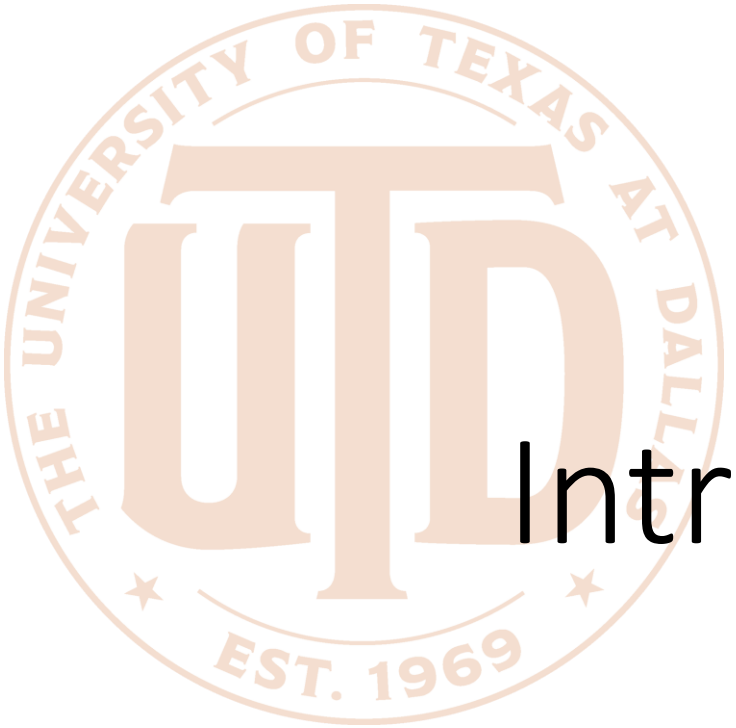


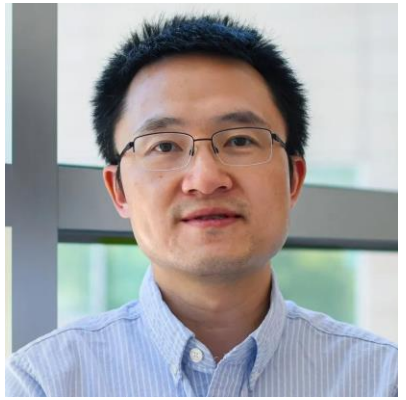
Introduction to Robotics

CS 6301 Special Topics: Introduction to Robot Manipulation and Navigation

Professor Yu Xiang

The University of Texas at Dallas

Who am I?

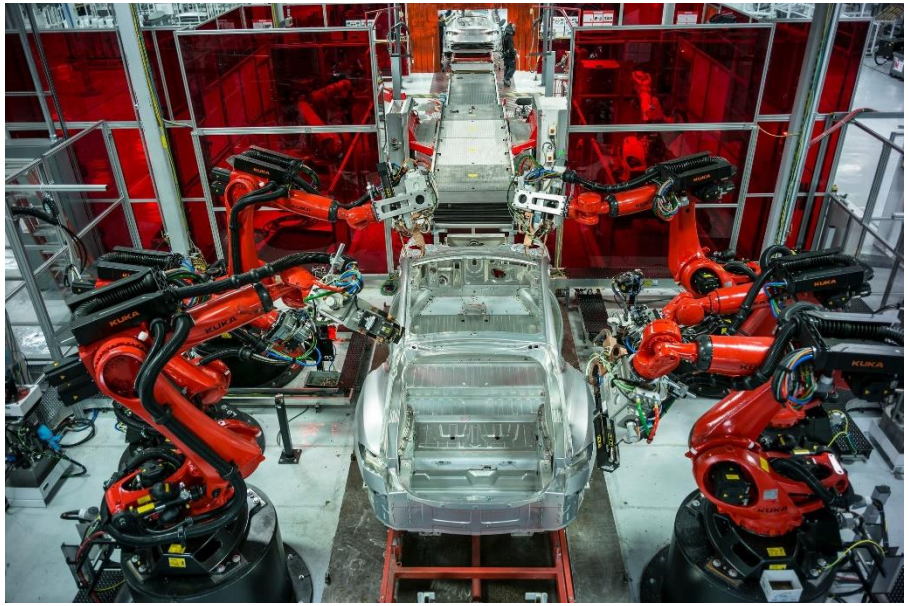


- Assistant Professor in CS at UT Dallas (joined Fall 2021)
- Ph.D., Electrical and Computer Engineering, University of Michigan, 2016
- Research area: robotics and computer vision
- Intelligent Robotics and Vision Lab (IRVL) https://labs.utdallas.edu/irvl/

Introduce yourself

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

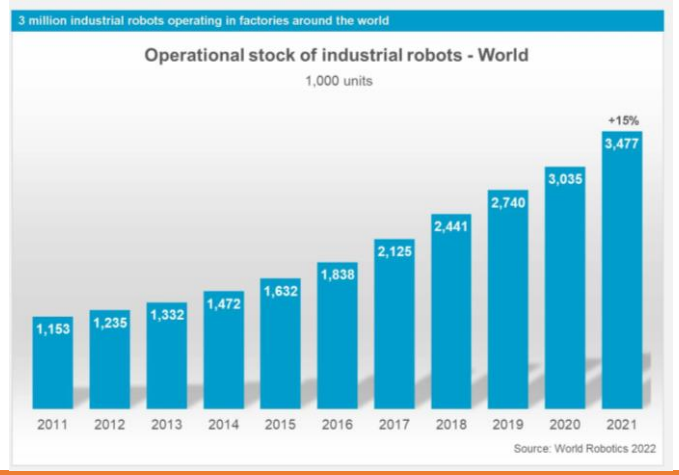
Robots in Factories and Warehouses



Welding and Assembling

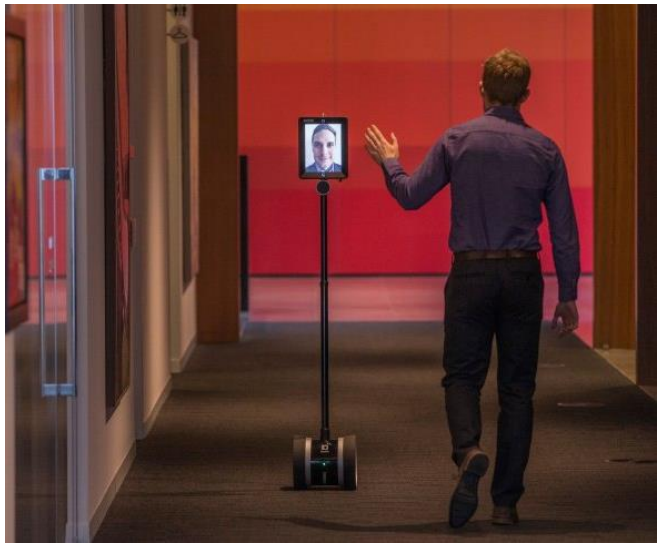
Material Handling

Delivering



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

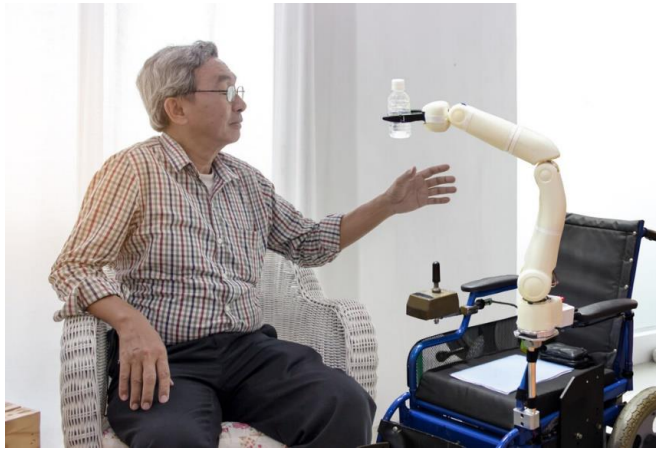
Google Everyday Robots

Tesla Bot

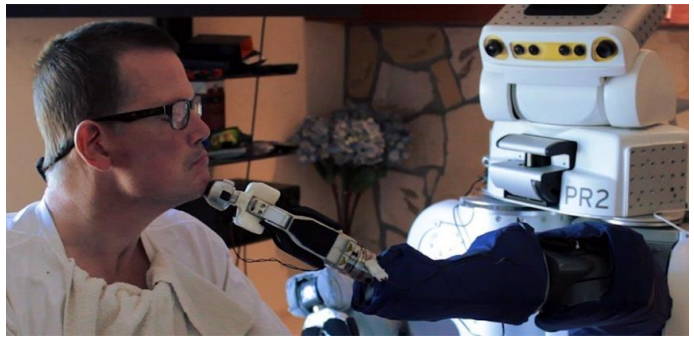
Figure + OpenAI

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

Future Intelligent Robots in Human Environments



Senior Care



Assisting

Serving

Cooking

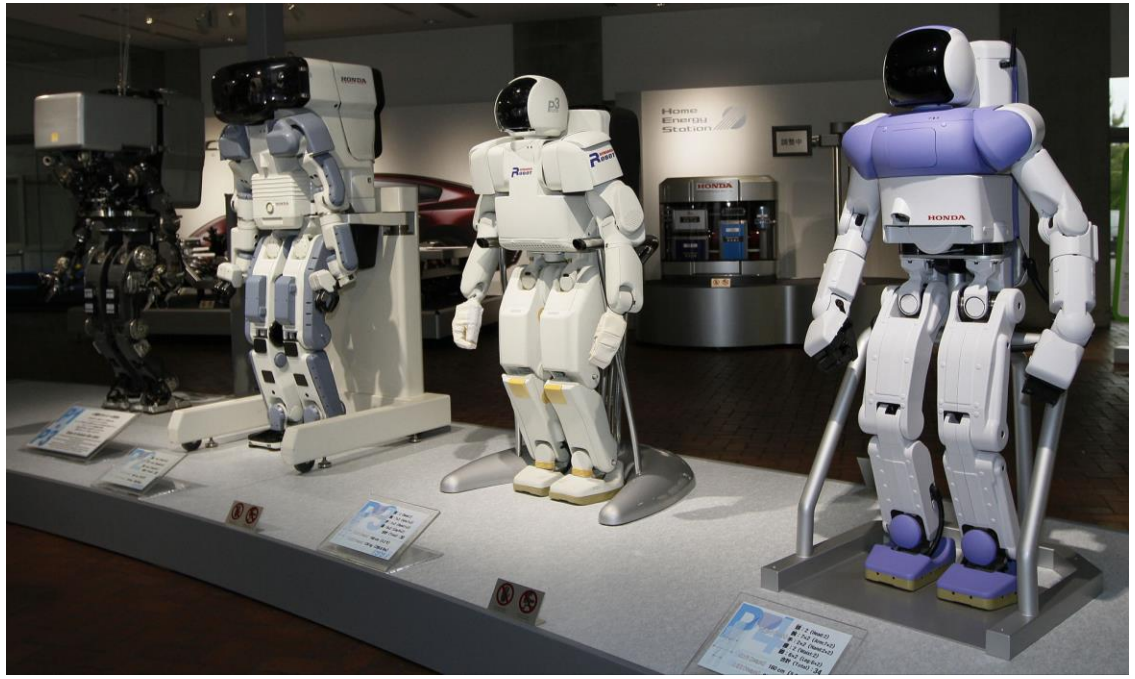
Cleaning

Dish washing

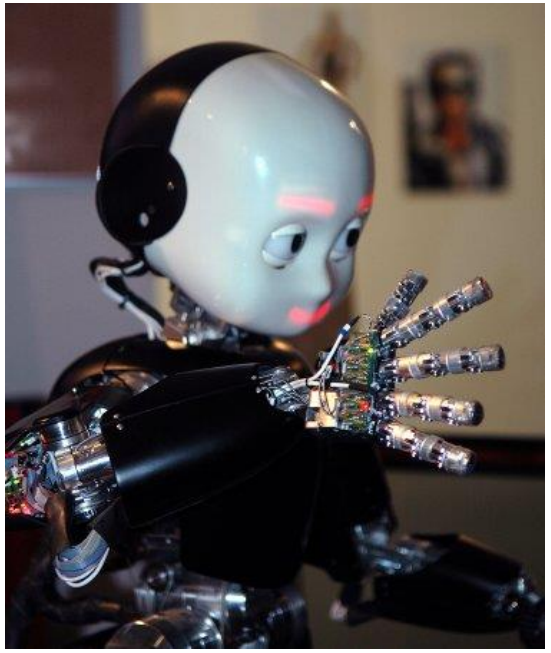
Robot Types

Humanoid Robots

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

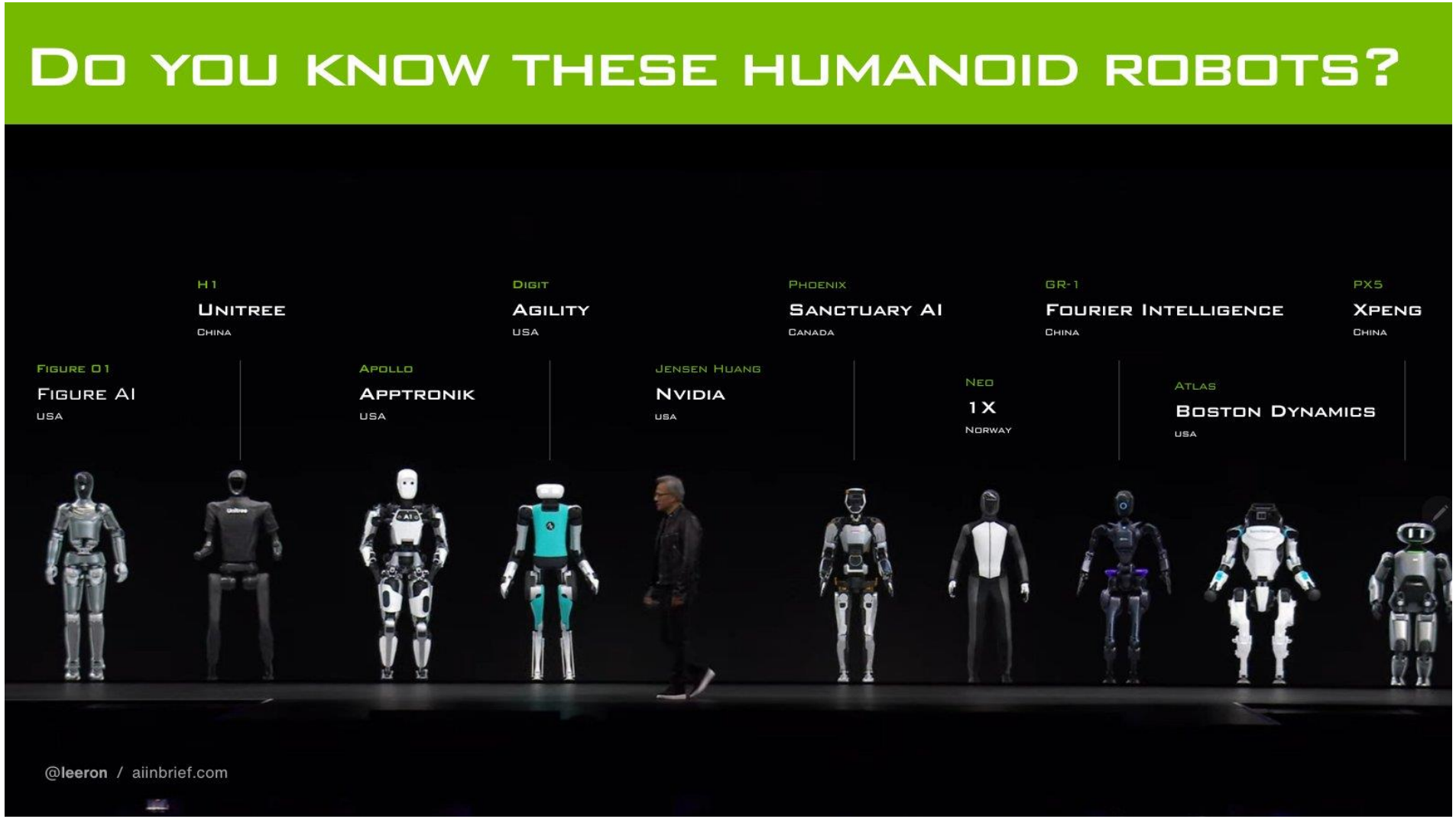


Honda P series



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

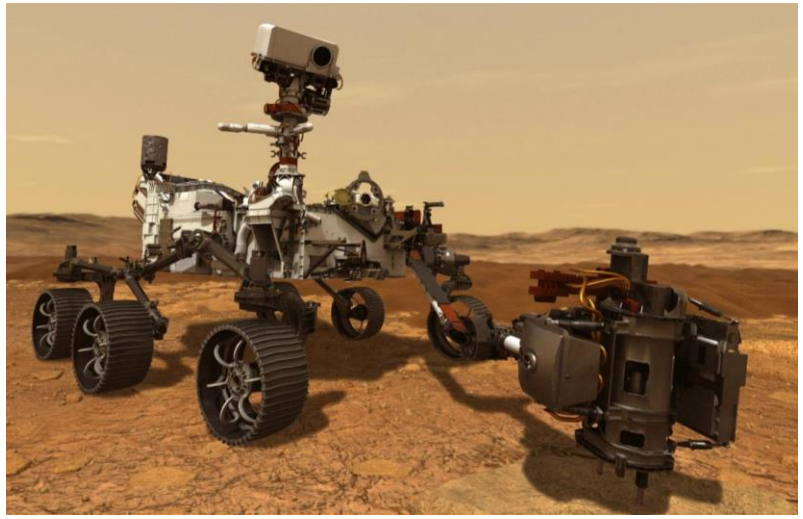
Franka Emika

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

Our Focus in this Course

- Robot Manipulation (more than 2/3 of the course)

- 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

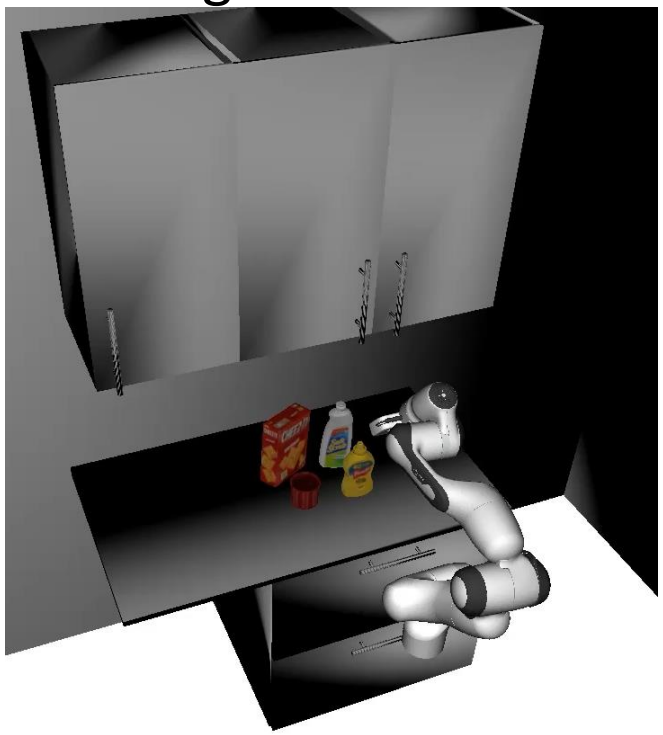
Robust and Accurate

High degree of freedom
Multi-modal grasping

Contact with objects

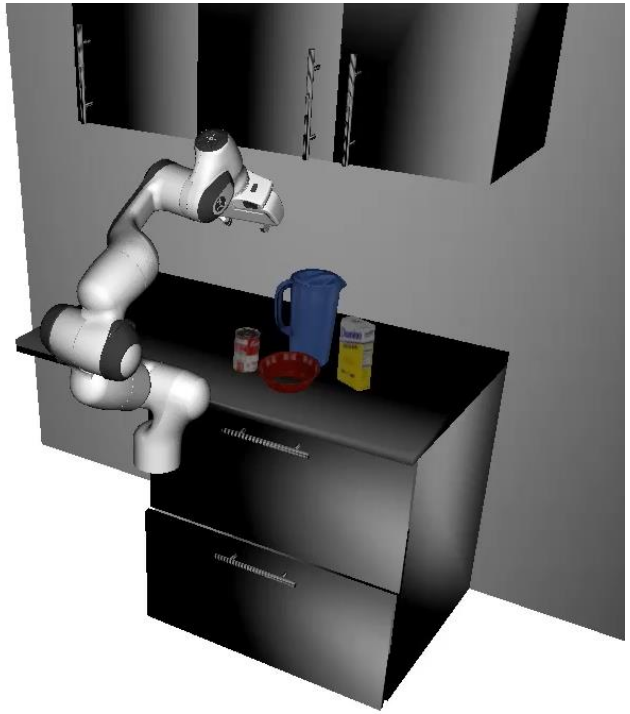
Sensed image

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)

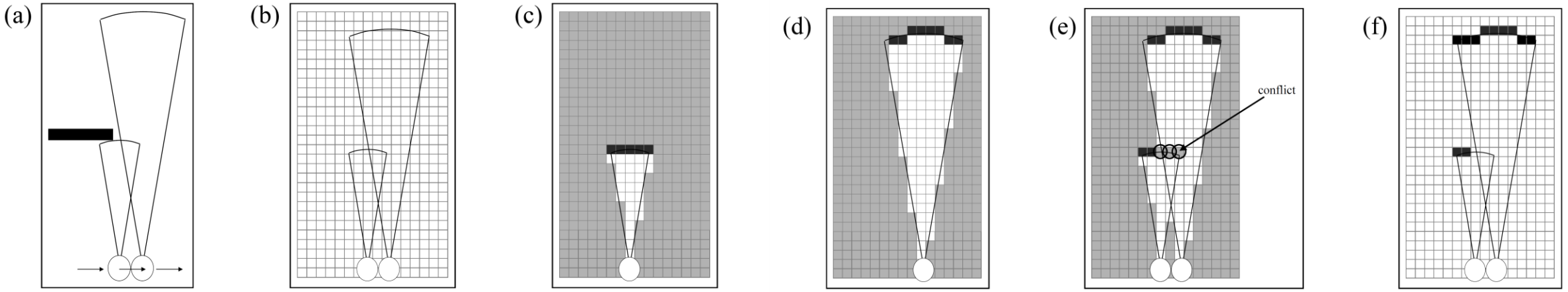
Path planning

Path following

Laser-based SLAM
2D occupancy grid map

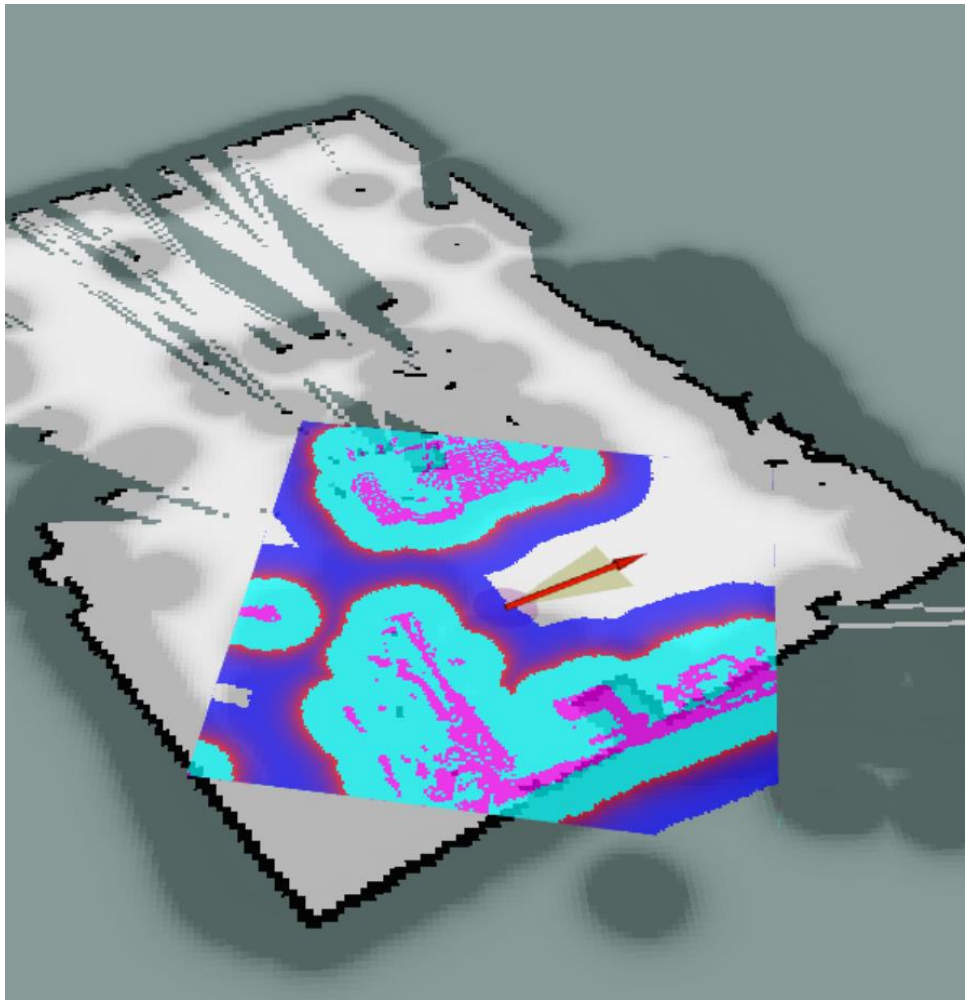
Occupancy Grid Mapping

- Occupancy grid
  - Status: unknown, occupied, empty



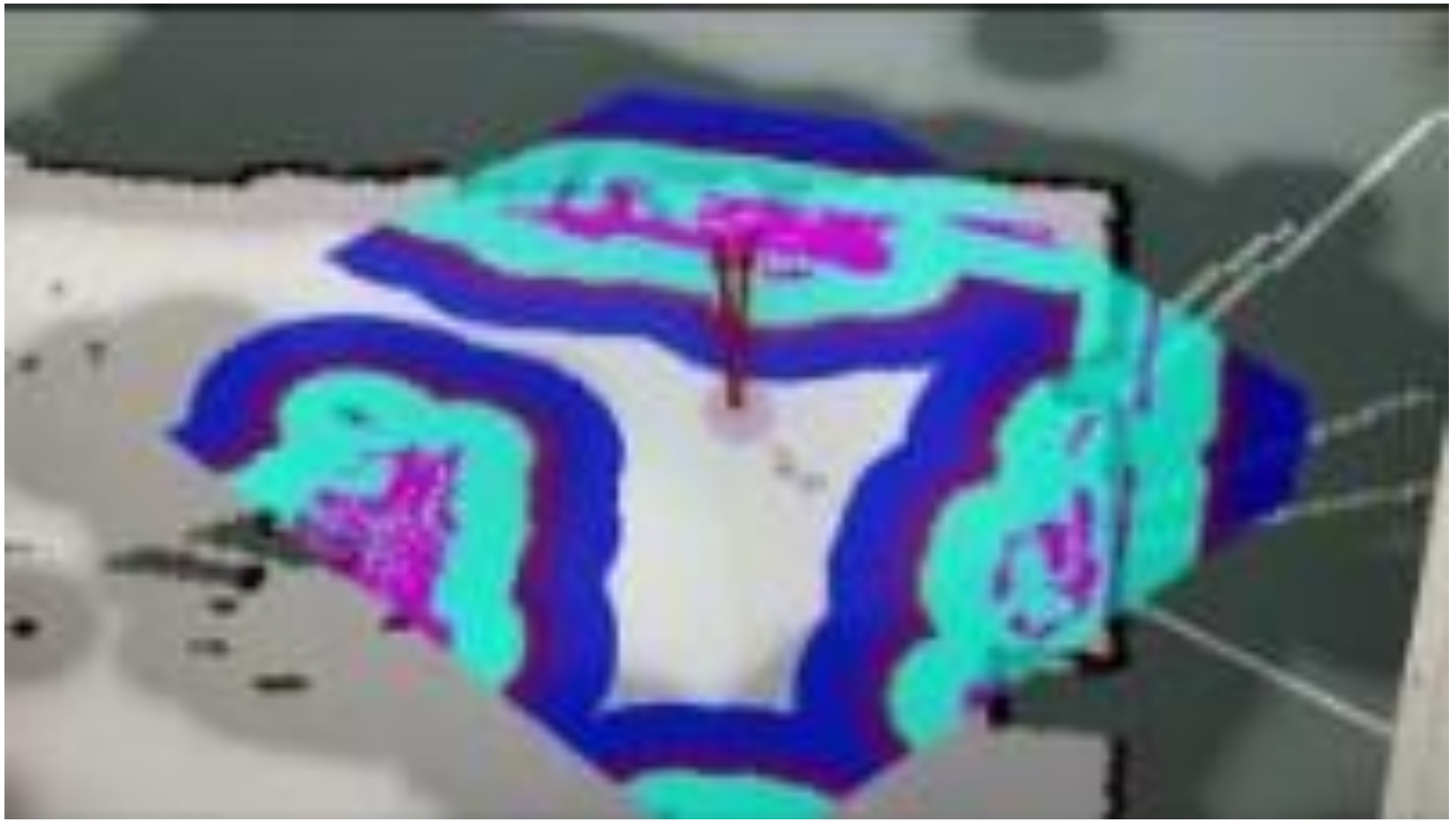
Learning Occupancy Grid Maps With Forward Sensor Models. Sebastian Thrun, 2002

Occupancy Grid Mapping



Navigation Demo using ROS

Credit: Gagan Bhat



What will you learn in this course?

- Design of robot manipulators and wheeled robots
- Kinematics and dynamics of robots
- Robot control in manipulation and navigation
- Robot perception in manipulation and navigation
- Robot Operating System (ROS) and robot simulators

What will you learn in this course?

- Mathematics in robotics
  - Lectures

- Programming in robotics
  - Homework and projects

Grading Policy

- Homework (50%)
  - 5 homework in total
  - Individual submission
- Team Project (45%)
  - 2 or 3 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?