

# Human-Robot Interaction and Autonomous Systems

AI 616

**Master of Science in Artificial intelligence**

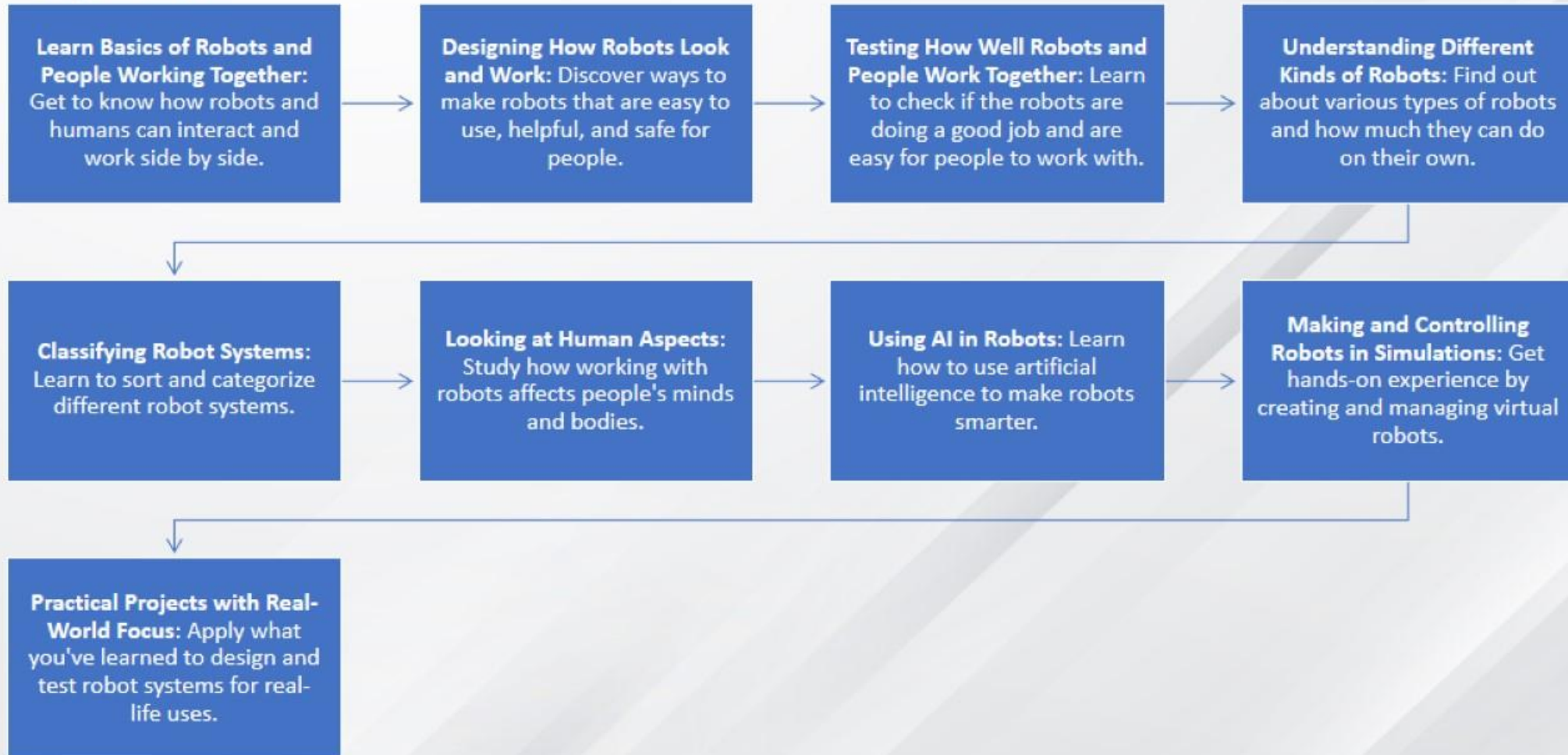
Prepared by Dr. Khaled Eskaf

## Lecture 1





## Learning Objectives





## Course Outlines

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

# Human-Robot Interaction An

## Introduction

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

## HUMAN-ROBOT INTERACTION

### *An Introduction*

Christoph Bartneck • Tony Belpaeme  
Friederike Eysel • Takayuki Kanda  
Merel Keijsers • Selma Šabanović



**Webots**

robot simulation

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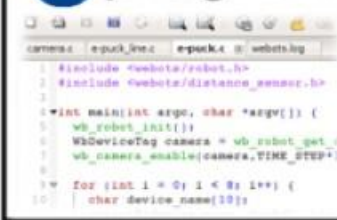
**Webots** is an open source and multi-platform desktop application used to **simulate** robots

<https://cyberbotics.com/>

**1** model



**2** program



**3** simulate



**4** transfer



# A Brief History of Robots

## Introduction: The Dawn of Robotics

Welcome to our exciting exploration into the world of robotics! Today, we embark on a fascinating journey, delving into the rich history that shapes modern robotics. From ancient innovations to cutting-edge technology, robotics is a field that has continually evolved, revolutionizing how we interact with machines.

### Ismail Al-Jazari: The Father of Robotics

Let's travel back to the 12th century, where Ismail Al-Jazari, a brilliant inventor, laid the groundwork for what we now call robotics. His ingenious creations, documented in his famous book, "The Book of Knowledge of Ingenious Mechanical Devices," include automata and mechanical devices that are considered the earliest forms of robotic technology.

Highlight: The remarkable 'Automaton Band,' a boat with four automatic musicians, demonstrates early concepts of programmable machines.



## 2. The Foundation of Modern Computation: Al-Khwarizmi

Al-Khwarizmi: The Father of the Algorithm

Moving forward, we meet a pivotal figure in the history of computation, Al-Khwarizmi. His work in the 9th century introduced the concept of the algorithm, a term derived from his name, which is the cornerstone of programming and control systems in robotics.

Impact: Without algorithms, the sophisticated programming that drives today's robots would not be possible.

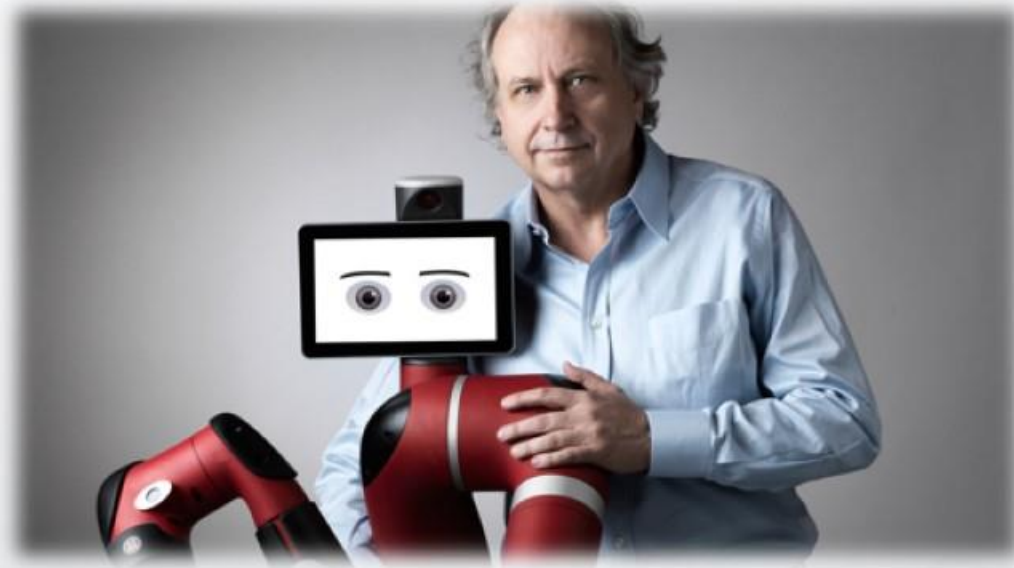


### 3. Contemporary Robotics: Standing on the Shoulders of Giants

#### Modern Innovators and Influencers

In our journey, we see the influence of these historical figures in contemporary robotics. Modern robotics pioneers, like **Rodney Brooks** with his work on autonomous robots, and **Hiroshi Ishiguro** with his human-like androids, are building upon the foundations laid by Al-Jazari and Al-Khwarizmi.

Current Trends: Today, robotics is a blend of engineering, computer science, and artificial intelligence, creating machines that can assist, enhance, and sometimes even replicate human actions.



Rodney Allen Brooks is an Australian roboticist, Fellow of the Australian Academy of Science, author, and robotics entrepreneur,

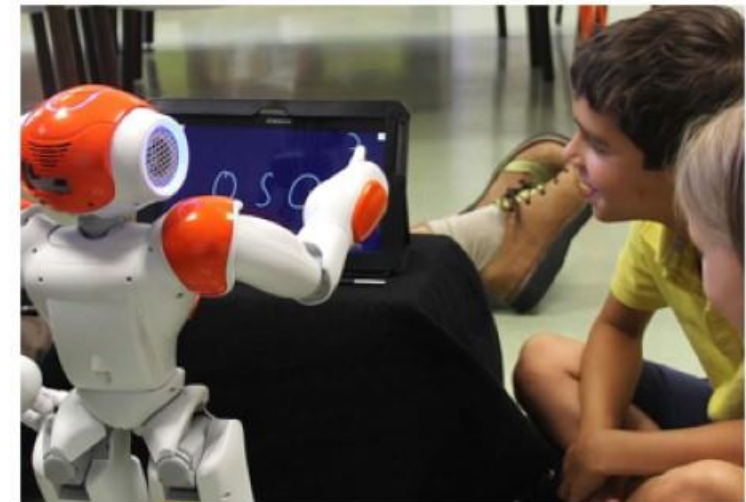
## HUMAN-LIKE ROBOT

Professor Dr. Hiroshi Ishiguro, the Director of the Intelligent Robotics Laboratory of the Department Systems Innovation, in the Graduate School of Engineering Science, at Osaka University, Japan interviewed by Ira Pastor ambassador IdeaXme.





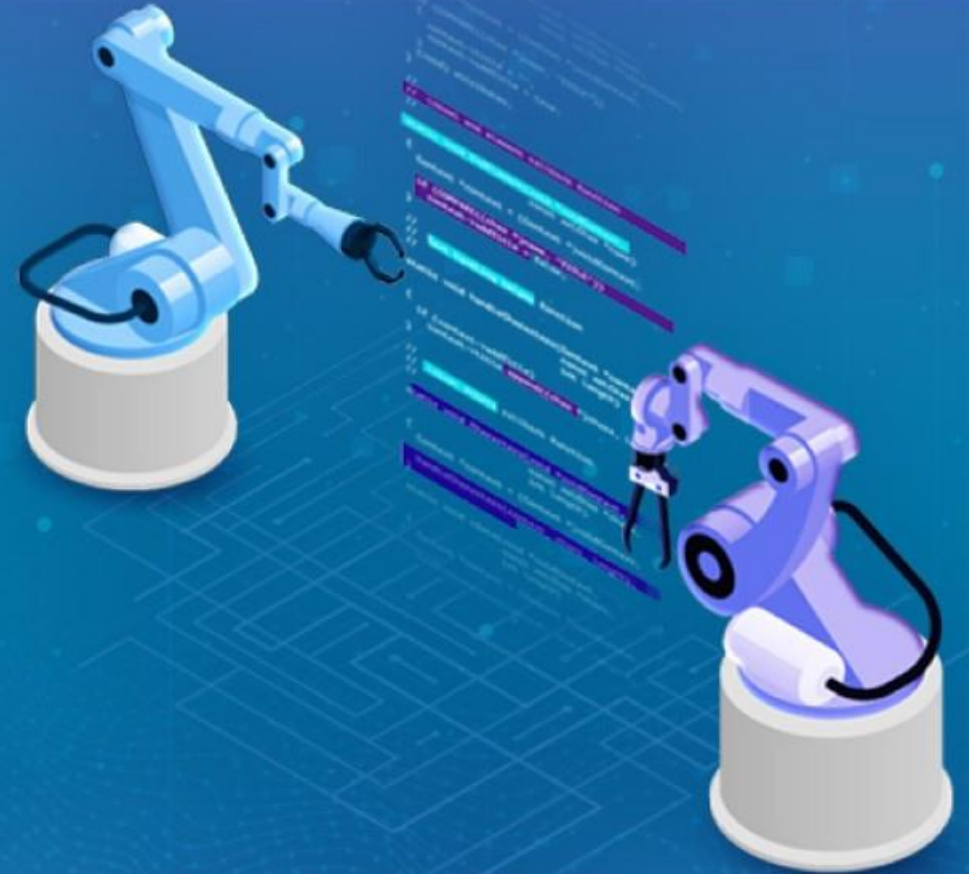
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# Robot Control Basics

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.**

### 2. Simplified Explanation:

1. Think of it as teaching a robot how to understand and respond to the world around it.



## 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.

### 2. Everyday Examples:

1. A robot vacuum navigating around your house without bumping into furniture.
2. An industrial robot arm assembling parts with precision.



### 3.The Role of Control Systems in Robotics

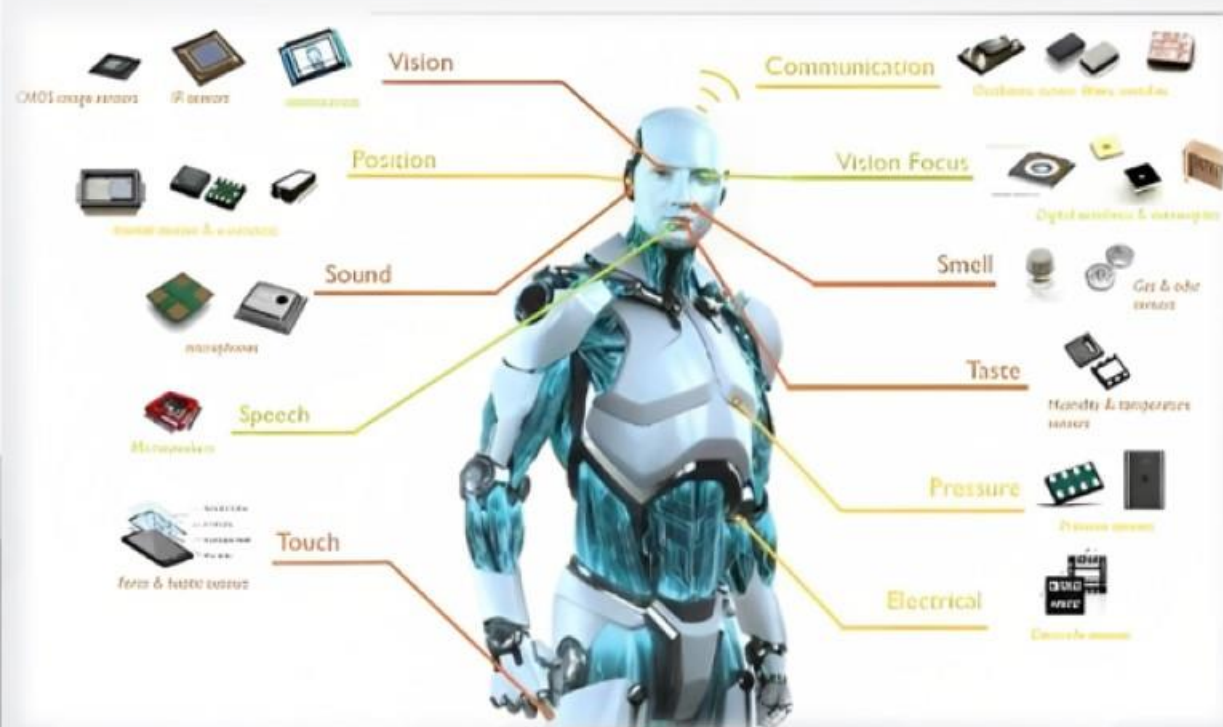
#### 1. Central to Robotic Applications:

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

#### 2. Real-Life Implications:

1. From simple automated toys to complex machines in manufacturing and healthcare, control systems define how effectively a robot can operate.

(Beginner's Perspective: Similar to how we use our senses and brain to decide how to move and act, robots use control systems to guide their actions.)



# Basic Concepts in Robot Control

Objective: Core Concepts in Robotic Movement

**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.

•**Simplified Explanation:**

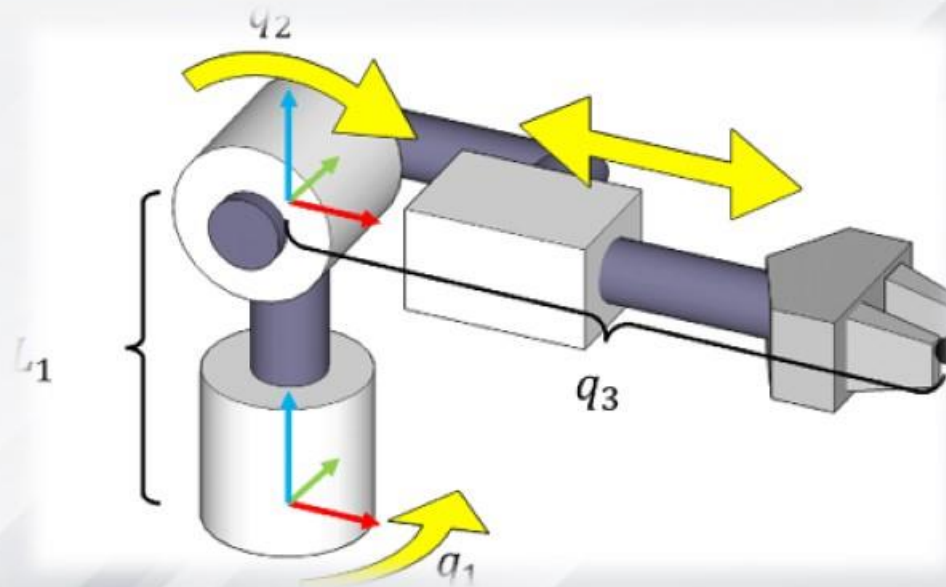
- Imagine a robot arm that needs to reach a specific spot – kinematics helps us calculate the path and angles needed to get there.

•**Example:**

- Calculating the position of a robotic arm in a factory assembly line to ensure it reaches the right spot to pick up or place items.

# EXAMPLE

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:

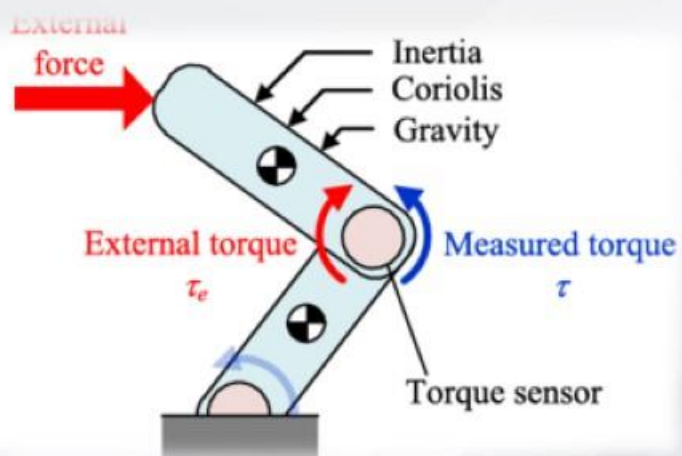
- Dynamics is about the forces and torques that cause the motion of robots. It considers the physical principles that govern movement.
- This includes how a robot's motors and gears work together to produce motion.

## •Simplified Explanation:

- Think of dynamics as understanding why and how a robot moves. For instance, how hard a robot should push or turn to move.

## •Example:

- Analyzing how a robot's wheels interact with the ground to move a robot forward, or how its motors adjust to lift a heavy object.



**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.

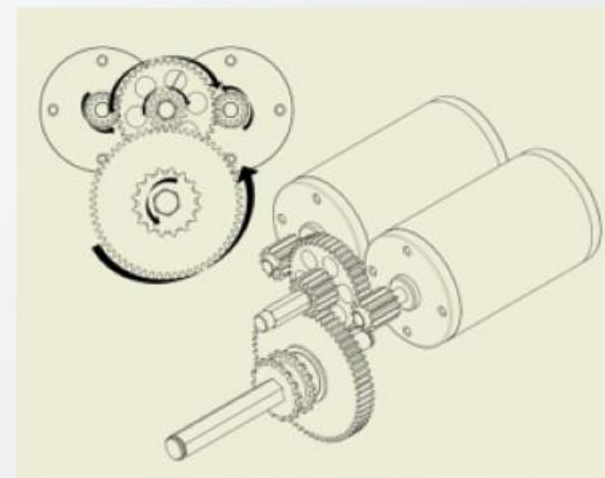
Now, how do robots get these powers? They have motors and gears, kind of like the muscles and bones in your body.

•**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.

When robots move, they have to think about how hard to push or pull, and how much to twist, just like you decide how hard to throw a ball or turn a doorknob. All of this helps the robot to walk, pick things up, or do a fun dance!

So, robot dynamics is like learning the best ways to use robot superpowers (forces and torques) with their muscles and bones (motors and gears) to move around and do cool stuff!



# Control Algorithms in Robotics

Objective: The Role of Control Algorithms in Robotics

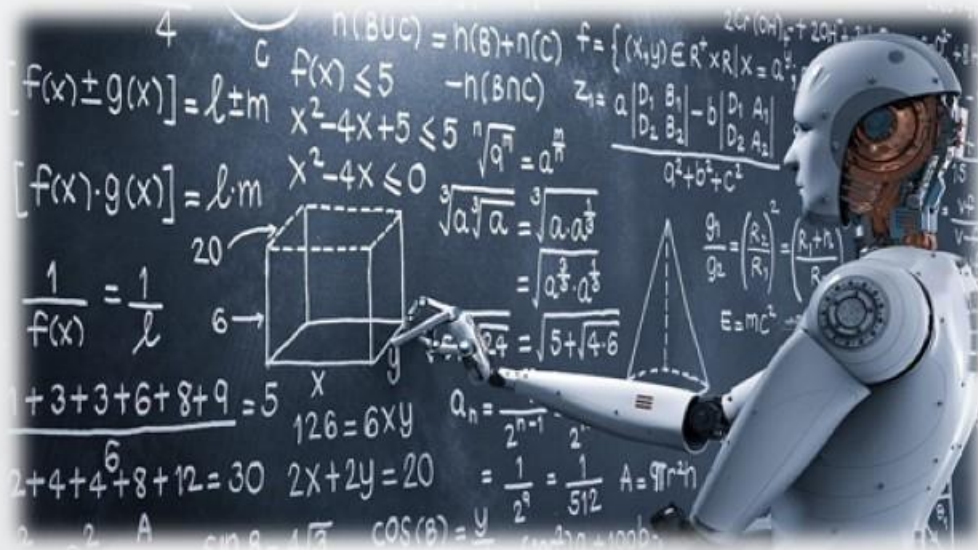
## What are Control Algorithms?

### •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.

### •Simplified Explanation:

- Imagine telling a friend how to get to a nearby store – you give specific instructions (turn left, go straight, etc.). Control algorithms do the same for robots, guiding them on what to do and when.



## Examples of Control Algorithms in Robotics:

### •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.



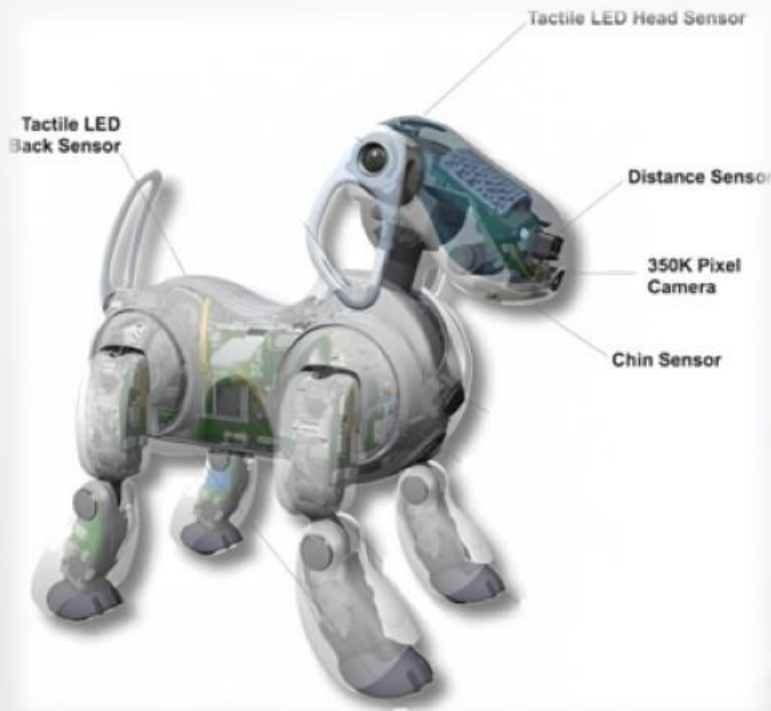
# Key Insight: Algorithms as the 'Brains' of Robots

## •Importance:

- Algorithms are crucial because they determine how a robot interprets data from its sensors and then decides what actions to take.

## •In Real Life:

- Just as our brains process information and make decisions, control algorithms serve a similar purpose for robots, making them smart and responsive.



## Practical Example - Robotic Car Movement

Objective: Step-by-Step Example: Programming a Robotic Car

Steps:

### 1. Programming the Robotic Car:

#### 1. Action: Writing Simple Code

1. We start by writing a basic code snippet. This code will send a command to the robotic car's motor to start moving. (For Beginners: Think of this like writing a note telling someone to start walking forward).

Code Example:

```
motor.start(speed);
```

This line of code 'tells' the car's motor to start running at a specified speed.

## Executing the Code:

### •Action: Uploading and Running the Code

- Next, we upload this code to the robotic car's microcontroller - the car's brain.
- **Visualization:** Imagine transferring your written note to a robot and watching it read and follow your instructions.
- **Observation:**
  - Watch how the car responds. Does it move forward smoothly, or does it stutter?

## Adjusting the Code:

### •Action: Modifying Parameters for Different Outcomes

- Based on our observations, we can adjust the code to change the car's speed or direction.
- **Experimentation:**
  - Try increasing the speed value in the code, or add commands for the car to stop or turn.
- **Code Adjustment Example:**

```
motor.start(newSpeed);  
motor.turn(direction);
```

Adjust 'newSpeed' and 'direction' to see different movement patterns.

# TYPES OF ROBOTS



## AUTONOMOUS MOBILE ROBOTS (AMRS)

Moves through an environment autonomously without a guided path.



## AUTOMATED GUIDED VEHICLES (AGVS)

Moves through an environment following a guided path.



## ARTICULATED ROBOTS

Has rotary joints that often resemble a human arm.



## HUMANOIDS

Resemble humans, also called an android.



## COBOTS

Intended for direct interaction with humans within a shared space.



## HYBRIDS

Consists of both electronic and biological elements.

# 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.



# Robotics Classification - Locomotion and Autonomy

**Objective:** Exploring Robotics: Locomotion Methods and Autonomy Levels

## •Locomotion Methods

- **Wheeled Robots:** Common in various environments, stable and efficient.
- **Legged Robots:** Navigate uneven terrain, from bipedal to multi-legged.
- **Aerial and Aquatic Robots:** Specialized for air and water environments.

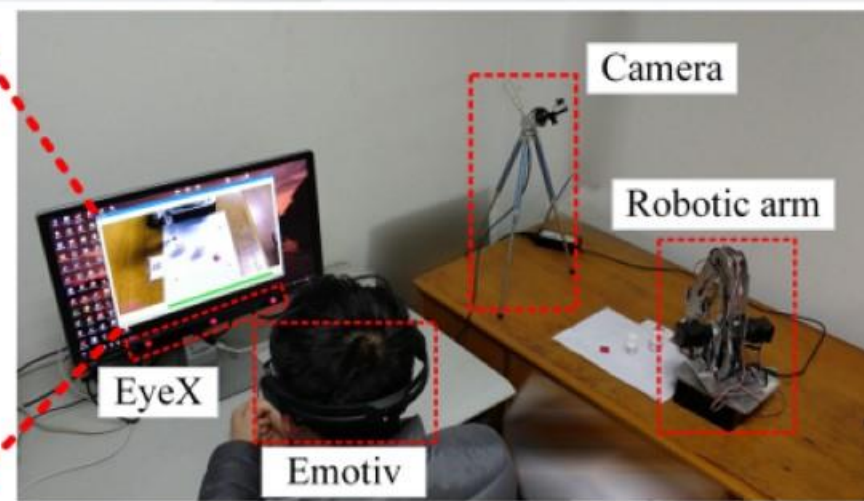
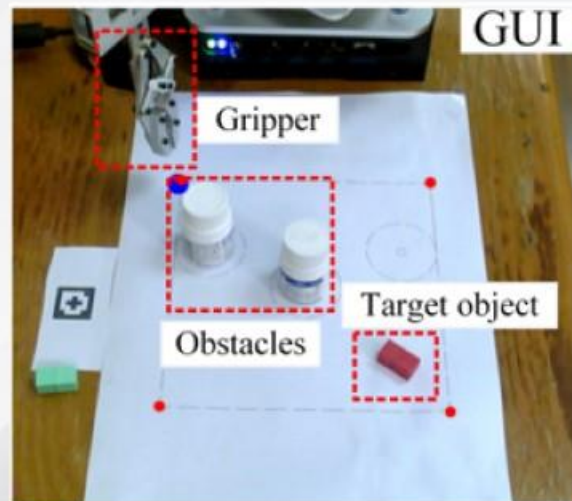
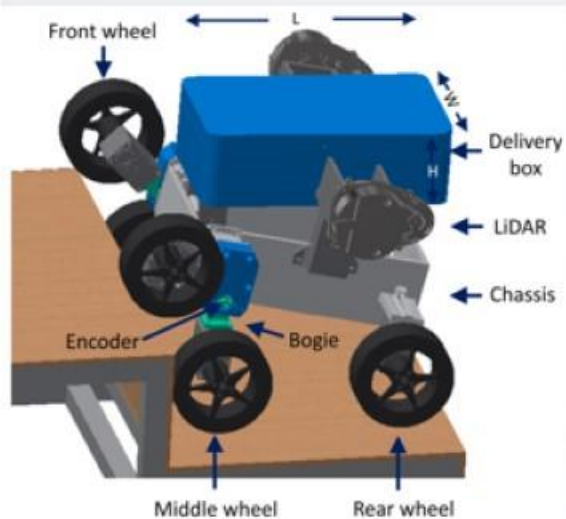


## • Levels of Autonomy

- **Manual Robots:** Fully controlled by humans.
- **Semi-Autonomous Robots:** Some tasks independently, some human input needed.
- **Fully Autonomous Robots:** Operate without human intervention.

## • Special Mentions

- **Humanoid, Collaborative (Cobots), and Swarm Robots:** Highlighting advanced, cooperative, and collective robot types.



## PROFESSIONAL



## PERSONAL

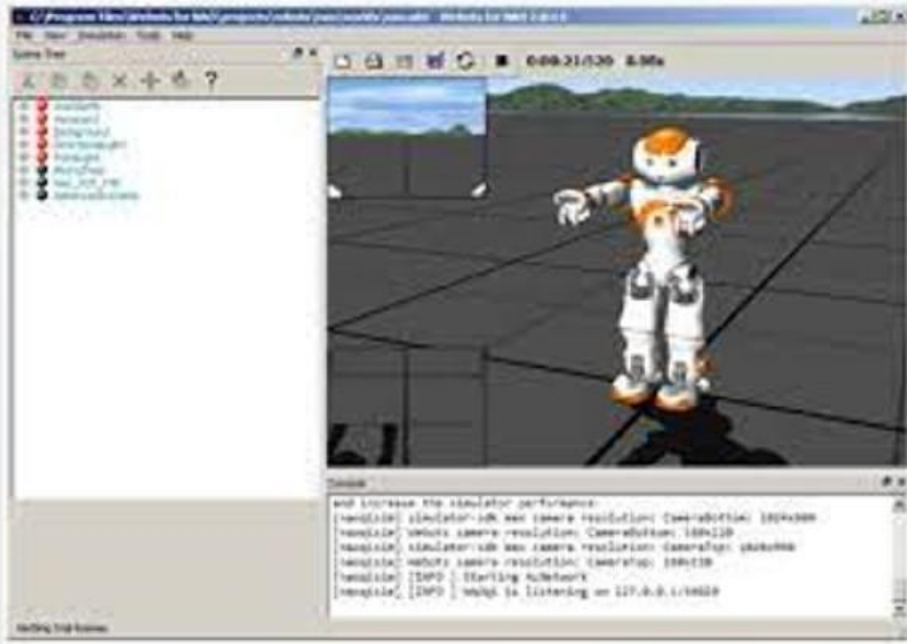




# Virtual Labs



**Webots**  
robot simulation





**Webots**  
robot simulation



**Video Play**



# Thank You