Introduction to Robotics

CS 6301 Special Topics: Introduction to Robot Manipulation and Navigation

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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

Operational stock of industrial robots - World

Source: World Robotics 2020

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Robots in Human Environments

Cleaning Robots
How can we have more powerful robots assisting people at homes or offices?
• Mobile manipulators
• Humanoids

Telepresence Robots

Smart Speakers

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Amazon Astro
Google Everyday Robots
Tesla Bot
Future Intelligent Robots in Human Environments

Senior Care
Cooking
Cleaning
Assisting
Serving
Dish washing
Robot Types
Humanoid Robots

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

Perception → Planning → Control

Tasks

Learning

Sensing

World

Action

Perception Planning Control

Tasks

Learning

Sensing

World

Action
Our Focus in this Course

• 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
Robust and Accurate

Planning
High degree of freedom
Multi-modal grasping

Control
Contact with objects

Sensed image
Planning scene
Real world execution

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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

Occupyancy 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%)

• No final exam

Start thinking about the course project
Course Details

• Textbook

• My office hour
  - Monday & Wednesday 2:30PM – 3:30 PM
  - ECSS 4.702

• TA office hour: TBD

• Course access and navigation: [eLearning](#)
Questions?