Robotic Interfaces

CS 6334 Virtual Reality
Professor Yu Xiang
The University of Texas at Dallas
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
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
Unseen Object Instance Segmentation:
Xie-Xiang-Mousavian-Fox, CoRL’19, T-RO’21
Xiang-Xie-Mousavian-Fox, CoRL’20

6-DOF GraspNet:
Mousavian-Eppner-Fox, ICCV’19
Wheeled Robots

- Use wheels for locomotion
  - Self-driving cars

Starship Technologies

Amazon Astro Robot

Perseverance Rover
Robot Navigation

Meng-Ratliff-Xiang-Fox, ICRA’19, ’20
Meng-Xiang-Fox, RA-L’21
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, IMUs, joint encoders
  • Humans: vision, vestibular, proprioceptive senses

• Control
  • Robots: motors
  • Humans: muscles

• Computation
  • Robots: robot brain, AI?
  • Humans: human brain
Robotic Systems

Perception -> Planning -> Control

Tasks

Learning

Sensing

World

Action
Virtual Reality and Robotics

• Teleoperating robots with VR

• Robot learning with VR
Teleoperation

https://www.shadowrobot.com/jeff-bezos-tries-our-tech/
Teleoperation

Teleoperation

da Vinci Robotic Assisted Surgery
Teleoperation with VR

• The feeling of presence
  • Presence is correlated with task performance in a positive, causal way

• Inhabit the body of a robot with VR? We could use robots as our surrogate selves
Teleoperation with VR

- Virtual environments for control

- Natural task execution in the virtual environment
- We can argument the virtual environment to provide guidance or constraints to the user
Teleoperation with VR

Baxter’s Homunculus: Virtual Reality Spaces for Teleoperation in Manufacturing. Lipton et al., RA-L’18.
Baxter’s Homunculus: Virtual Reality Spaces for Teleoperation in Manufacturing. Lipton et al., RA-L’18.
Teleoperation with VR

A VR System for Immersive Teleoperation and Live Exploration with a Mobile Robot. Stotko et al., IROS’19.
A VR System for Immersive Teleoperation and Live Exploration with a Mobile Robot. Stotko et al., IROS’19.
Robot Learning

• How can robots learn various skills?
  • Navigation
  • Manipulation

• Reinforcement learning
  • Learning from trial and error

• Imitation learning
  • Learning from demonstrations
Reinforcement Learning

Kinesthetic Teaching

- A human teacher physically guides the robot in performing the skill

Watching Human Demonstrations

Demonstrations from Teleoperation

RotoTurk: [https://roboturk.stanford.edu/realrobotdataset#dataset](https://roboturk.stanford.edu/realrobotdataset#dataset)
Demonstrations from VR

• Use VR in teleoperation to generate demonstrations

Demonstrations from VR

TRI Robotics Example
Summary

• Teleoperating robots with VR

• Robot learning with VR
Further Reading

• Section 13.3, Virtual Reality, Steven LaValle