

Human-Robot Interaction and Autonomous Systems

AI 616

Master of Science in Artificial intelligence

Prepared by Dr. Khaled Eskaf

Lecture 2





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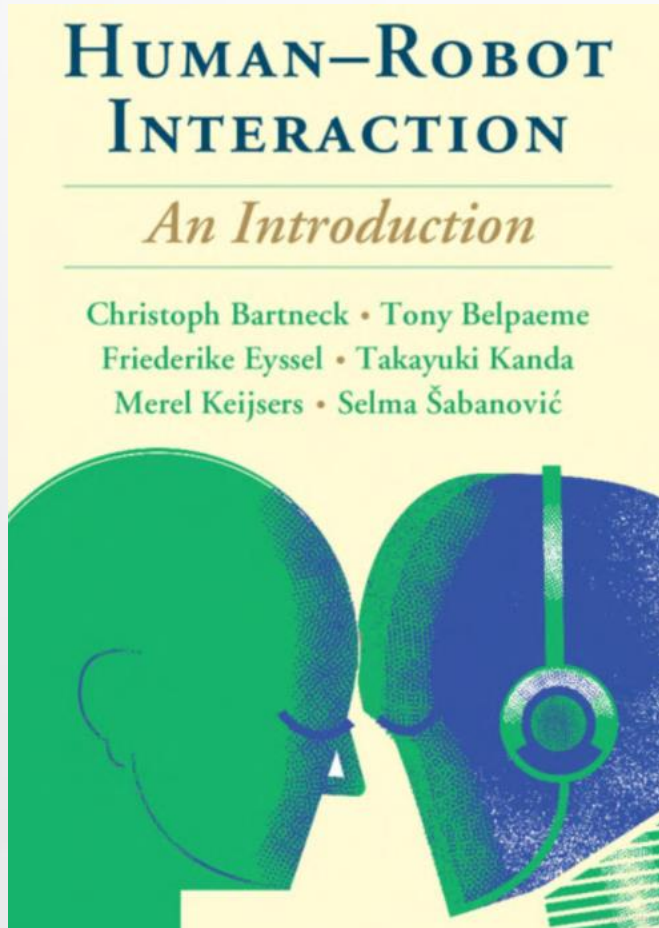
Course Outlines

Module	Content	Simulation Lab
1. Introduction to Robotics	- Fundamentals of Robot Control - Classification of Robotics - Exploration of Robot Types	- Basic Robot Control - Modeling Robot Classes - Simulating Various Robot Types
2. Advanced HRI Studies	- Introductory to Advanced Concepts in HRI	- Basic to Complex HRI Scenarios
3. Social Dynamics in Robotics	- Architectures for Social Interaction - Case Studies and History of HRI	- Social Interaction Simulations Historical Evolution in HRI
4. Strategic HRI System Design	- Core Principles and Communication Strategies in HRI	- Designing Interfaces - Communication Protocol Simulations
5. HRI Efficiency and Effectiveness	- Metrics for Mission Effectiveness and Human Factors	- Implementing and Analyzing HRI Metrics
6. Innovative HRI System Design	- Exploring Innovative Designs and Real-World Applications	- Testing Innovative Designs - Simulating Diverse Scenarios
7. HRI System Classification	- Developing Comprehensive Classifications	- Classification Application and Case Studies
8. Human Factors in HRI	- Analyzing Ergonomics and Human Factors	- Ergonomic Simulations - Scenario-Based Human Factor Analysis
9. Robotics and AI Integration	- Theoretical Concepts and Practical AI Applications	- AI Algorithm Implementation - AI-Driven HRI Modeling
10. HRI Case Studies	- Mobile Assistive Robot Studies	- Designing and Testing Mobile Assistive Robots

Human-Robot Interaction An

Introduction

By [Christoph Bartneck](#), [Tony Belpaeme](#), [Friederike Eyszel](#), [Takayuki Kanda](#), [Merel Keijsers](#), [Selma Šabanović](#) · 2020



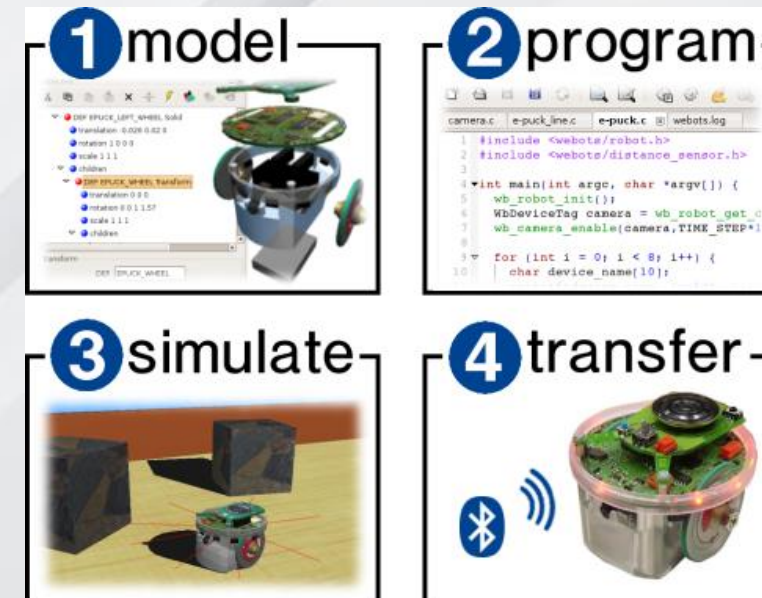
Webots

robot simulation

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Webots is an open source and multi-platform desktop application used to **simulate** robots

<https://cyberbotics.com/>



Chapter

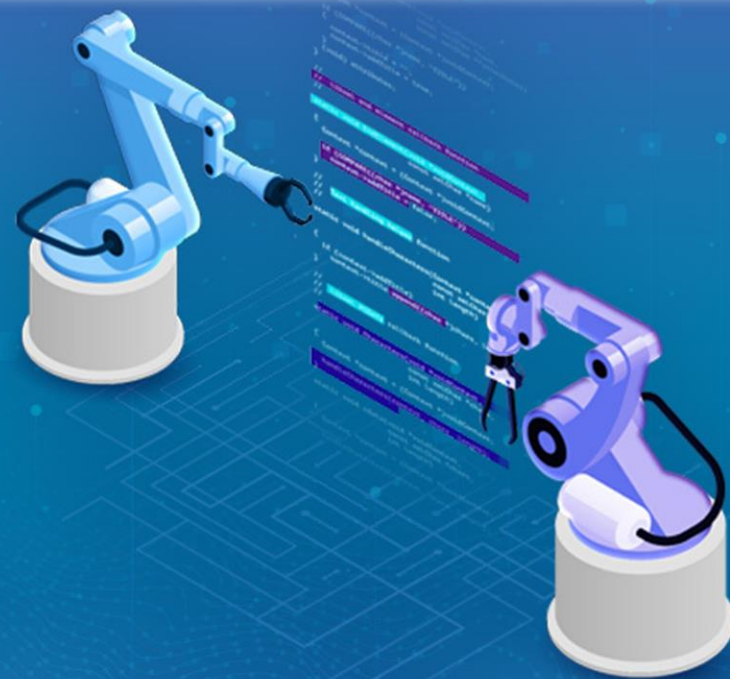
01



Fundamentals of Robot Control

Robot Control Basics

Learn various methods and techniques of modern robot control.



Introduction to Robot Control

Objective: Understanding the Fundamentals of Robot Control

1. What is Robot Control?

1. Definition:

1. Robot Control refers to the various methods and algorithms that enable a robot to perceive, navigate, and interact with its environment.

Introduction to Robot Control

2. Why is Robot Control Important?

1. Key to Robot Performance:

1. Efficiency: Ensures that the robot can complete tasks quickly and accurately.
2. Safety: Critical for preventing accidents, especially when robots work near humans.
3. Functionality: Determines the range and quality of tasks a robot can perform.

Introduction to Robot Control

3.The Role of Control Systems in Robotics

1. Central to Robotic Applications:

1. Control systems act as the brain of a robot, making decisions based on the programming and sensors.

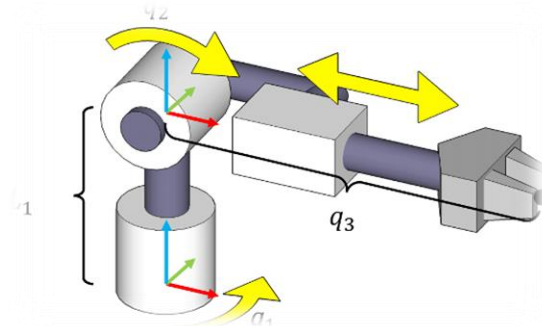
Basic Concepts in Robot Control

Kinematics: علم الحركة

• **Definition:**

- Kinematics in robotics refers to the study of the motion of robots without considering the forces that cause this motion.
- It involves understanding how a robot moves from one point to another.

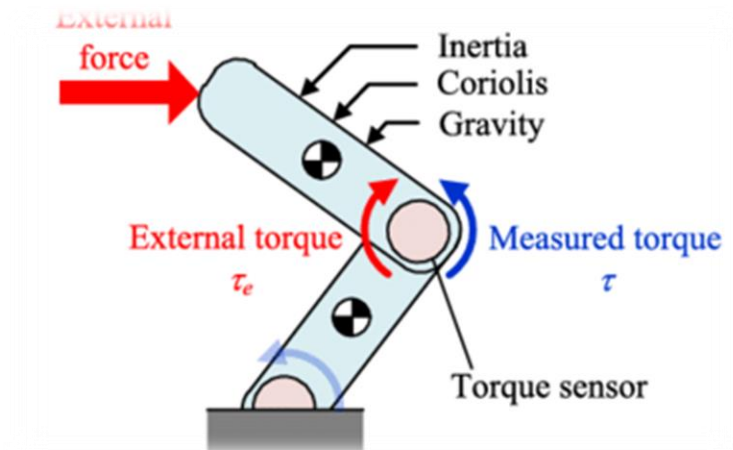
For example, if we move the robot's arm up, down, or in a circle, we're seeing kinematics in action - it's all about the movements, not what's making them happen!



Dynamics:

•Definition:

- Dynamics is about the forces and torques that cause the motion of robots. It considers the physical principles that govern movement.



Chapter

01

1.Forces: This is like a push or a pull. If you push a toy car, it moves, right? That's a force. Robots use forces to move their arms, legs, or wheels.

2.Torques: This is a twisty force. Think of opening a jar of cookies by twisting the lid - that's using torque. Robots use torques to turn their heads or twist their arms.

Now, how do robots get these powers? They have motors and gears, kind of like the muscles and bones in your body.

- Motors:** These are like robot muscles. They help the robot to move. When the robot wants to lift its arm, the motor works like your muscle does when you lift something.

- Gears:** These are like the bones in your hand that help you grab and hold things. Gears work with the motors to control how fast or how strong the robot's movement should be.

Control Algorithms in Robotics

What are Control Algorithms?

•Definition:

- Control Algorithms in robotics are sets of step-by-step instructions that guide a robot's actions and decisions.
- They are like recipes that tell the robot how to respond to various situations.

•Line-Following Algorithm:

- A basic but practical example where a robot follows a predefined path, like a line on the floor. Used in automated guided vehicles in factories.

•Obstacle Avoidance Algorithm:

- This algorithm helps a robot detect and navigate around obstacles. Imagine a robot vacuum that changes direction when it encounters a chair leg.

Robotics Classification - Capabilities and Applications

Objective: Understanding Robotics: Capabilities and Applications

•Operational Capabilities

- **Industrial Robots:** For manufacturing tasks like assembly and welding.
- **Service Robots:** Used in non-industrial settings such as homes, hospitals.

•Application Areas

- **Medical Robots:** In surgeries and rehabilitation.
- **Military Robots:** For surveillance and defense.
- **Space Robots:** Employed in space exploration and operations.

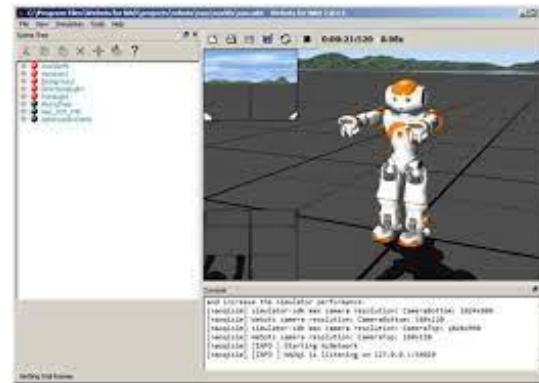
Chapter

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Virtual LAB



Webots
robot simulation



Chapter

02

Course Outline

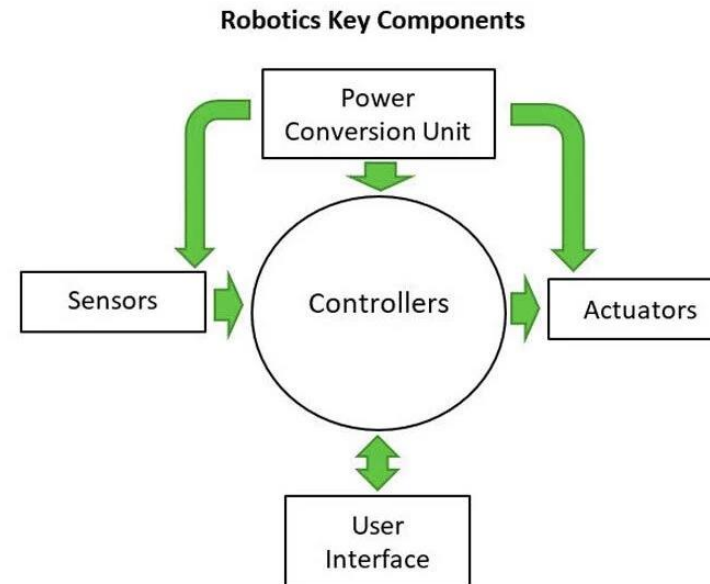


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The Core Components of a Robot

An illustrative diagram showing the robot's core components: Computer Parts, Mechanical Components, Sensors, and Embedded Systems, leading to Human-Robot Interaction.



The Core of Robotics : Understanding Computer Parts

Chapter

02

Computer Parts in Robotics

Simplified explanations of CPUs, Memory, and Storage, using metaphors like the robot's "brain" and "memory bank."



Chapter

02

Actuators: The Muscles of Robots

1. What Are Actuators?

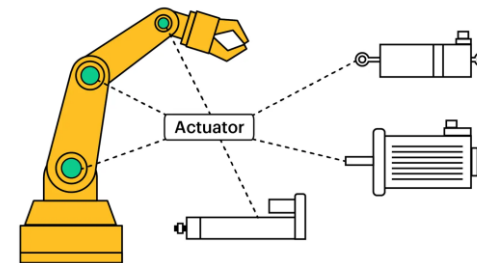
1. Brief Definition: Devices that convert electrical energy into physical motion.
2. Analogy: Just as muscles allow humans and animals to move, actuators enable robots to walk, grasp, lift, and perform other actions.

2. Types of Actuators

Electric Motors: The most common type, used in robotic arms, drones, and more. Illustrate with a snippet showing an electric motor in a robotic arm.

3. Why Actuators Are Important

Emphasize the role of actuators in expanding what robots can do, making them capable of interacting with the physical world in diverse and complex ways.



Chapter

02

Motors: Powering Robotic Movement

1. Introduction to Motors in Robotics

1. Brief explanation of how motors are the driving force behind robotic movement, acting as the "muscle" that powers everything from robotic arms to autonomous vehicles.

2. Types of Motors

1. Servo Motors:

1. Characterized by their ability to control angular position with precision. Commonly used in robotic arms, antennas, or any application where precise positioning is required.

2. Stepper Motors:

1. Known for their accuracy in controlling steps, making them ideal for applications requiring exact movements, such as 3D printers and CNC machines.

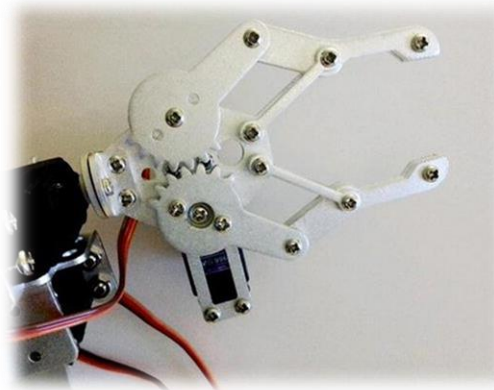
3. DC Motors:

1. Direct Current motors offer simple control and are used in a wide range of applications due to their speed variability and torque. Examples include hobby robots, drones, and electric vehicles.

Chapter

02

Servo Motor



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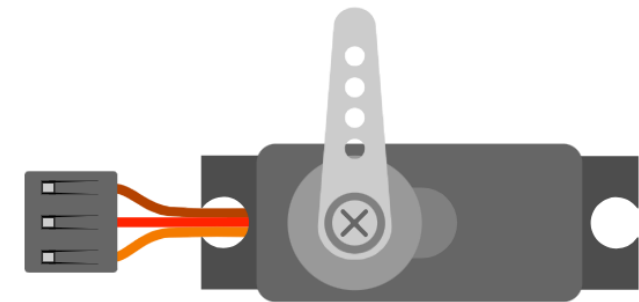
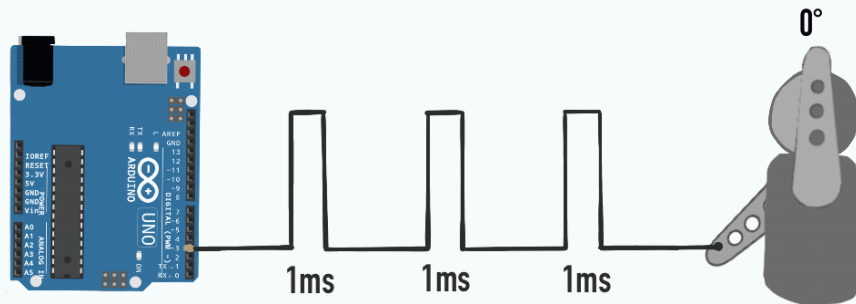
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Servo motor

You can rotate the servo motor shaft from 0° to 180° by varying the PWM pulse width from 1 ms to 2 ms.

PWM (Pulse Width Modulation)

SERVO MOTOR CONTROL



NAME	WIRE COLOR	DESCRIPTION
PWM	Yellow	Input control signal for the motor
V+	Red	Positive supply terminal
Ground	Brown	Ground terminal

Chapter

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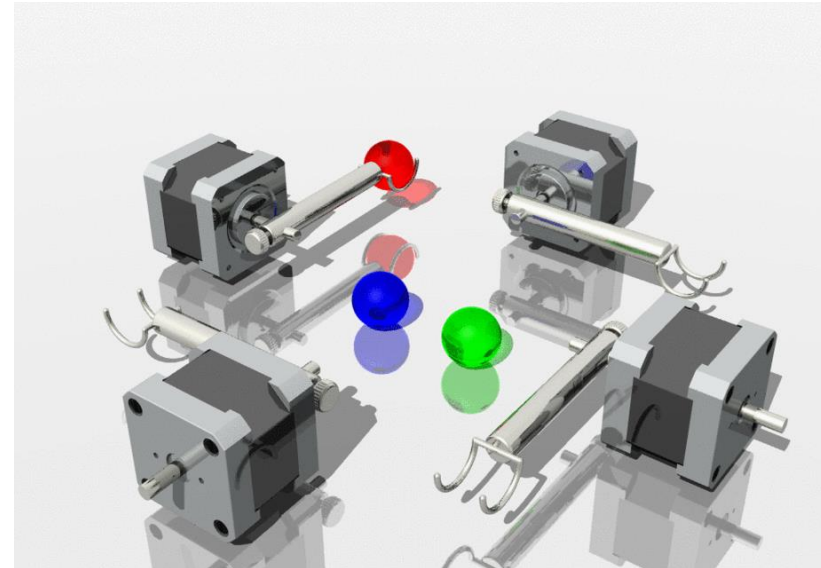
Stepper Motor



Chapter

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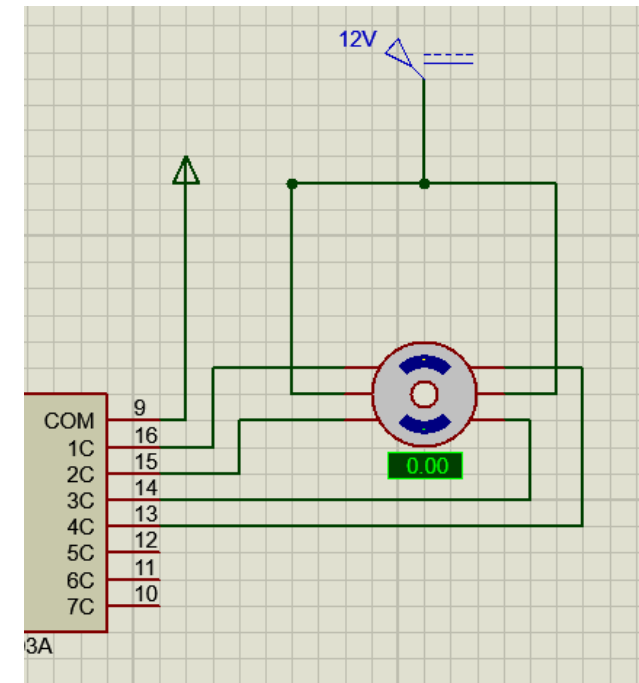
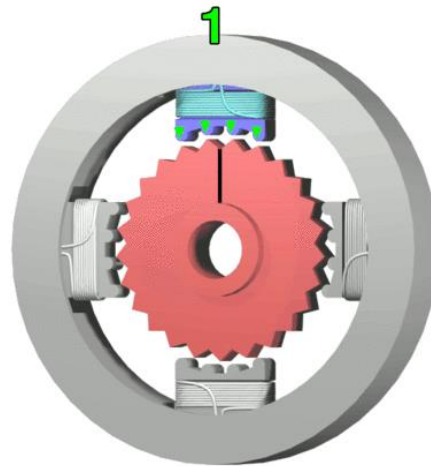
Stepper Motor



Chapter

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Stepper Motor



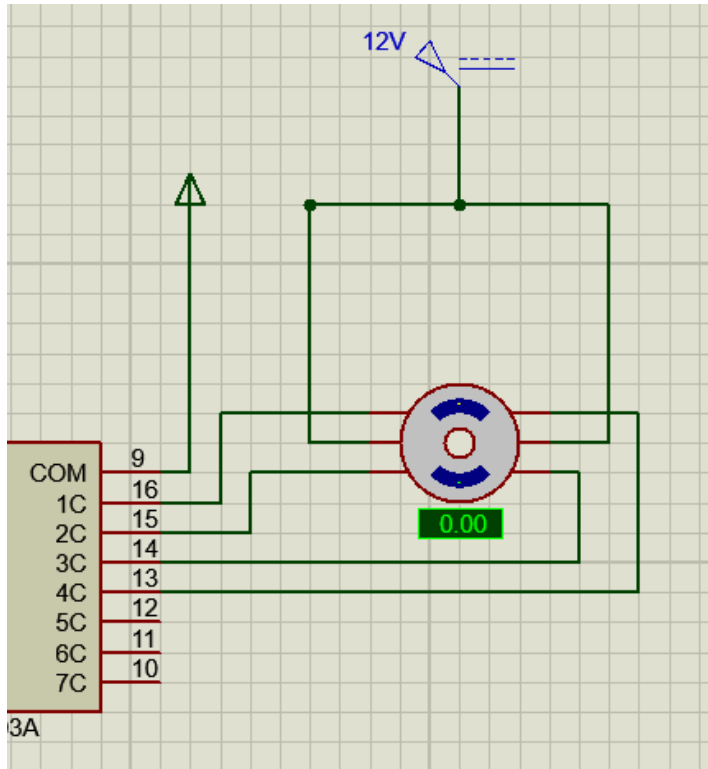
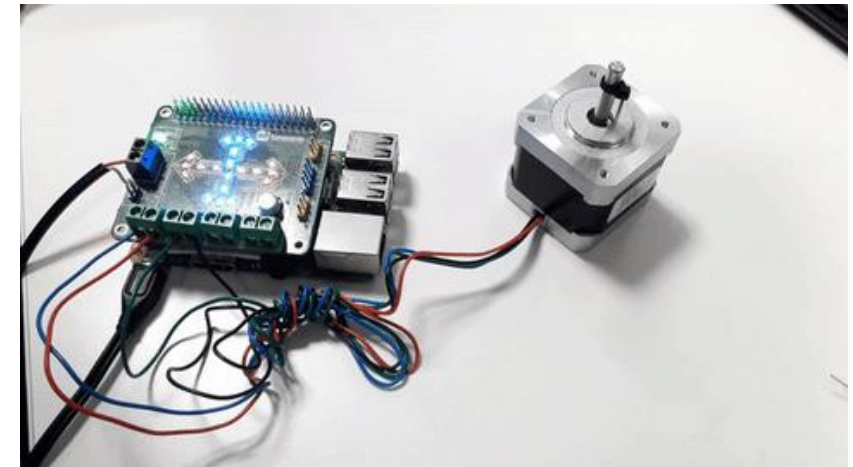
Chapter

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Stepper Motor

In the following table, A-B-C-D refers to the stator coils, that are to be energized sequentially in the manner and '1's and '0's refers to 'HIGH' and 'LOW' states.

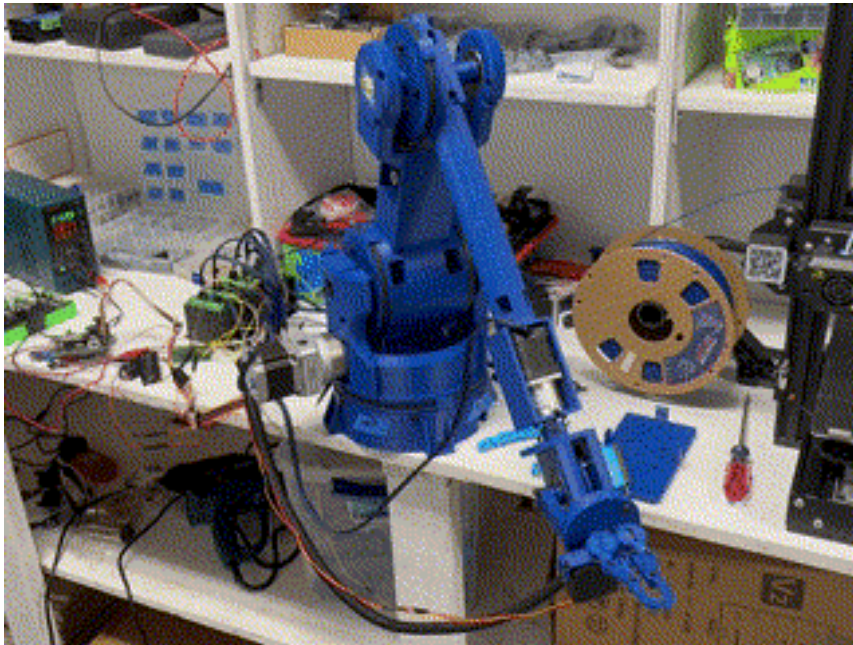
Steps	A	B	C	D	HEX
1	1	0	0	0	0x08
2	0	1	0	0	0x04
3	0	0	1	0	0x02
4	0	0	0	1	0x01



Chapter

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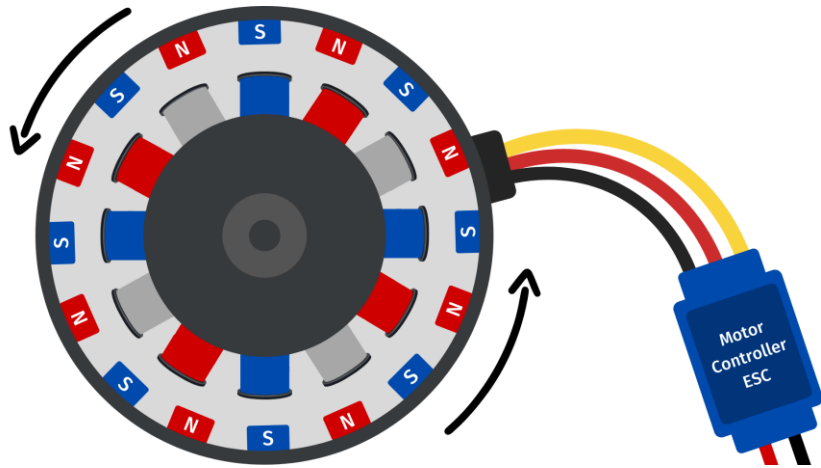
Stepper Motor



Chapter

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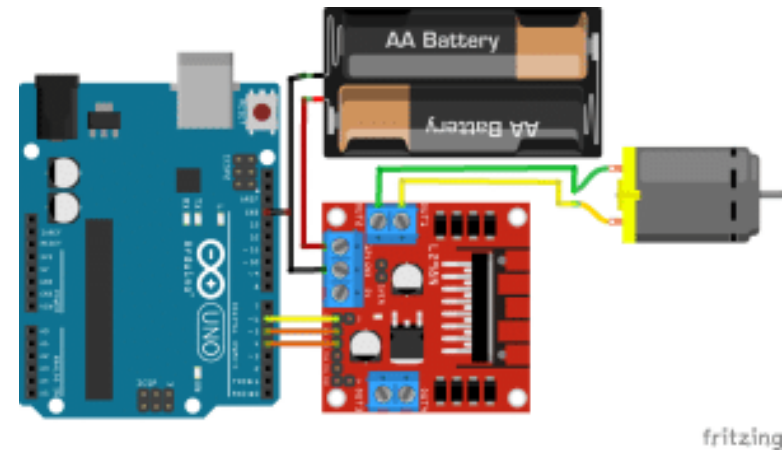
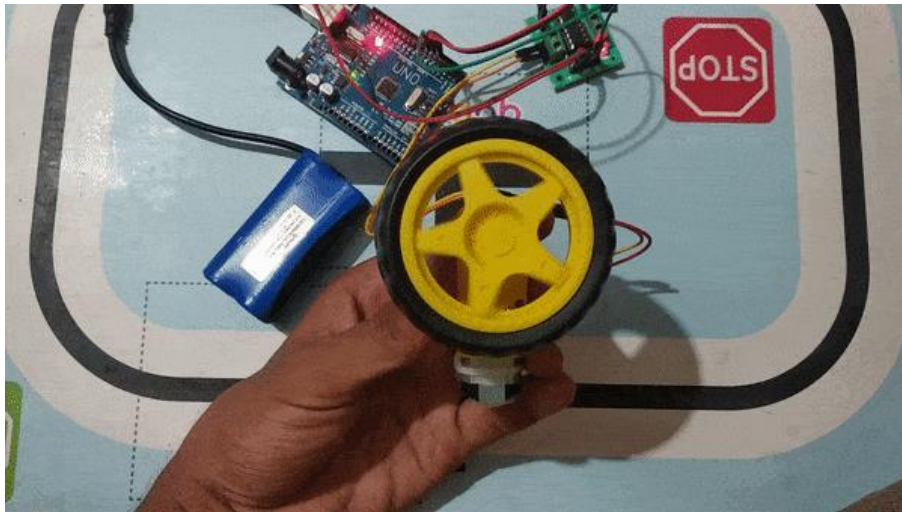
DC Motor



Chapter

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DC Motor



Arduino uno

D5

D4

GND

Motor driver

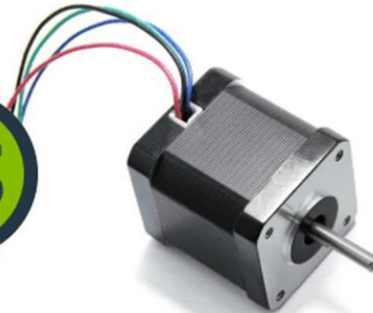
IN1

IN2

GND

Motor Conclusion

The Difference Between



DC Motors

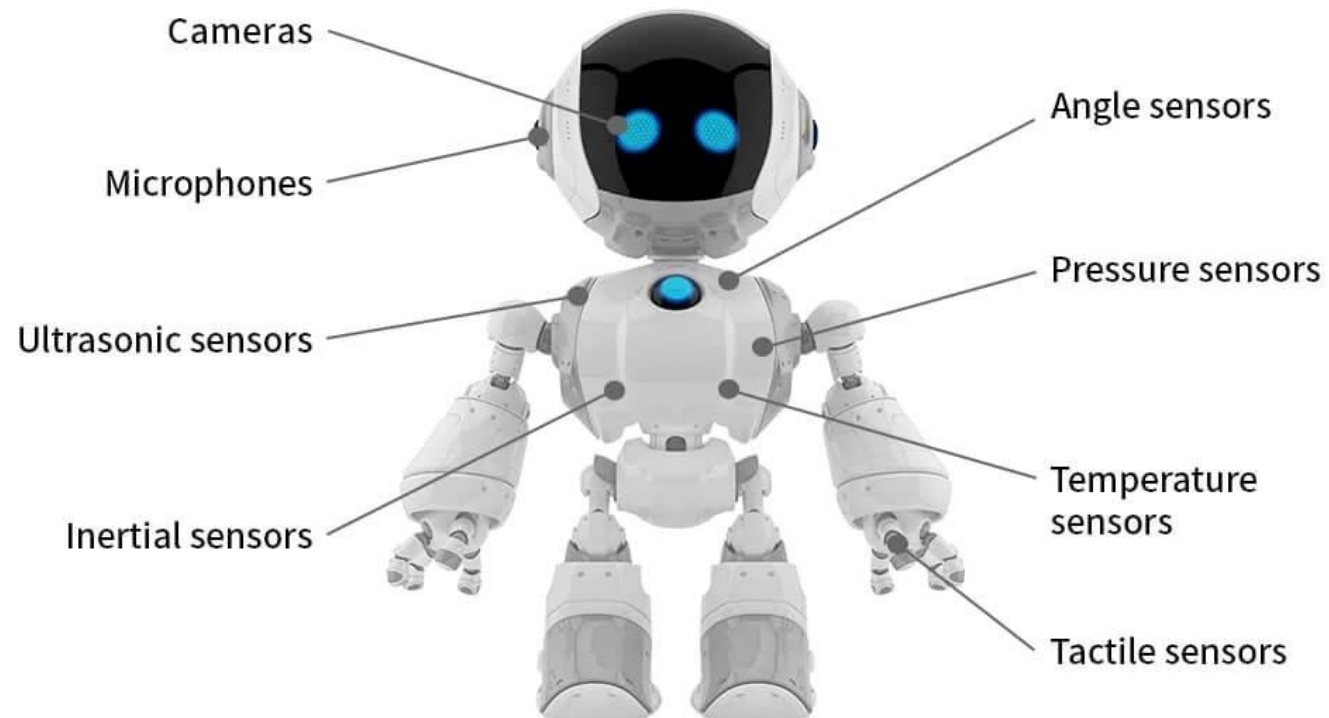
Stepper Motors

Servo Motors

fundamental differences between DC, Servo, and Stepper motors

Motor Type	Control	Precision	Speed	Torque	Primary Use in Robotics
DC Motor	Variable speed control	Low	High	Medium	Ideal for applications requiring variable speed and direction, such as robot wheels or drones.
Servo Motor	Positional control	High	Medium	High at low speeds	Best for precise control of movement, such as robotic arms or where specific positioning is crucial.
Stepper Motor	Step control	High	Low to Medium	High at low speeds	Suited for precise steps in motion, making them perfect for 3D printers, CNC machines, and robots requiring detailed positioning without feedback.

Sensors



Vision Sensors: The Eyes of Robots

•**Overview:** Introduction to how vision sensors allow robots to perceive their environment visually, simulate human sight.

•**Types:**

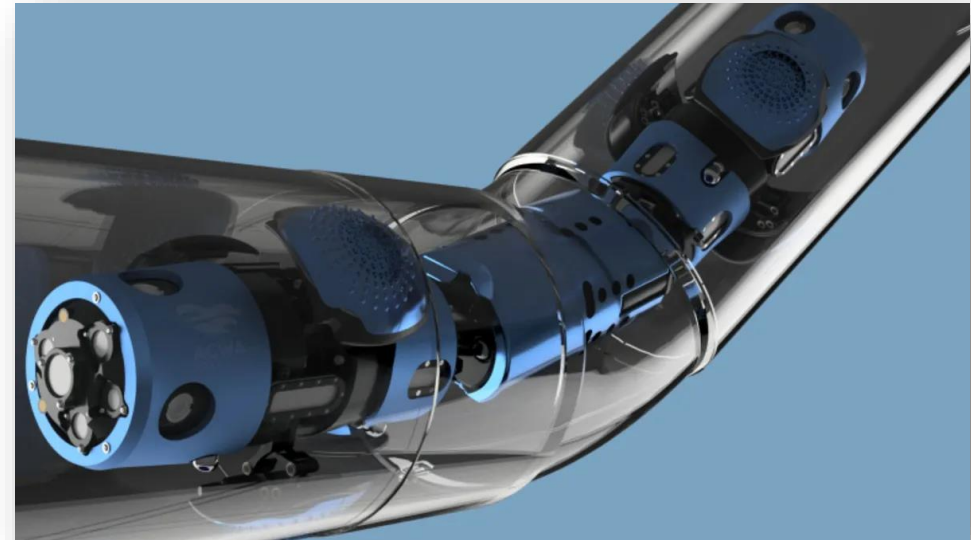
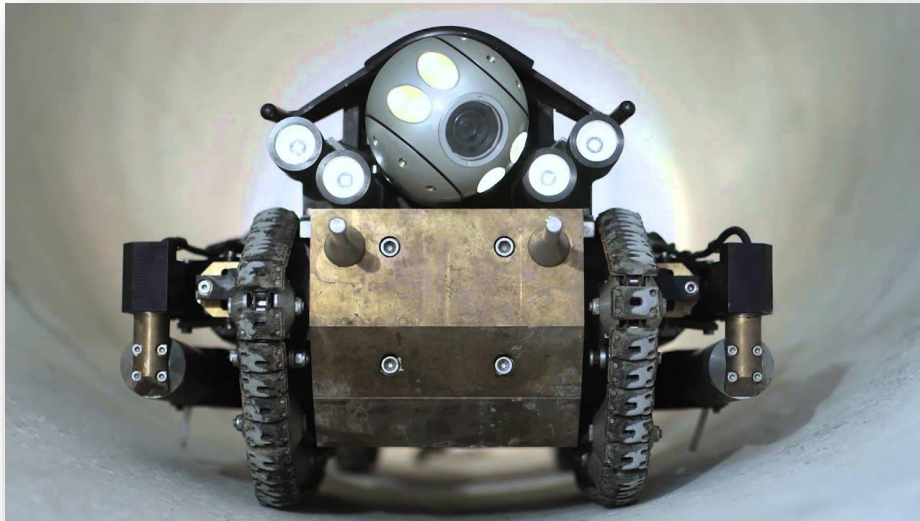
- **Cameras (2D and 3D):** Capture visual information. 2D cameras provide flat images, while 3D cameras add depth perception, crucial for tasks requiring spatial understanding.
- **LIDAR (Light Detection and Ranging):** Uses laser pulses to map out the robot's surroundings in high detail, essential for navigation and obstacle avoidance.

•**Applications:**

- Object recognition, navigation, and environmental mapping.



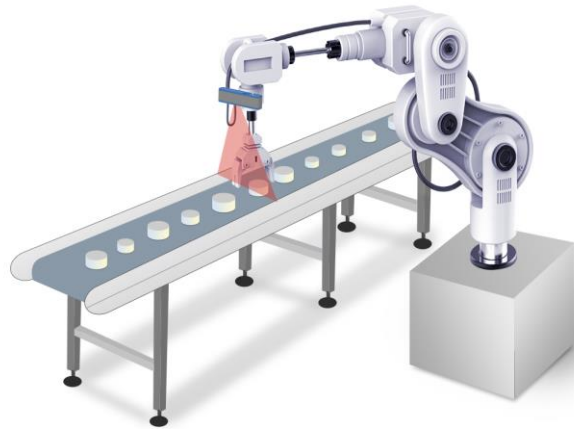
2D Camera Sensor



Chapter

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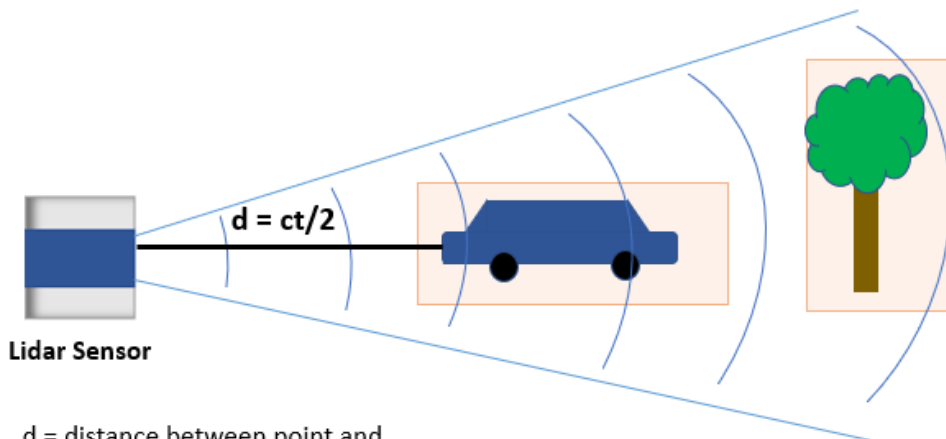
3D Camera Sensor



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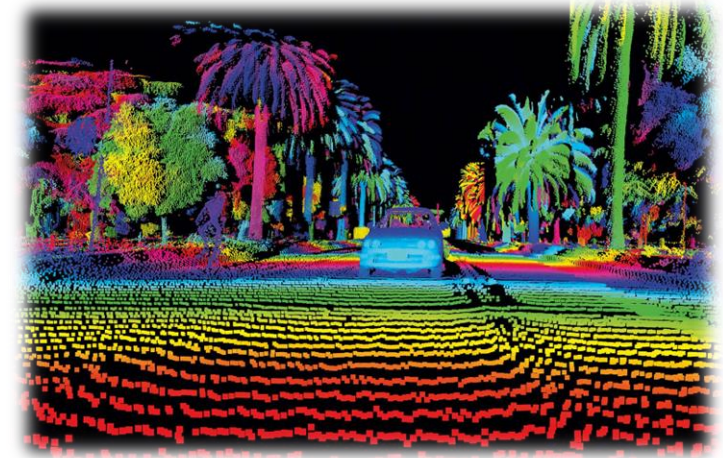
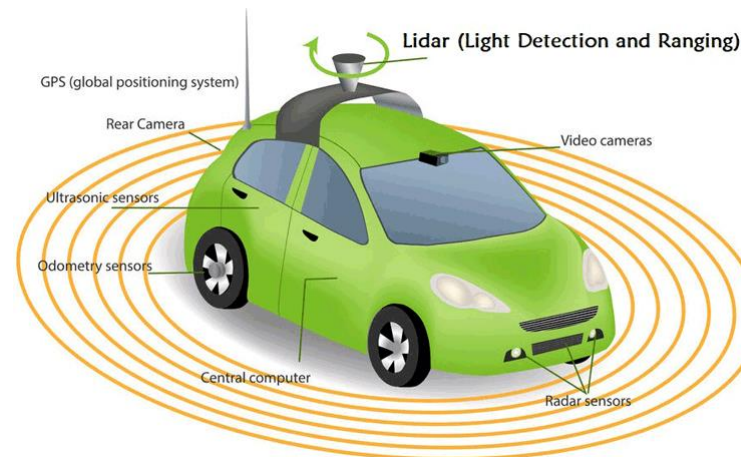
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LIDAR (Light Detection and Ranging):



Lidar Sensor

d = distance between point and the sensor
 c = speed of light
 t = time of flight



•**Overview:** Explaining the role of proximity and distance sensors in detecting the presence of objects and measuring the distance to them.

•**Types:**

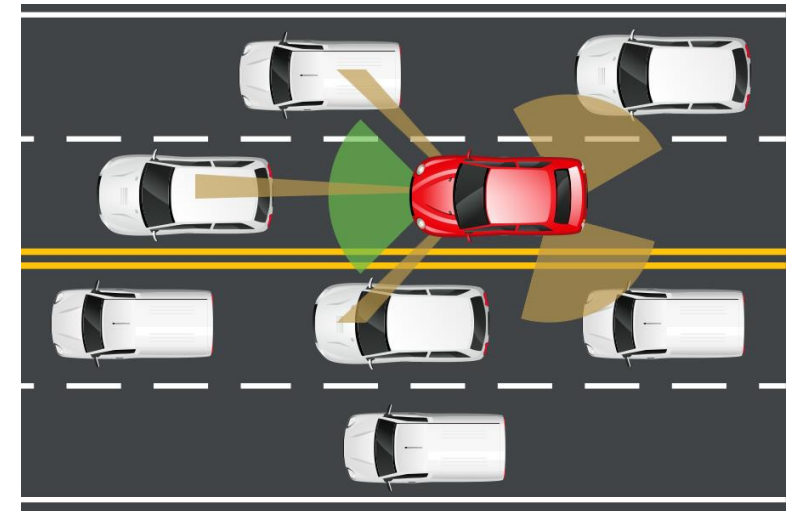
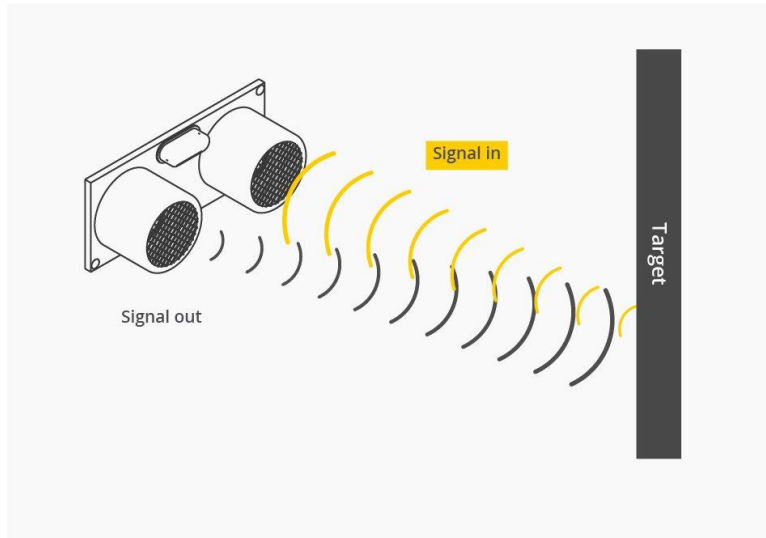
- **Ultrasonic Sensors:** Emit ultrasonic waves and measure the reflection time to determine distance to objects. Widely used in robotic cars for obstacle detection.
- **Infrared Sensors:** Use infrared light to detect objects and estimate distance, useful in line-following robots and simple navigation tasks.

•**Applications:**

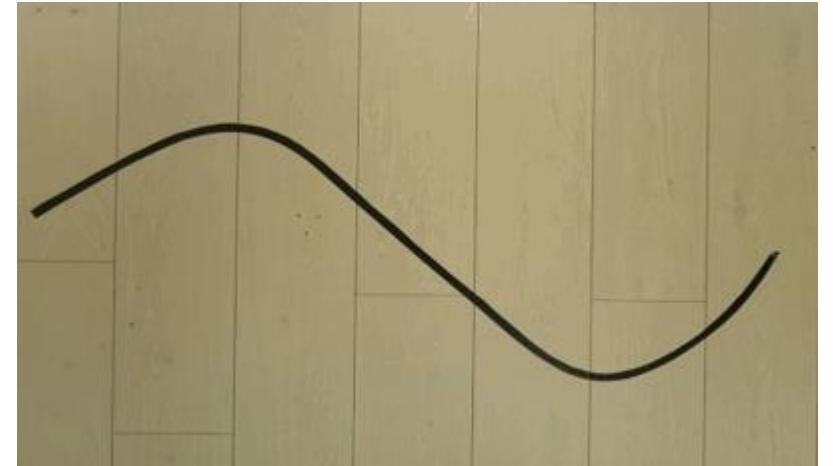
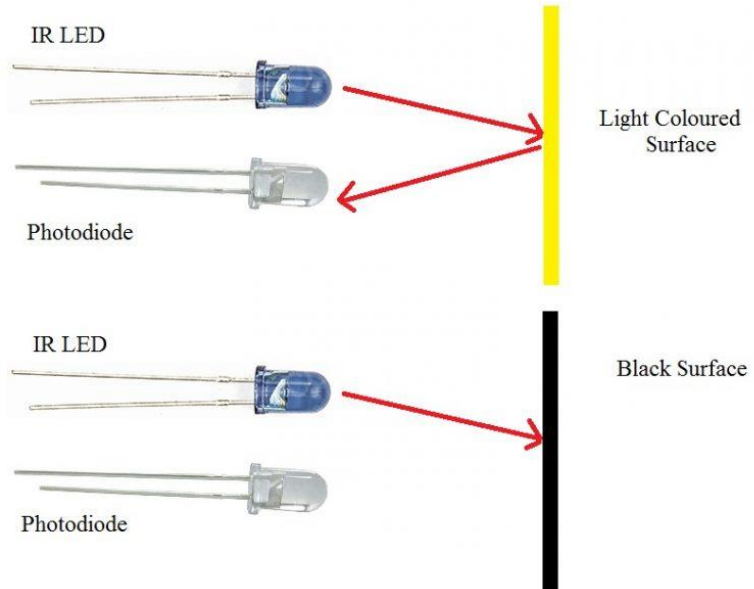
- Collision avoidance, area scanning, and precise movements in tight spaces.



Ultra Sonic Sensor



Infra red Sensor



Feeling and Interacting: Tactile and Environmental Sensors

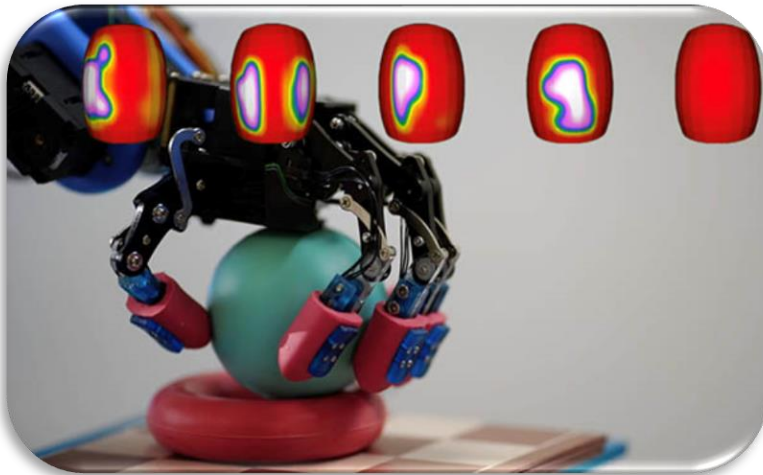
• **Overview:** Highlighting sensors that allow robots to 'feel' their environment and respond to physical interactions or changes in their surroundings.

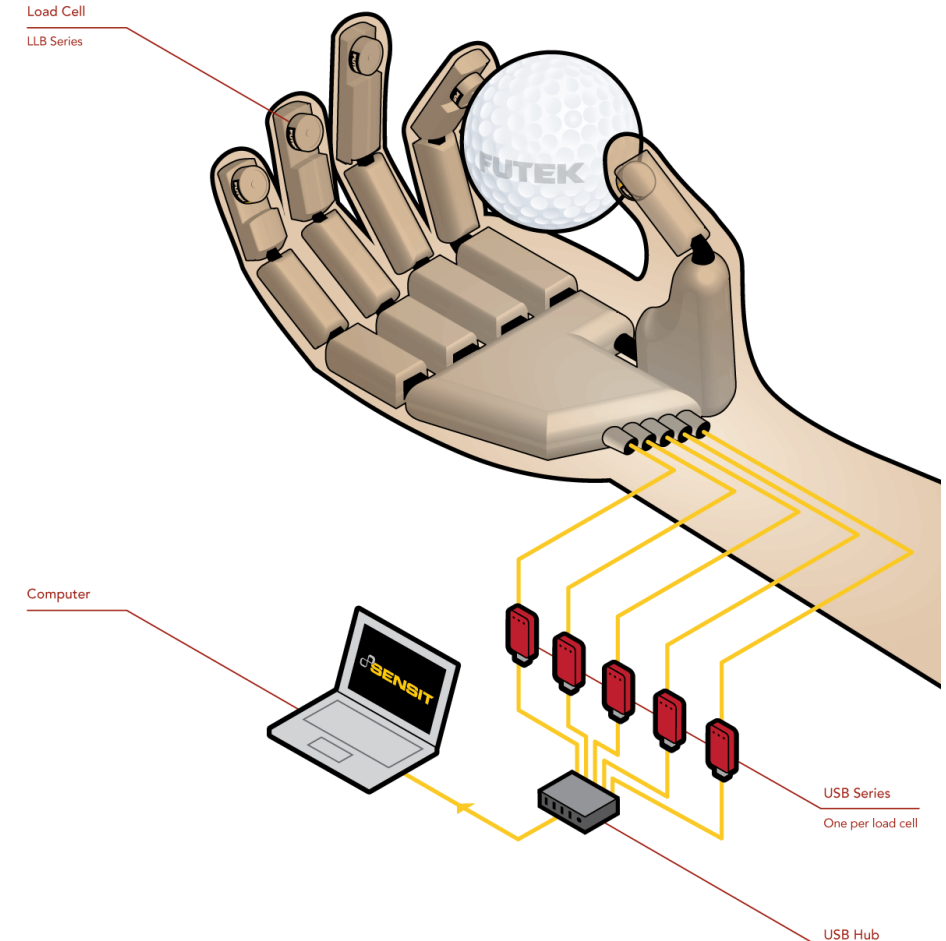
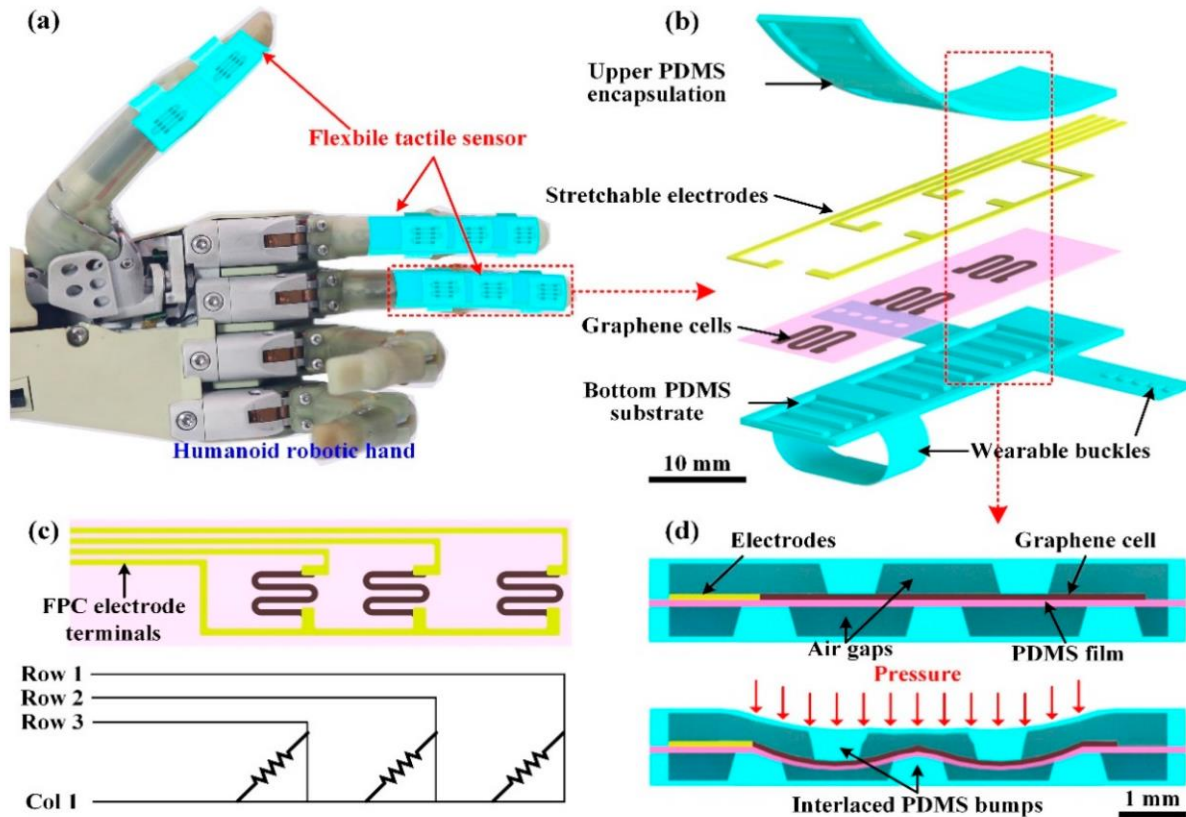
• **Types:**

- **Tactile Sensors:** Enable robots to detect physical contact, pressure, and textures. Key in applications requiring delicate handling or manipulation, like robotic hands.
- **Environmental Sensors:** Measure temperature, humidity, or gas concentrations, critical for robots operating in varying or extreme conditions, such as disaster response robots.

• **Applications:**

- Hazard detection, material handling, and adapting to environmental conditions.

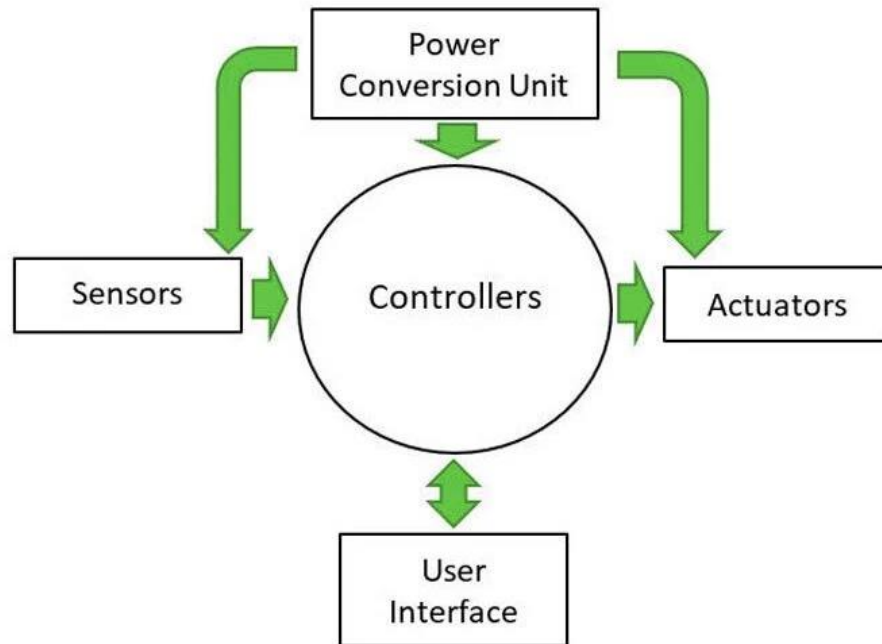






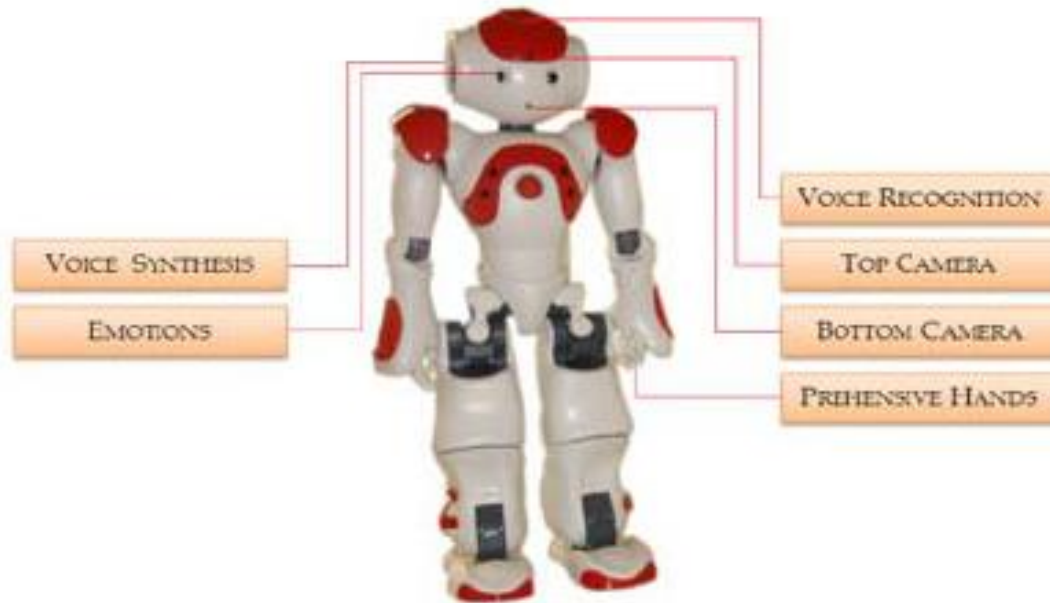
Bringing It All Together

Robotics Key Components

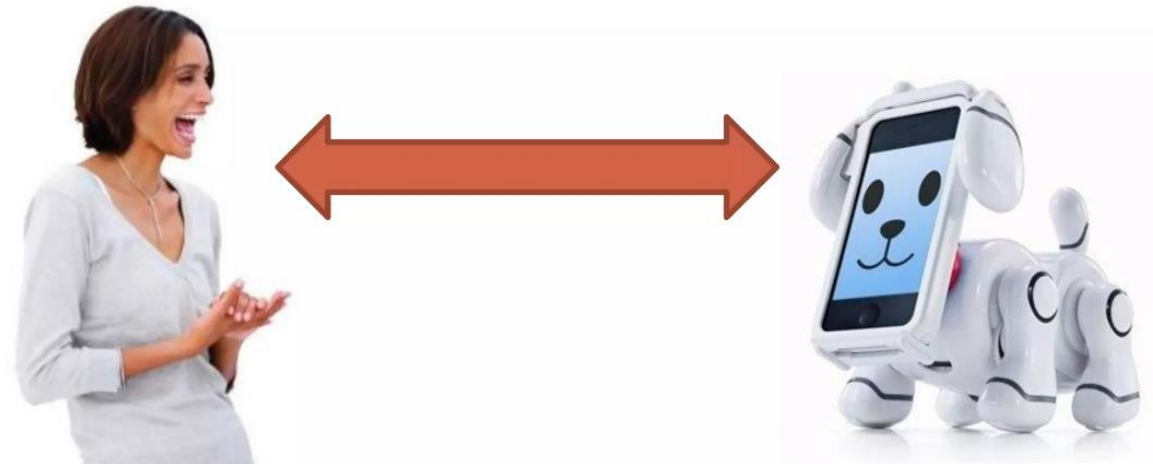


Introduction to Human-Robot Interaction (HRI)

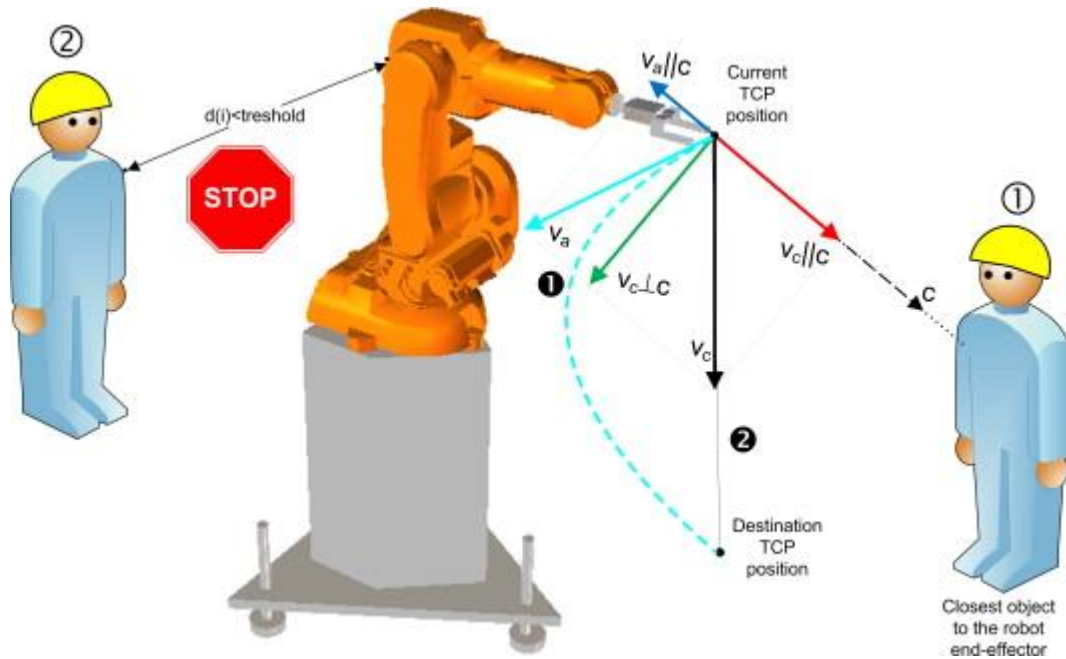
- Brief introduction to HRI as the study of how humans and robots interact and communicate.
- Highlight the importance of HRI in integrating robots into human environments, from homes to workplaces.



speech, text, touch screen, image, video, gestures, emotions, sound localization, voice biometrics, face recognition...









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Thank You

