

# Welcome to "Little Bits to Big Ideas"

Lab 13: Robots

TAs: Ashish & Shivani

CAs: Abhinav, Harry, & Sherry



# Today's Lab

- **What is a Robot?**
  - Definitions, components, concepts
- **A Brief History**
  - From factory arms to autonomous vehicles
- **Types of Robots**
  - Wheeled, legged, arms, soft, and more
- **How Robots Work**
  - Sense → Think → Act Loop
- **CS Connects Here**
  - Loops, logic and data in the real world
- **Show and Tell**
  - Live demos: wheeled robot + soft manipulator



# What is a Robot?

A robot is a **machine that senses its environment, makes decisions, and acts on the world**, automatically.

## SENSE

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Perceive the world  
via cameras, IR,  
touch, IMU...

## THINK

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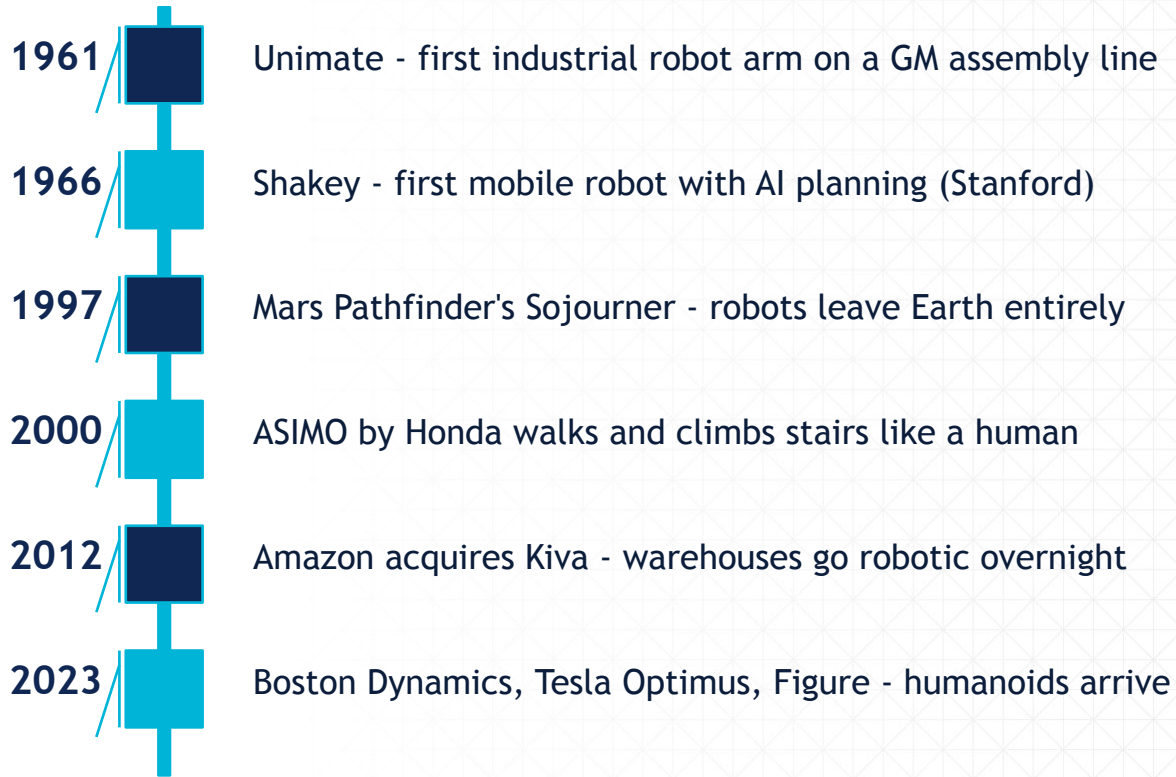
Process data and  
decide what to do  
(that's your code!)

## ACT

---

Move, grab, speak,  
display - change  
the environment

# A Brief History of Robots



# Types of Robots



## Wheeled

Easy locomotion on flat surfaces.  
Self-driving cars, vacuums, rovers.



## Arm / Manipulator

Fixed base, flexible arm. Factory  
assembly, surgery.



## Legged

Handles rough terrain. Spot (Boston  
Dynamics), ASIMO.



## Soft

Compliant, safe to touch. Inspired by  
octopus, used in surgery & food.



## Aerial (Drone)

Flight via rotors. Delivery, inspection,  
mapping.



## Humanoid

Human-shaped for human spaces.  
Atlas, Optimus, Figure.



# How Robots Work: The Control Loop

## Sensors

*Camera · LiDAR · IMU*

## Perception

*What objects are near? Where am I?*

## Planning

*What should I do next?*

## Control

*Convert decision → motor commands*

## Actuators

*Motors · Servos · Grippers · Wheels*

Feedback

## CS Concepts at Play

### Loops

*The control loop runs 10-1000× per second*

### Conditionals

*If obstacle detected → stop & re-route*

### Data Structs

*Maps, queues, graphs for path planning*

### Networking

*Robots talk to each other & the cloud*

### Real-time OS

*Timing matters - a delayed command crashes*

### ML / AI

*Vision, NLP, and reinforcement learning for the “thinking” part*



# You already know this...

*Everything in this class applies directly to robotics.*

Bits & Bytes



Sensor readings, coordinates, states

Algorithms & Data Structures



Path planning, graphs based search

Programming Languages



Robot code is written in Python, C++

Internet and Cloud



Robots offload heavy computation to the cloud

AI



Lets robots recognize objects, reason about them, learn to move, etc. without being hand-coded

LLMs



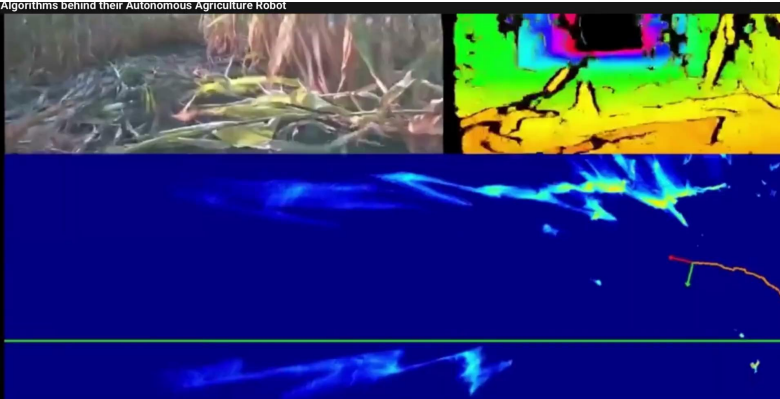
This is the newest frontier - robots are now being given LLMs as their "brain" for high-level task planning



# Show and Tell- Wheeled Robot



Algorithms behind their Autonomous Agriculture Robot



Algorithms behind their Autonomous Agriculture Robot



<https://www.youtube.com/watch?v=PuWph3cN46g>



# Soft Manipulator

*Live Demo*

## Why Soft?

Safe to interact with humans

Handles fragile objects gently

Inspired by biology (hands, tentacles!)

Actuated by air pressure or cables

# Robots don't always look like that...

## Compliance

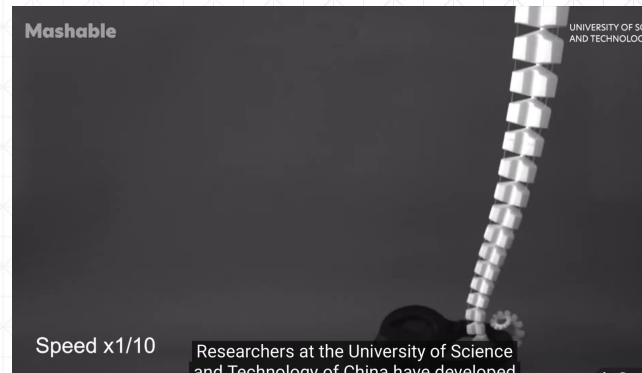
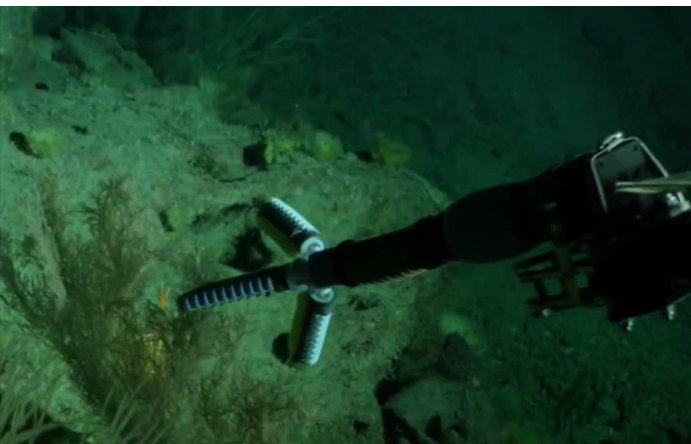
The arm bends rather than breaks. Rigid robots can harm humans; soft robots deform safely.

## Actuation

Pneumatic (air pressure) or cable-driven. Each segment inflates/deflates to bend.

## CS Challenge

No exact model for control → ML helps!



1. Kamtikan, Shivani, et al. "HyReach: Vision-Guided Hybrid Manipulator Reaching in Unseen Cluttered Environments." *arXiv preprint arXiv:2603.21421* (2026).
2. <https://www.youtube.com/watch?v=2tDsYarbNzA>
3. Wang, Zhanchi, Nikolaos M. Freris, and Xi Wei. "SpiRobs: Logarithmic spiral-shaped robots for versatile grasping across scales." *Device* 3.4 (2025)
4. N. K. Uppalapati and G. Krishnan, "VaLeNS: Design of a Novel Variable Length Nested Soft Arm," in *IEEE Robotics and Automation Letters*, vol. 5, no. 2, 4, pp. 1135-1142, April 2020

# Let's talk...

1

After watching both robots - what surprised you most?

2

What problem would YOU want to solve with a robot? Which type would you pick?

3

What CS skill from this class would be most critical to build the wheeled robot?

4

If you had to write one function for the wheeled robot, what would it do?

