Many pre-modern cultures, including ancient Egypt and Greece, have myths about automata—humanoid machines.
- **Early Industrial Age**: The term "robot" was first used in the late 19th century by Czech author Karel Čapek in his play "R.U.R. (Rossum's Universal Robots)" (1920).
- **WABOT**: One of the first humanoid robots was the WABOT-1 (WAseda roBOT-1), which was created in Japan in 1973. It was able to move around, handle things, and speak using speech synthesis and recognition.
- **ASIMO**: Honda introduced its ASIMO (Advanced Step in Innovative Mobility) vehicle in 2000. It rose to prominence as one of the most well-known humanoid robots thanks to its ability to walk on two legs and interact with humans.
- **Boston Dynamics and Advanced Humanoid Robots**: Robotics company Boston Dynamics produced the high-tech bipedal and humanoid robots PETMAN, Atlas, and Spot. These robots displayed remarkable balance, agility, and mobility.
- **Recent Advancements**: Companies like Softbank Robotics have developed robots like Pepper, designed for human interaction in various settings.

Applications

- **Personal Assistance**: assist individuals with daily tasks such as household chores
- **Healthcare**: utilized in healthcare settings to provide companionship to patients
- **Education**: serve as educational tools, assisting in teaching various subjects, languages, or skills
- **Customer Service**: act as customer service representatives, providing information, guiding customers, and assisting with transactions.
- **Entertainment:** used for entertainment purposes, such as performing shows
- **Research and Development**: Employed in research laboratories to study human-like movement, cognition, and social interaction

Main Components

Design

Propulsion System

Navigation System & Control

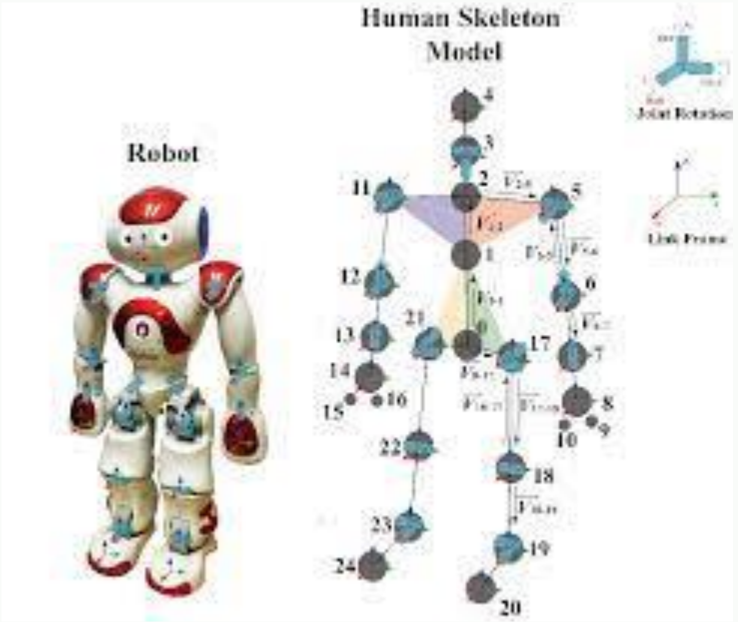
Data Collection

Data Transmission

Power Management

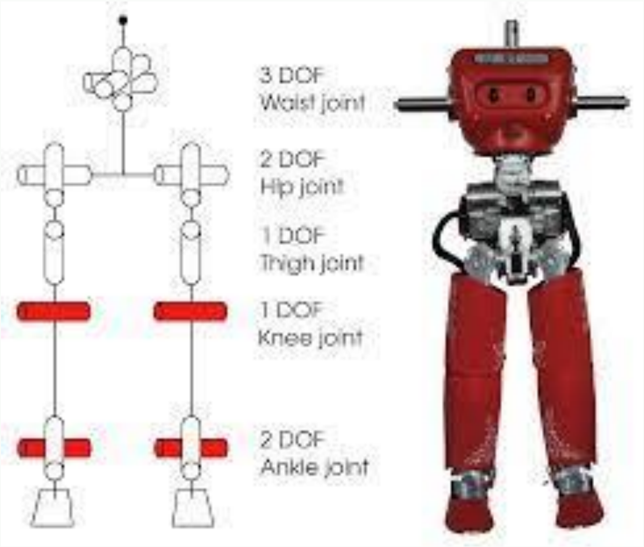
Design

- Structural Frame:
  - provides support and stability to the overall robot's body.
  - It is usually made of lightweight and rigid materials such as aluminum, carbon fiber composites, or high-strength plastics.
  - The frame is designed to withstand the loads and forces generated during movements and interactions

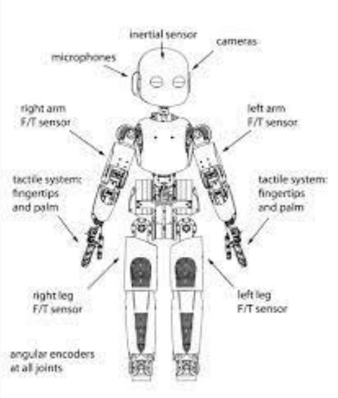


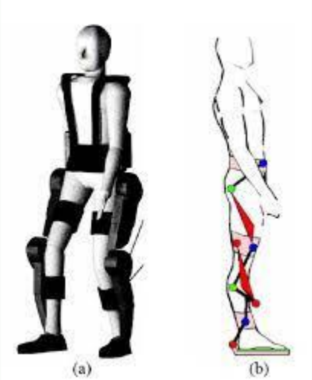
Design

- Joints And Actuators:
  - Humanoid robots have multiple joints, allowing them to achieve a range of movements and postures similar to Humans.
  - Joints are usually actuated by motors, hydraulic systems, or pneumatic systems to provide the necessary force and flexibility



Design





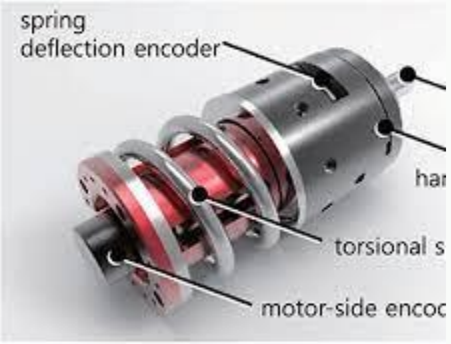
- Sensory Integration:
  - incorporate various sensors throughout their body which include cameras, depth sensors, touch sensors, force sensors, accelerometers, and gyroscopes.
  - The design of the frame and hull takes into account the optimal placement of sensors to enable effective perception and feedback.
- Ergonomics & Anthromorphism:
  - Humanoid robots strive to mimic human form and movement, which involves considering anthromorphic proportions and ergonomics in their design.
  - The frame and hull are designed to resemble human body segments, with considerations for limb length, joint placement, and range of motion.

Propulsion System

- Electric Motors
  - provide rotational motion and actuation for the robot's joints,

- Hydraulic Systems
  - used in robots designed for heavy lifting or demanding tasks.

- Pneumatic Systems
  - Use compressed air or gas, can provide fast and responsive actuation for humanoid robots



- Series Elastic Actuators
  - incorporate elastic elements between the motor and the joint to provide compliant and force-controlled movement.

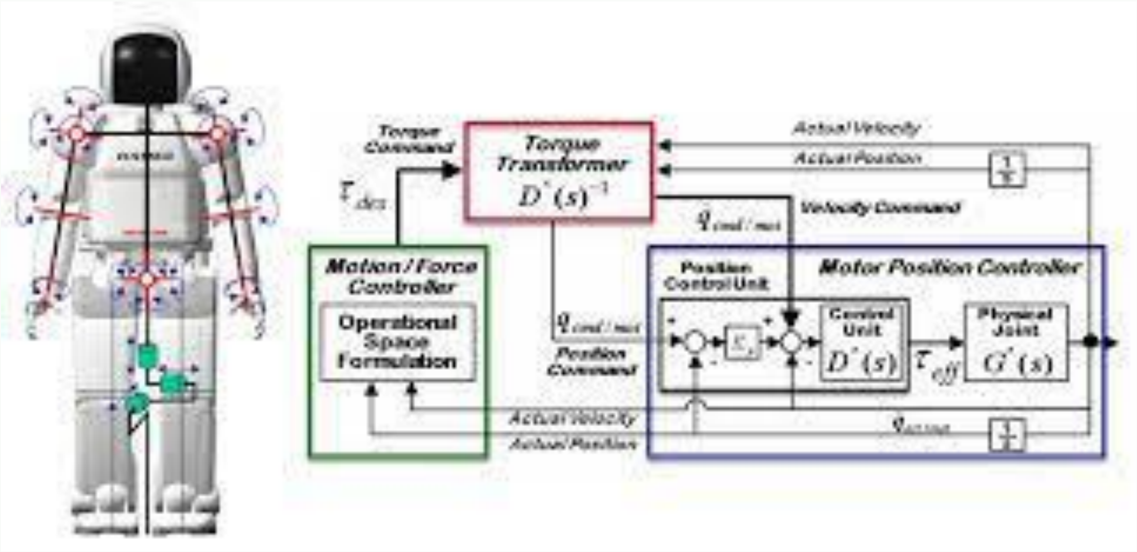
Propulsion System

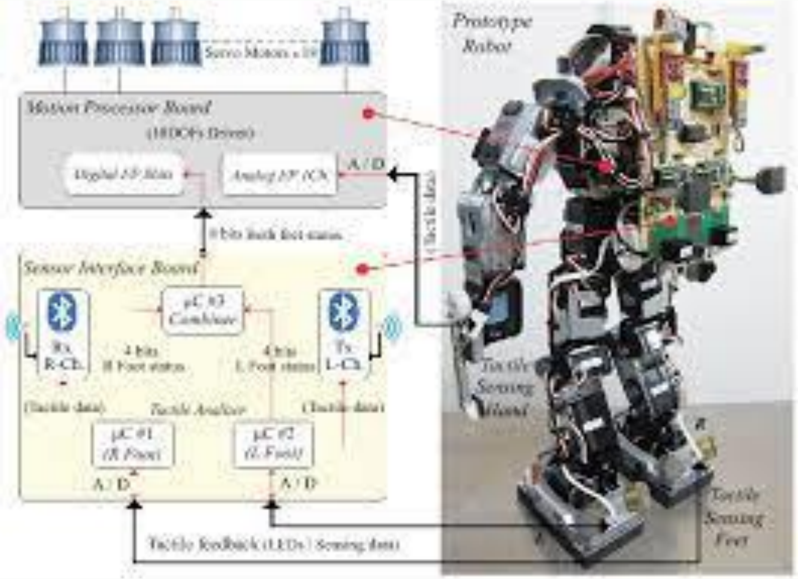
- **Tendon Drive Systems**: utilize cables or tendons connected to the robot's joints and driven by motors or actuators
- **Wheeled/Legged**:
  - Wheeled systems, often combined with stabilizing mechanisms, allow for efficient movement on flat surfaces.
  - Legged systems, resembling human or animal legs, enable the robot to traverse diverse terrains and navigate obstacles.
- **Hybrid**: combine multiple propulsion systems to achieve versatile and adaptive locomotion

Navigation System

- **Sensors**: provide information about the robot’s position, orientation, distance to object, and obstacle detection
- **Perception & Mapping**: creating a map of the surroundings, identifying objects, and estimating their positions and distances. Advanced perception algorithms, such as simultaneous localization and mapping (SLAM)
- **Path Planning**: Path planning algorithms take into account obstacles, the robot's physical capabilities, and any constraints or objectives specified by the task at hand.
- **Localization**: often done by comparing the sensor data to the map and estimating the robot's pose (position and orientation) relative to the map
- **Obstacle Avoidance**: The navigation system continuously monitors the environment and uses the sensor data to detect obstacles. Algorithms like potential field methods or artificial potential fields are commonly used to plan robot movements
- **Human-Robot Interaction**: involve recognizing and responding to human commands, following gestures, or adapting the robot's behavior based on social cues from humans in the environment

Control System

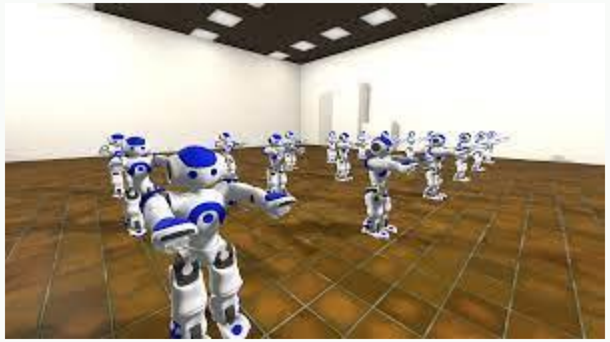


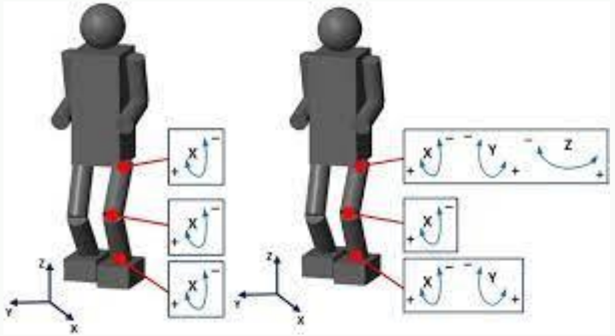


Data Collection

- Sensors
  - Camera
  - IMU
  - LiDar
  - Ultrasonic Sensor
  - Force/Torque Sensor
  - Tactile Sensor
  - Proximity
- Actuators
  - Electric Motor
  - Hydraulic Actuator
  - Pneumatic
  - Series Elastic Actuator SEA
  - Tendon Drive
  - Grippers
  - End effector

Data Collection





- MoveIt
- Gazebo
- Simulink

Data Transmission

- Ethernet
- USB
- Wifi
- RS-232
- ZigBee
- Radio Frequency
- CAN
- I2C

Power Management

- **Battery Power Management**: regulated the charging and discharging of batteries to ensure optimal performance
- **Power Saving Techniques**: utilize sleep or idle modes for subsystems that are not actively performing tasks
- **Power Distribution & Regulation**: PDUs distribute power from main source to various subsystems and components of the humanoid robot
- **Energy Harvesting**: providing a renewable and continuous power source
- **Charging and Docking Stations**: provide a convenient and automated way for robots to recharge their batteries when they are not actively performing tasks