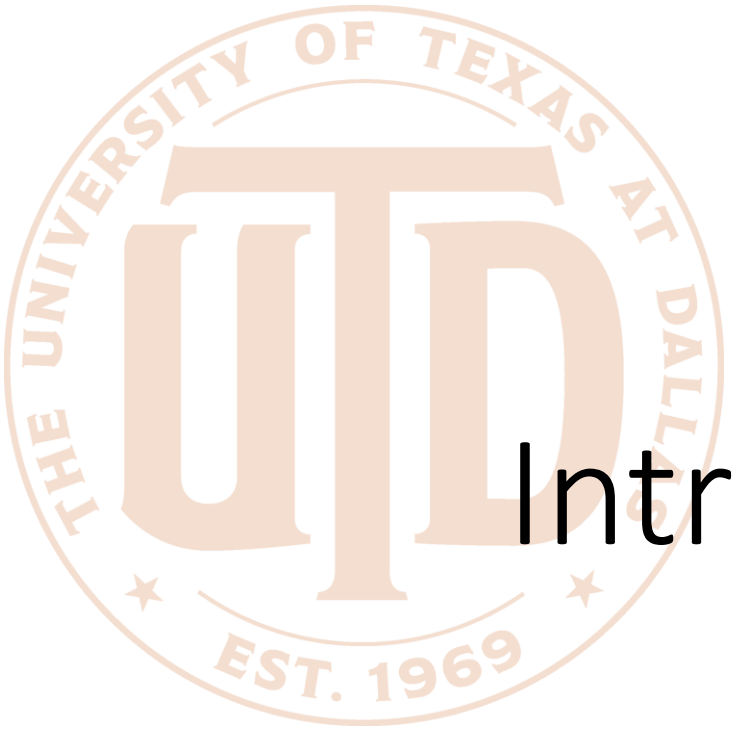


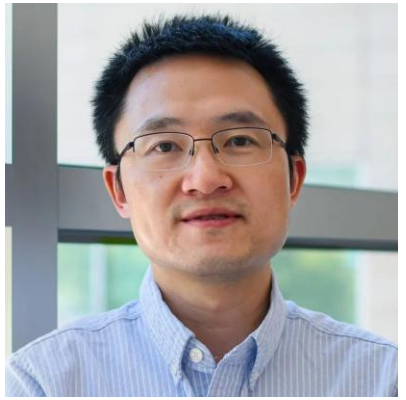
Introduction to Robotics

CS 6341 Robotics

Professor Yu Xiang

The University of Texas at Dallas

Who am I?

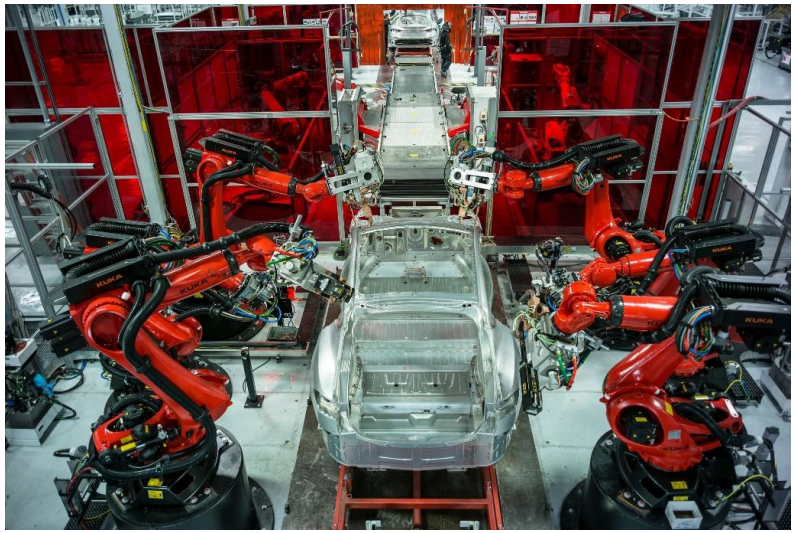


- Assistant Professor in CS at UT Dallas (joined Fall 2021)
- Ph.D., Electrical and Computer Engineering, University of Michigan, 2016
- Research area: robotics and computer vision
- Intelligent Robotics and Vision Lab (IRVL) https://labs.utdallas.edu/irvl/

Introduce yourself

- Name
- Major program
- Which year in the program?
- Why are you interested in robotics?

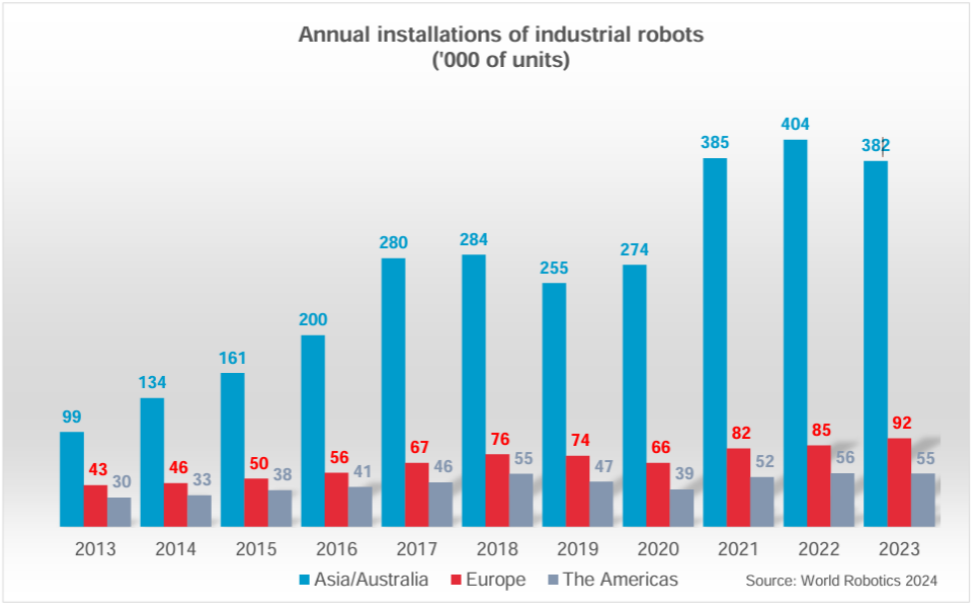
Robots in Factories and Warehouses



Welding and Assembling

Material Handling

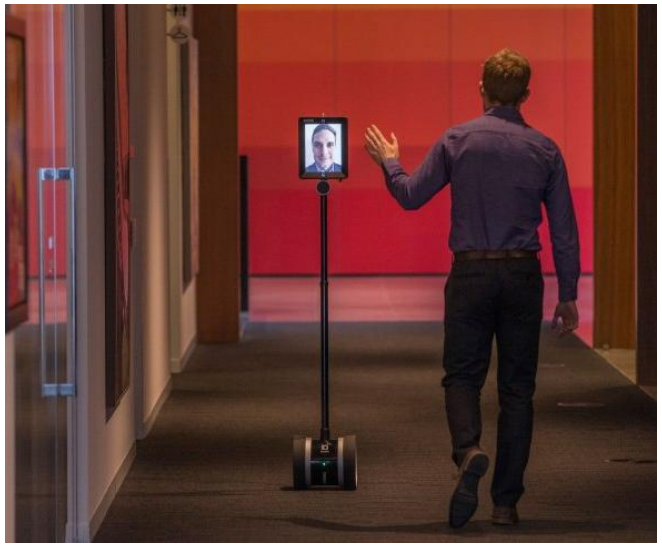
Delivering



https://ifr.org/wr-industrial-robots/

Robots in Human Environments

Cleaning Robots



Telepresence Robots

Smart Speakers

How can we have more powerful robots assisting people at homes or offices?

- Mobile manipulators
- Humanoids

Amazon Astro

https://www.youtube.com/watch?v=YiHE5y1L2Bk 2022

Google Everyday Robots

https://www.youtube.com/watch?v=tZn3ekmLvZQ 2022

Tesla Bot

https://www.youtube.com/watch?v=XiQkeWOFwmk 2023

Figure + OpenAI

https://www.youtube.com/watch?v=Sq1QZB5baNw 2024

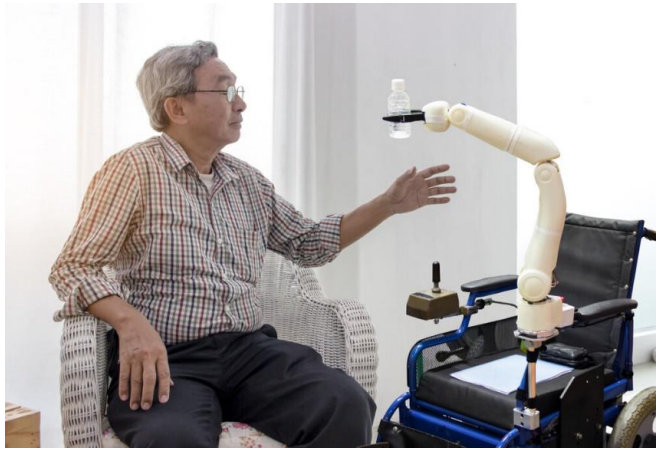
Boston Dynamics + Toyota Research Institute

https://www.youtube.com/watch?v=HYwekersccY 2025

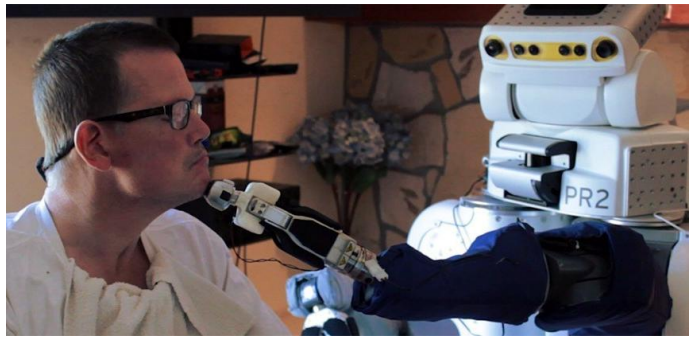
Unitree

https://www.youtube.com/watch?v=mSPxRVTJW1I 2025

Future Intelligent Robots in Human Environments



Senior Care



Assisting

Serving

Cooking

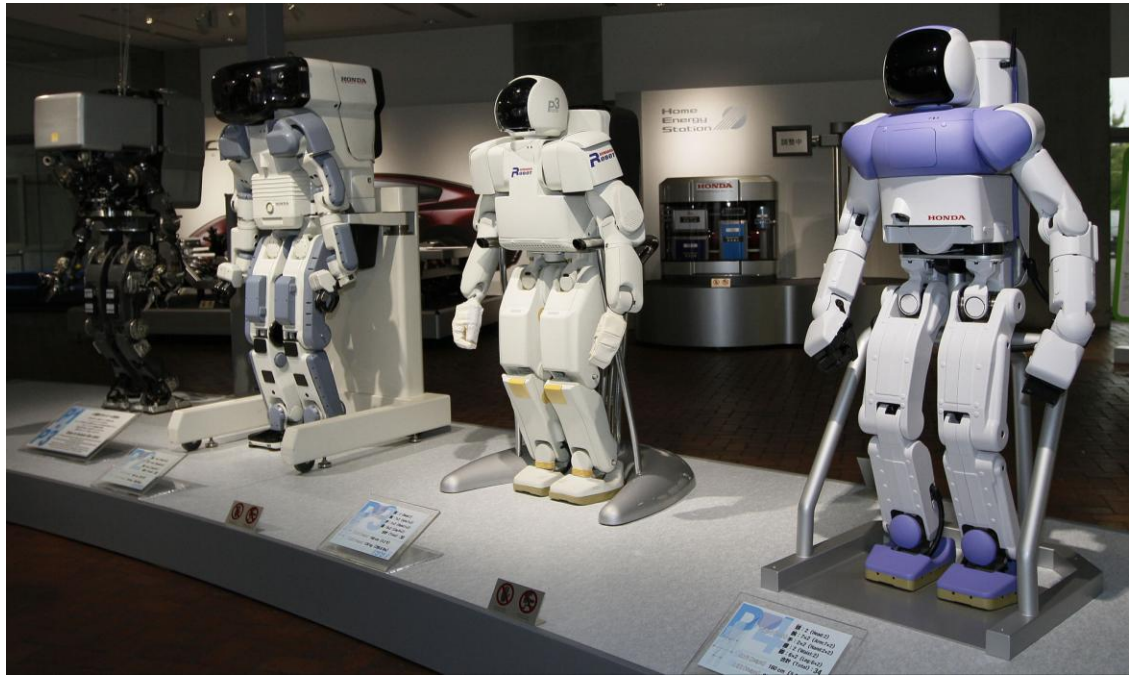
Cleaning

Dish washing

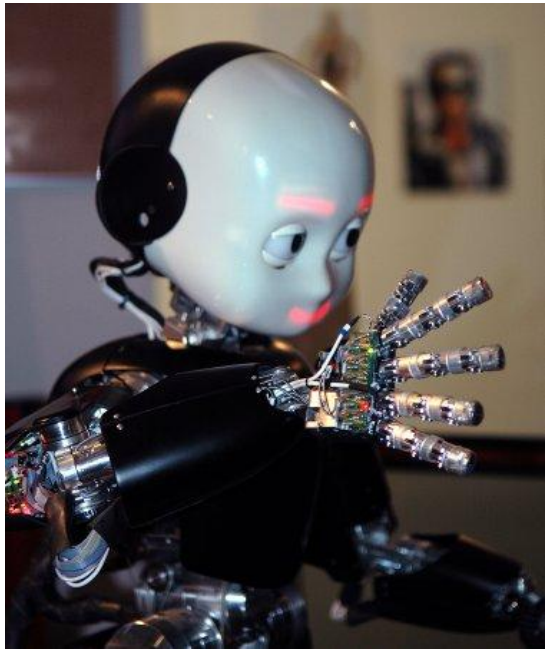
Robot Types

Humanoid Robots

- A humanoid robot is a robot with its body shape built to resemble the human body

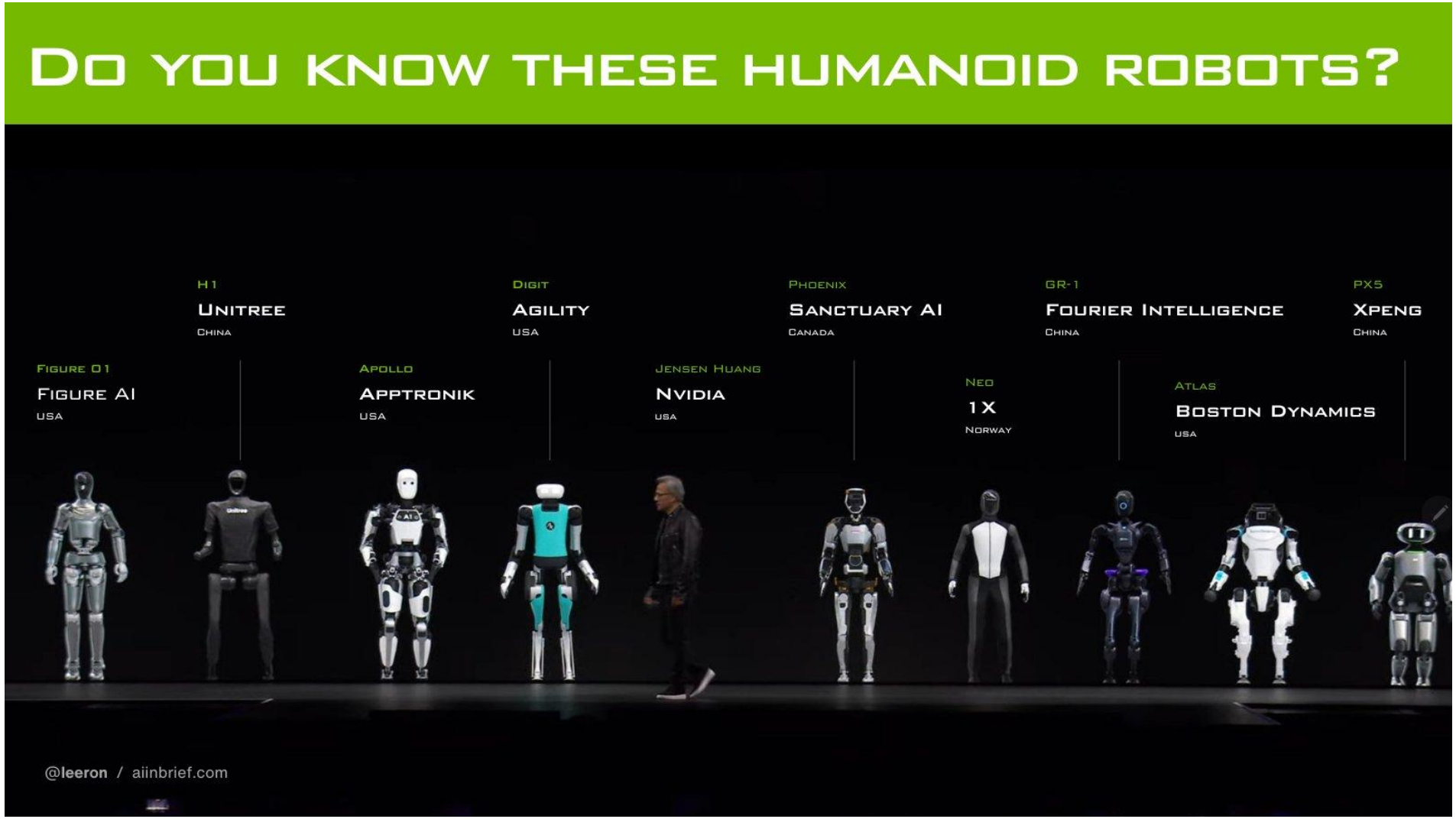


Honda P series



iCub robot

Humanoid Robots



Boston Dynamics Atlas

Robot Manipulators

- A device used to manipulate materials without direct physical contact of the operator

ABB

KUKA

FUNUC

Yaskawa

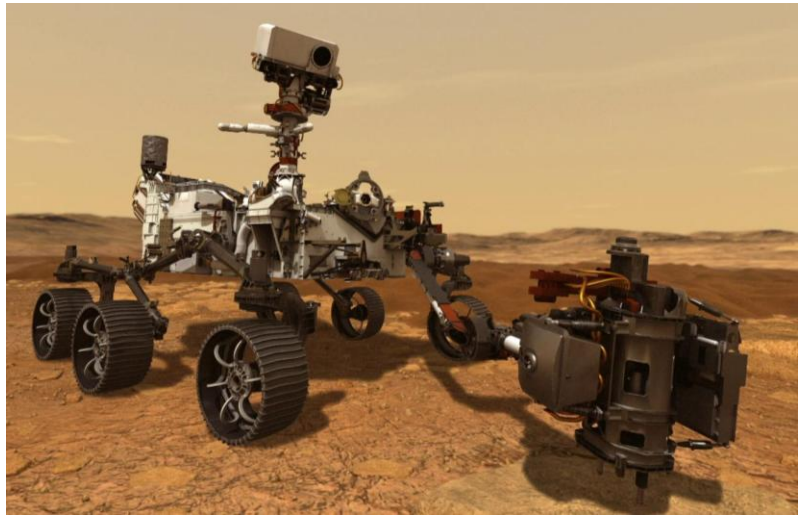
Franka Emika

Wheeled Robots

- Use wheels for locomotion
  - Self-driving cars

Starship Technologies

Amazon Astro Robot



Perseverance Rover

Walking Robots

- Legged robots, use articulated limbs to provide locomotion

Boston Dynamics

Robot Cassie

Boston Dynamics

Other Robots

- Flying robots
  - Drones
- Swimming robots
  - Underwater gliders
- Snake robots

Robotic Fish: *iSplash*-II

Two robot snakes. Left one has 64 motors (with 2 degrees of freedom per segment), the right one 10.

Robots vs. Humans

- Sensing
  - Robots: cameras, Inertial Measurement Units (IMUs), joint encoders
  - Humans: vision, vestibular, proprioceptive senses
- Control
  - Robots: motors
  - Humans: muscles
- Computation
  - Robots: robot brain, AI?
  - Humans: human brain

What is a Robot?

What is a Robot?

- A robot is a machine capable of carrying out a complex series of actions automatically (Wikipedia)

- A goal-oriented machine that can **sense**, **plan** and **act**

  - A robot senses its environment and uses that information, together with a goal, to plan some action

  - The action might be to move the tool of an arm-robot to grasp an object, or it might be to drive a mobile robot to some place

Robotic Systems



Tasks



Perception → Planning → Control

Learning

Sensing

World

Action

Robot Applications

- Robot Manipulation

- Robot Navigation

Robot Manipulation

- The ways robots interact with objects

- Examples
  - Grasping an object
  - Placing an object
  - Pushing an object
  - Opening a door
  - Folding laundry
  - Etc.

https://am.is.mpg.de/research_projects/autonomous-robotic-manipulation

Robot Manipulation

Perception → Planning → Control

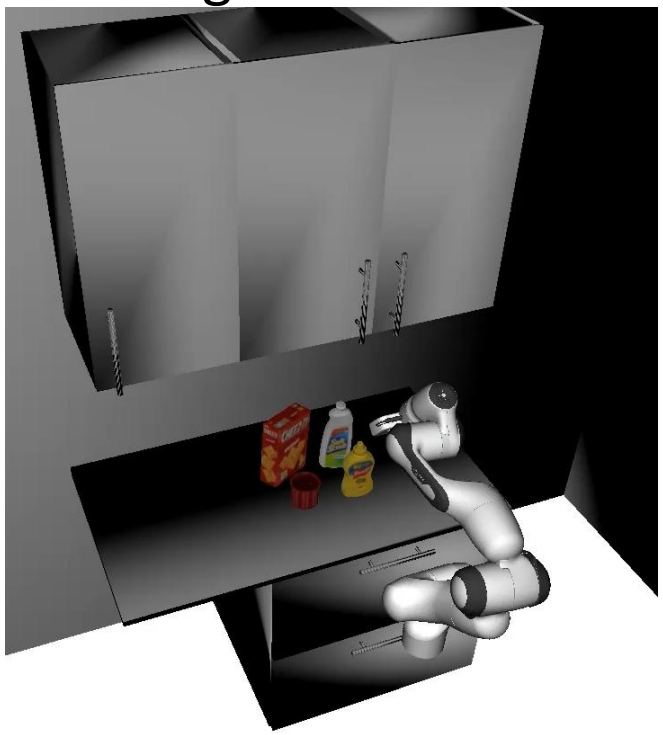
Robust and Accurate

High degree of freedom
Multi-modal grasping

Contact with objects

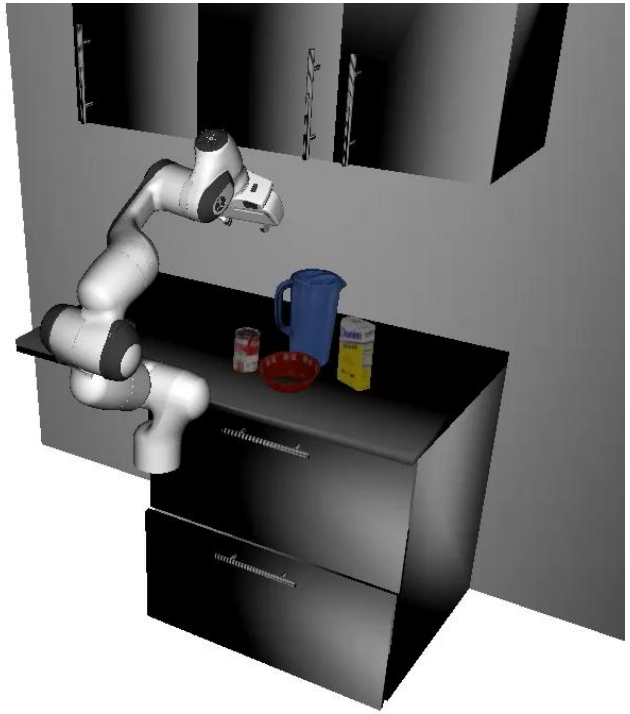
Sensed image

Planning scene



Real world execution

6D Object Pose Estimation for Robot Manipulation



Robot Navigation

- Go from A to B without hitting anything

Perception → Planning → Control

Simultaneous localization and mapping (SLAM)

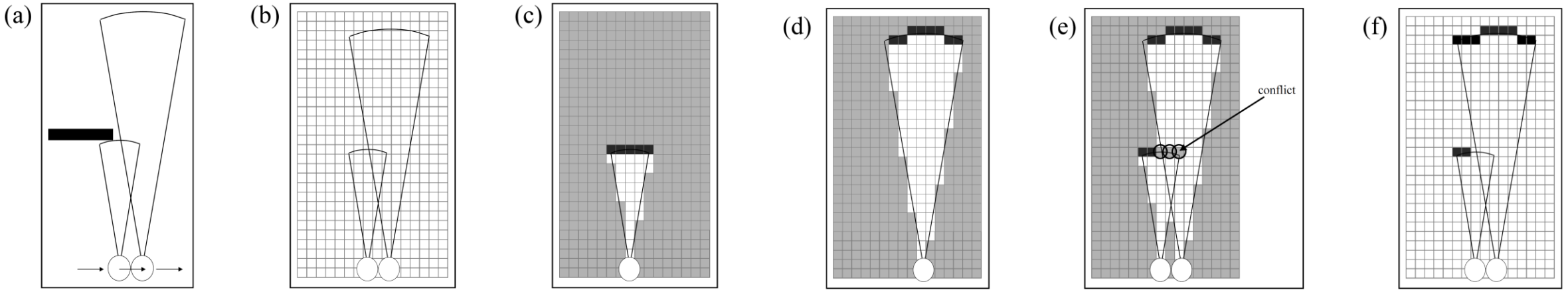
Path planning

Path following

Laser-based SLAM
2D occupancy grid map

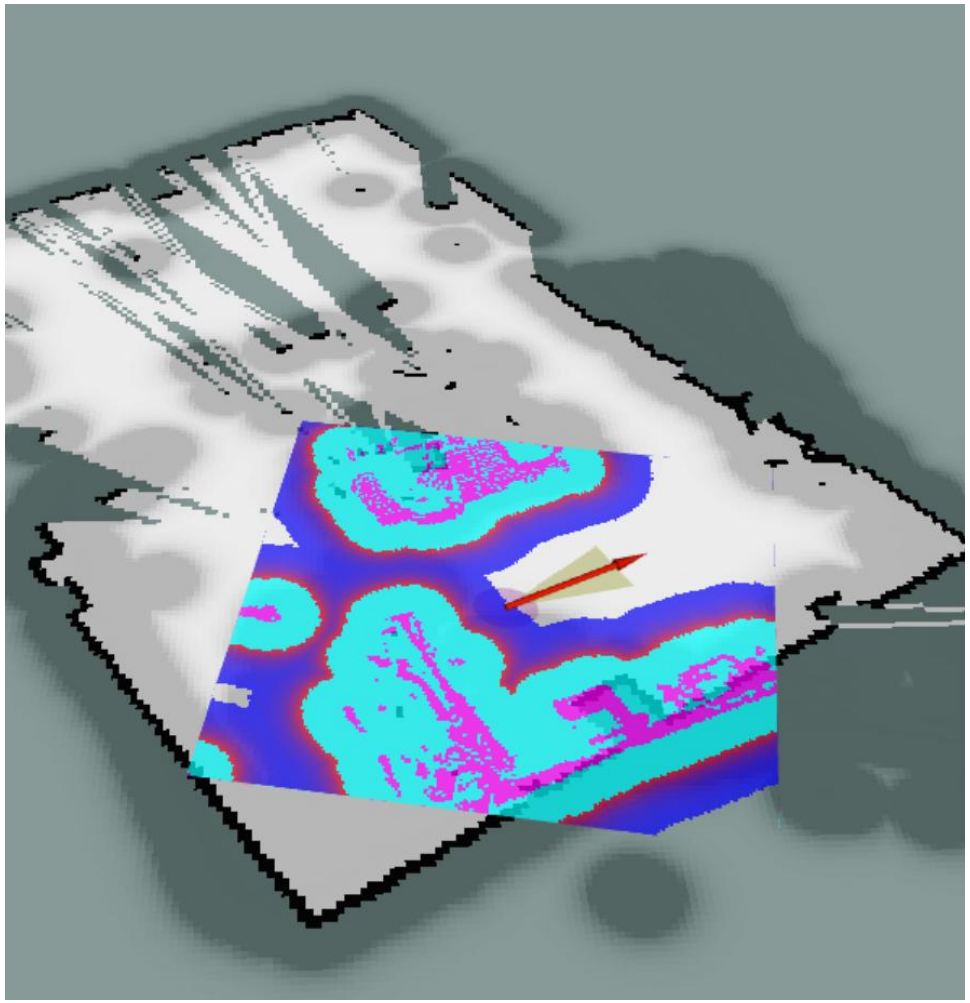
Occupancy Grid Mapping

- Occupancy grid
  - Status: unknown, occupied, empty



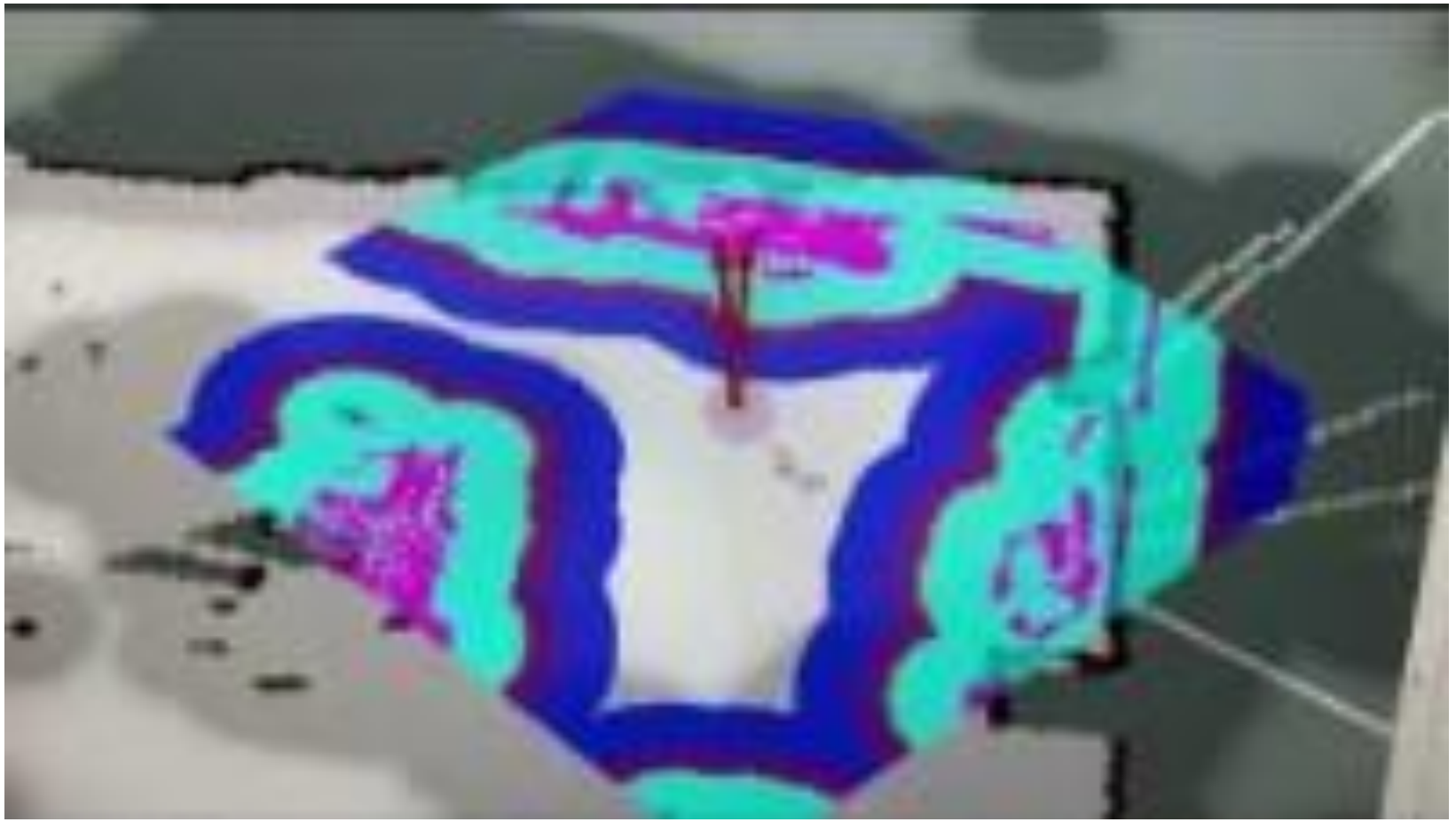
Learning Occupancy Grid Maps With Forward Sensor Models. Sebastian Thrun, 2002

Occupancy Grid Mapping



Navigation Demo using ROS

Credit: Gagan Bhat



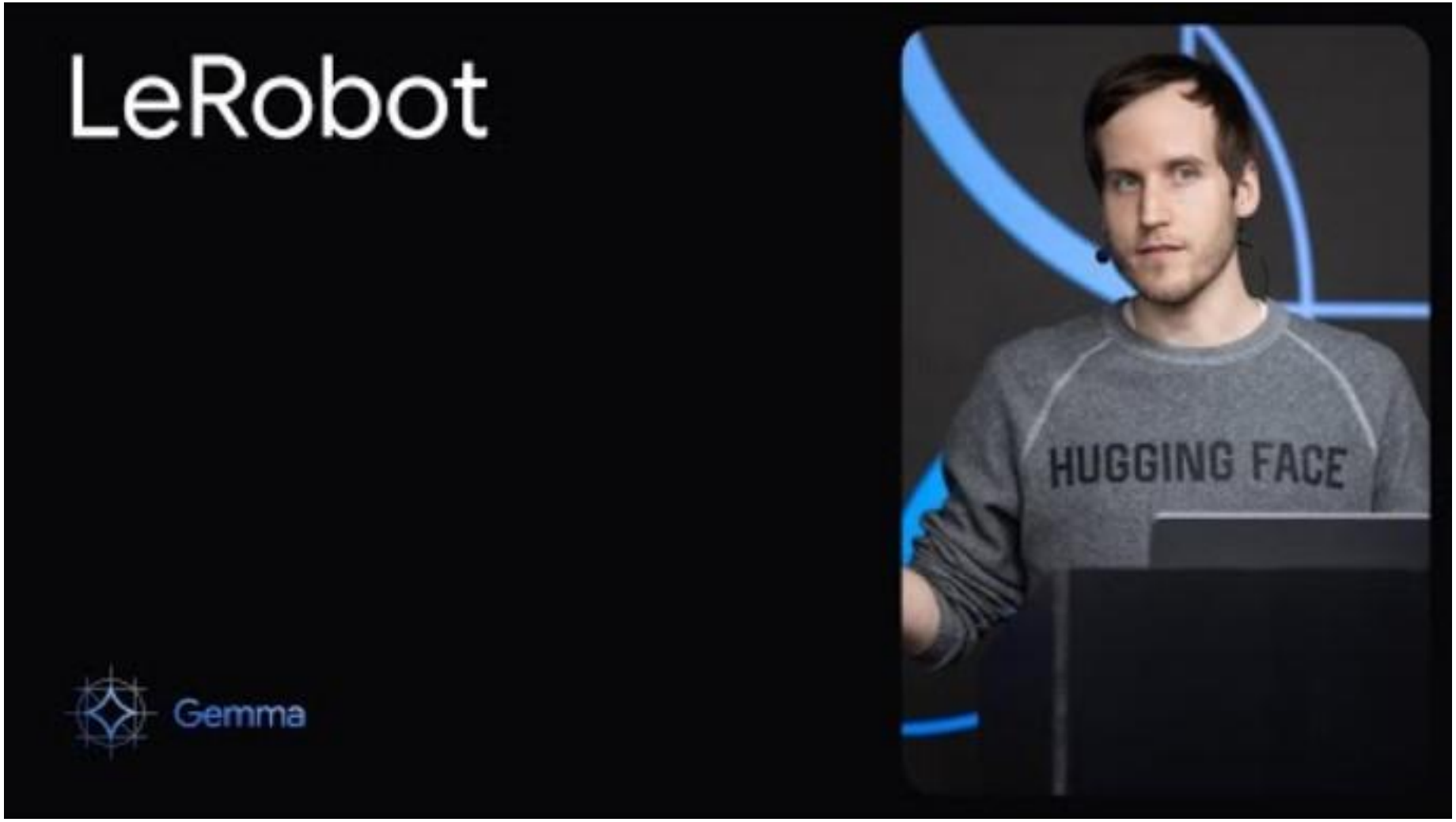
What will you learn in this course?

- Robot mechanism
  - Design of robot manipulators and wheeled robots
- Kinematics and dynamics of robots
- Robot motion planning and control
- Robot learning
  - Imitation learning, reinforcement leanring
- Robot Operating System (ROS) and robot simulators

What will you learn in this course?

- Mathematics in robotics
  - Lectures
- Programming in robotics
  - Homework and projects

LeRobot



https://www.youtube.com/watch?v=L0uxfZMlkag Remi Cadene, Principal Research Scientist at Hugging Face

Grading Policy

- Homework (50%)
  - 5 homework in total
  - Individual submission
- Team Project (45%)
  - 3 or 4 students for a project
  - Project proposal (5%)
  - Project mid-term report (10%)
  - Project presentation (15%)
  - Project final report (15%)
- In-class Activity (5%)
  - Quiz
- No final exam

Start thinking about the course project

Course Details

- Textbook
  - Kevin M. Lynch and Frank C. Park. Modern Robotics: Mechanics, Planning, and Control. 1st Edition http://hades.mech.northwestern.edu/images/7/7f/MR.pdf
  - Kevin Lynch's lectures https://modernrobotics.northwestern.edu/nu-gm-book-resource/foundations-of-robot-motion/
- My office hour

  Monday & Wednesday 3:00PM – 4:00 PM
  ECSS 4.702
- TA office hour: TBD
- Course access and navigation: eLearning

Questions?