Robotic Interfaces

CS 6334 Virtual Reality

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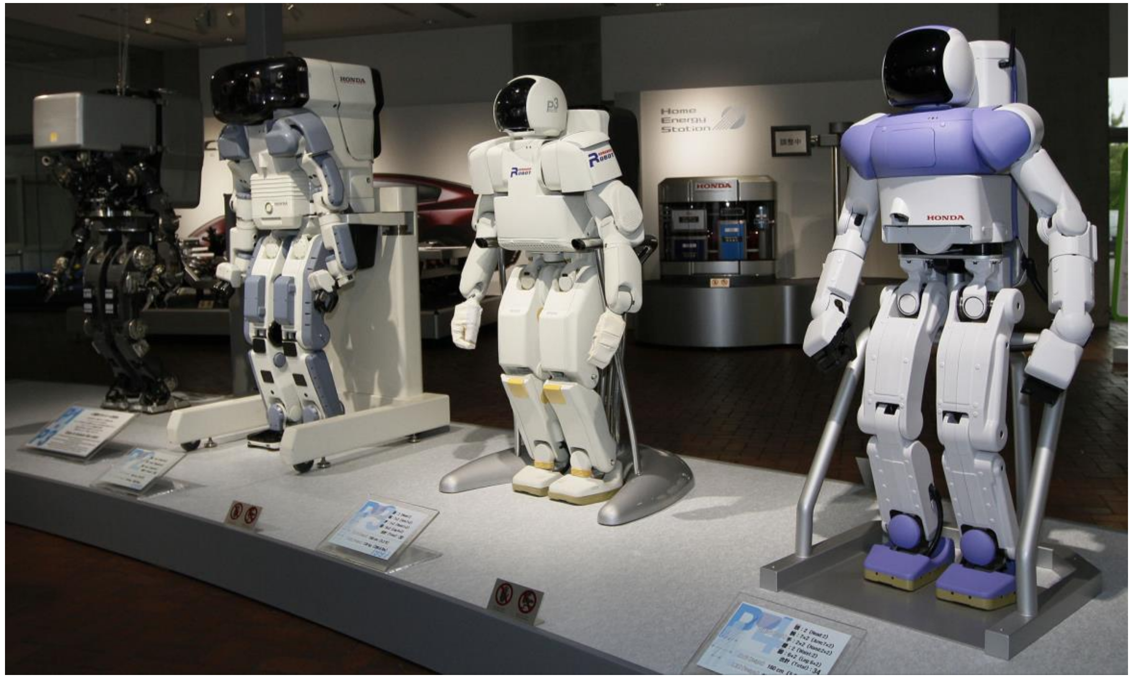
What is a Robot?

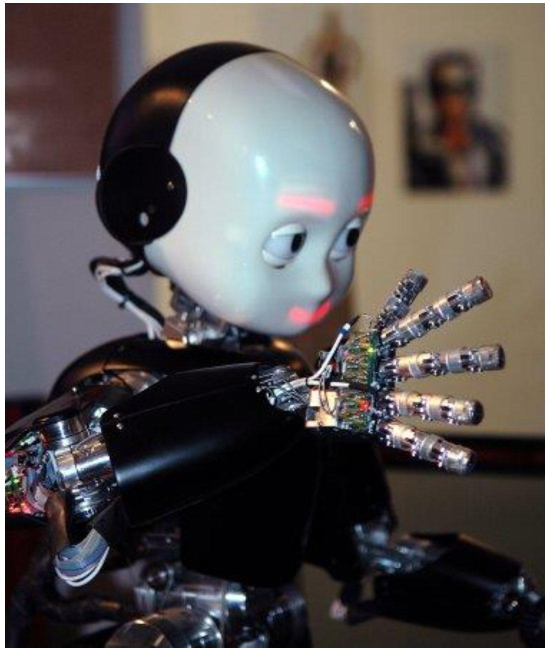
- A robot is a machine capable of carrying out a complex series of actions automatically (Wikipedia)
- A goal-oriented machine that can **sense**, **plan** and **act**
  - A robot senses its environment and uses that information, together with a goal, to plan some action
  - The action might be to move 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



Honda P series



iCub robot


HONDA

Robot Manipulators

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

ABB

KUKA

FUNUC

Yaskawa

Franka Emika

Robot Manipulation

Unseen Object Instance Segmentation:
Xie-Xiang-Mousavian-Fox, CoRL’19, T-RO’21
Xiang-Xie-Mousavian-Fox, CoRL’20

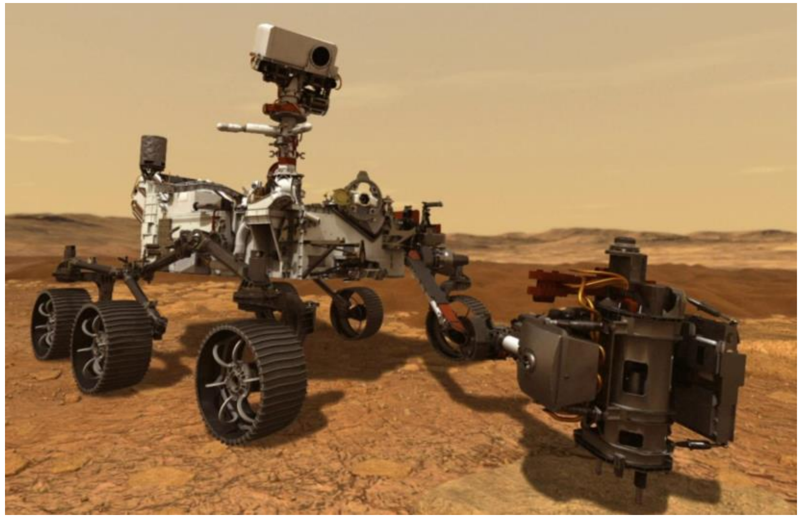
6-DOF GraspNet:
Mousavian-Eppner-Fox, ICCV’19

Wheeled Robots

- Use wheels for locomotion
  - Self-driving cars

Starship Technologies

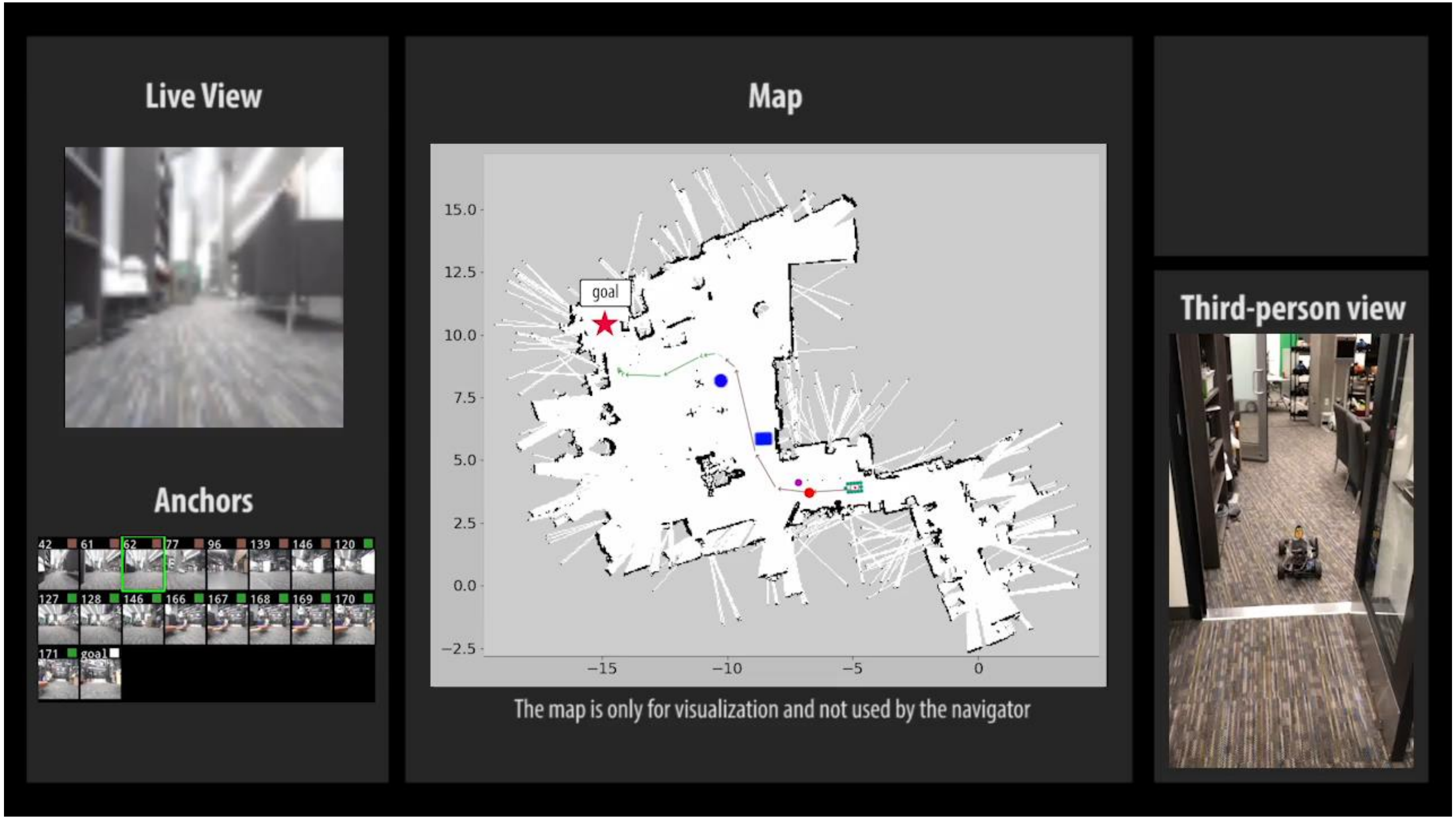
Amazon Astro Robot



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

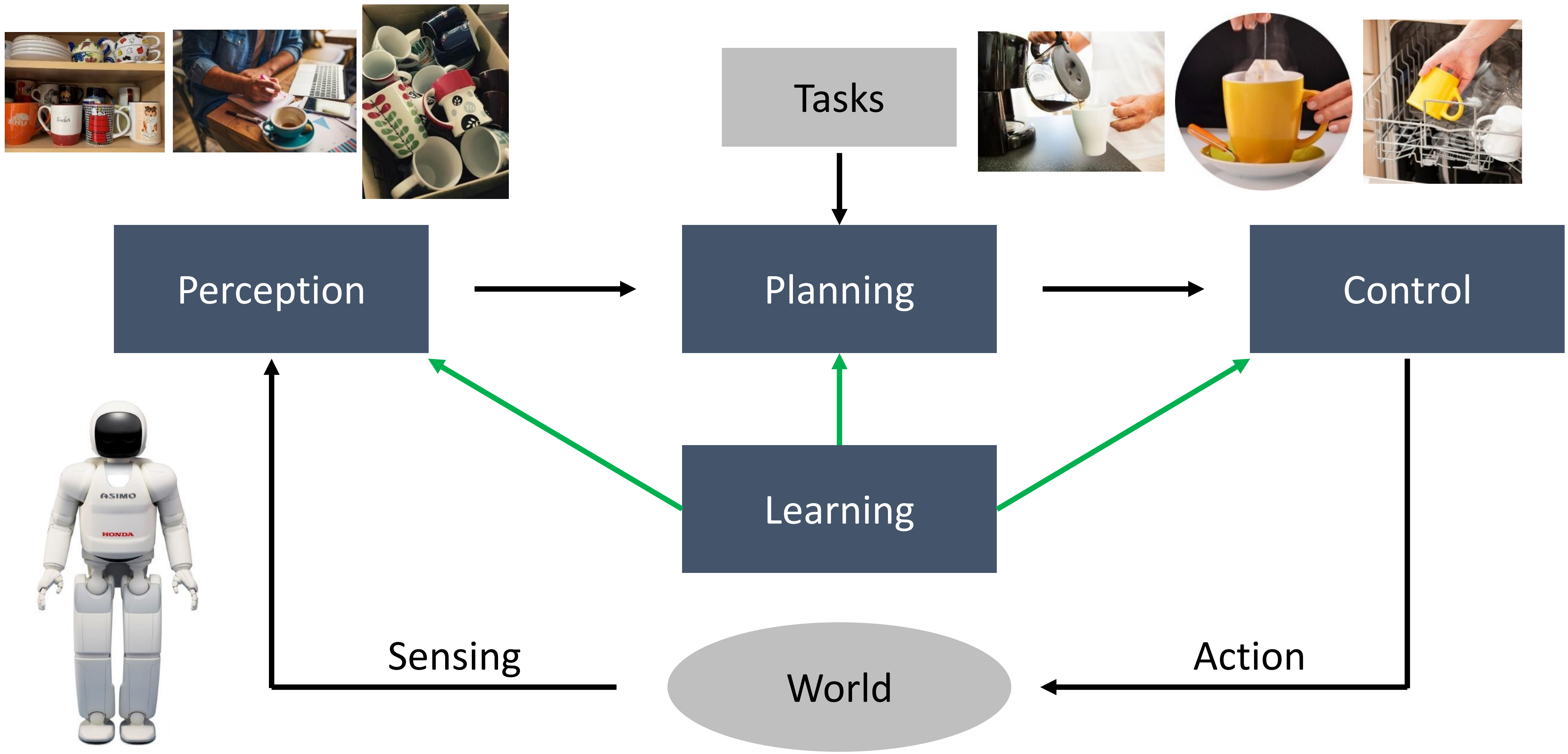
Robotic Fish: *iSplash*-II

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

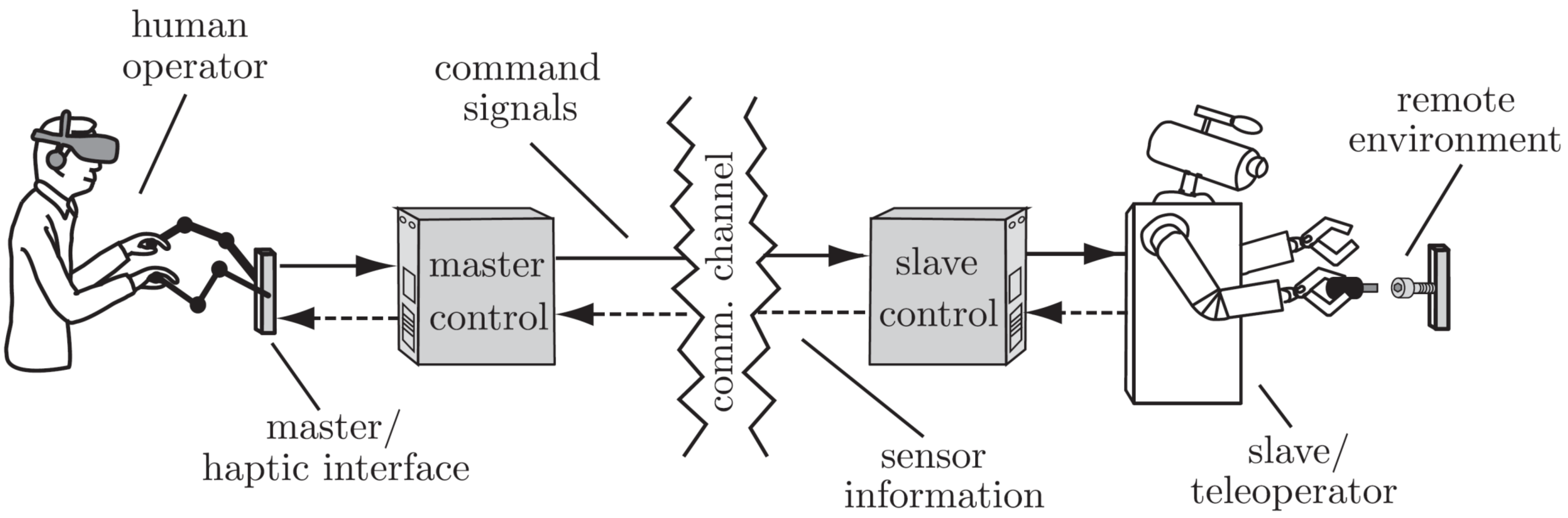


Virtual Reality and Robotics

- Teleoperating robots with VR

- Robot learning with VR

Teleoperation



A survey of environment-, operator-, and task-adapted controllers for teleoperation systems. Passenberg et al., Mechatronics, 2010.

Teleoperation

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

Teleoperation

DexPilot: Vision Based Teleoperation of Dexterous Robotic Hand-Arm System. Handa et al. ICRA'21.

Teleoperation

da Vinci Robotic Assisted Surgery

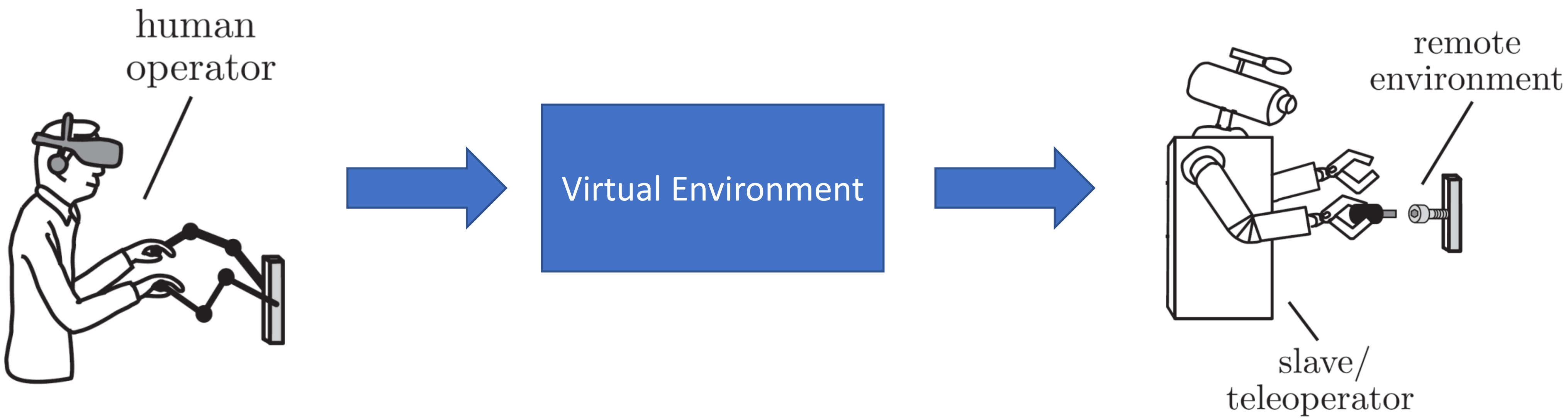
Teleoperation with VR

- 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

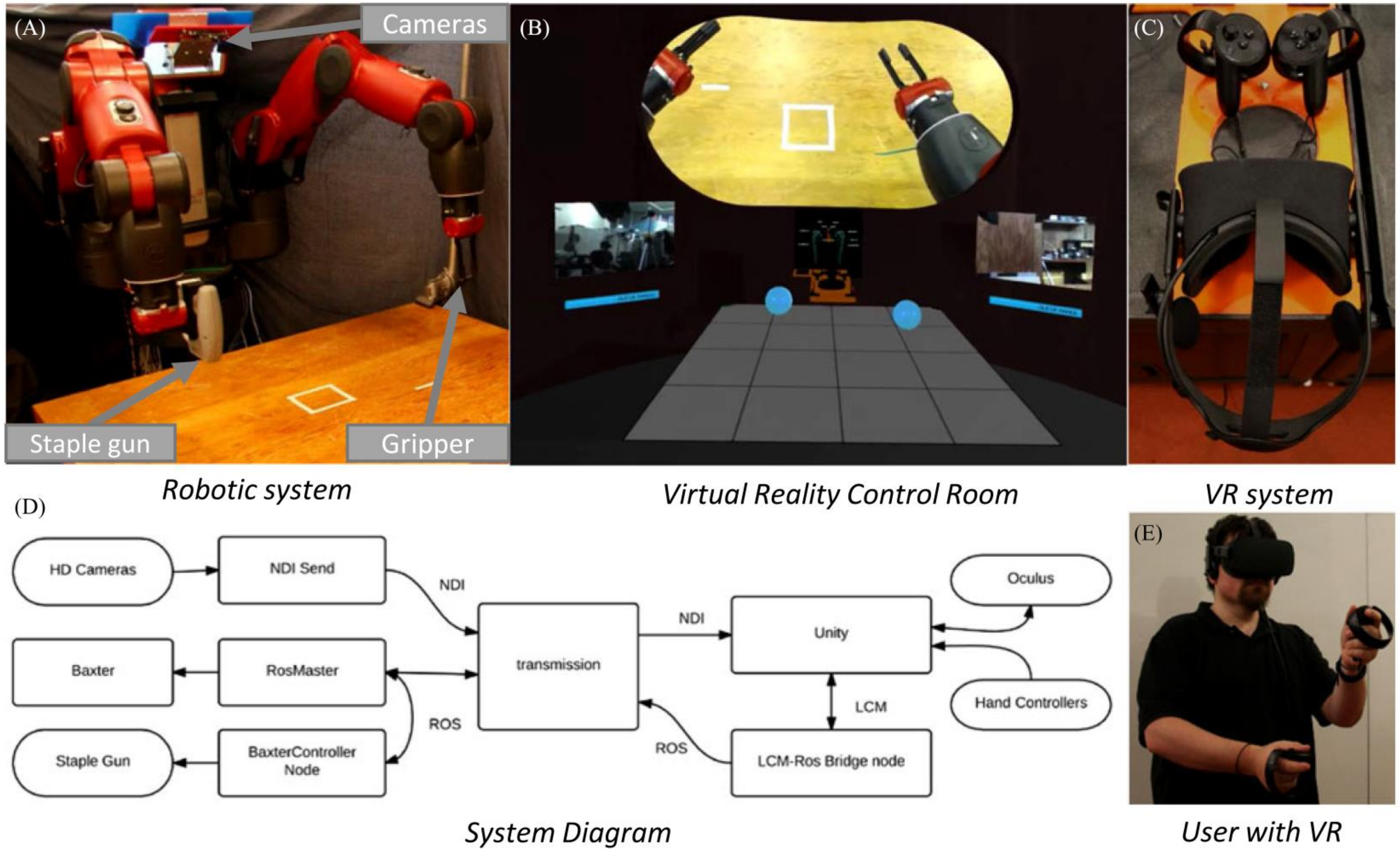
Teleoperation with VR

- 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.

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Teleoperation with VR

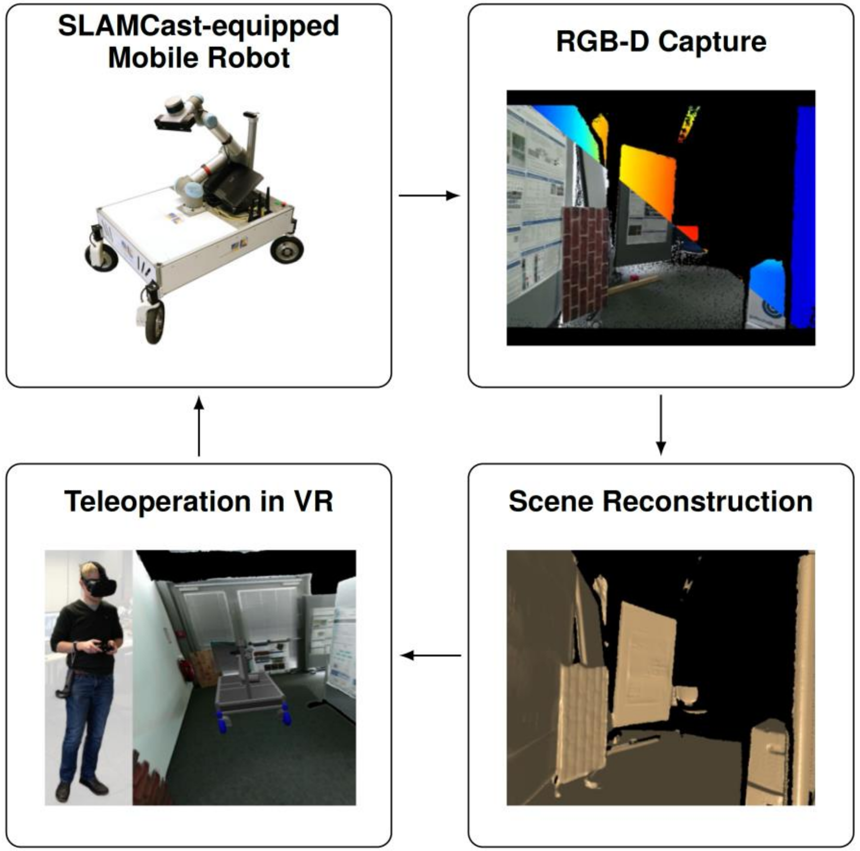


Fig. 4. Reconstructed 3D model of the teleoperation scene.

Fig. 5. Teleoperation experiment. Left: Baseline experiment with wide-angle camera feed. Right: Teleoperation using the proposed VR system.

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.

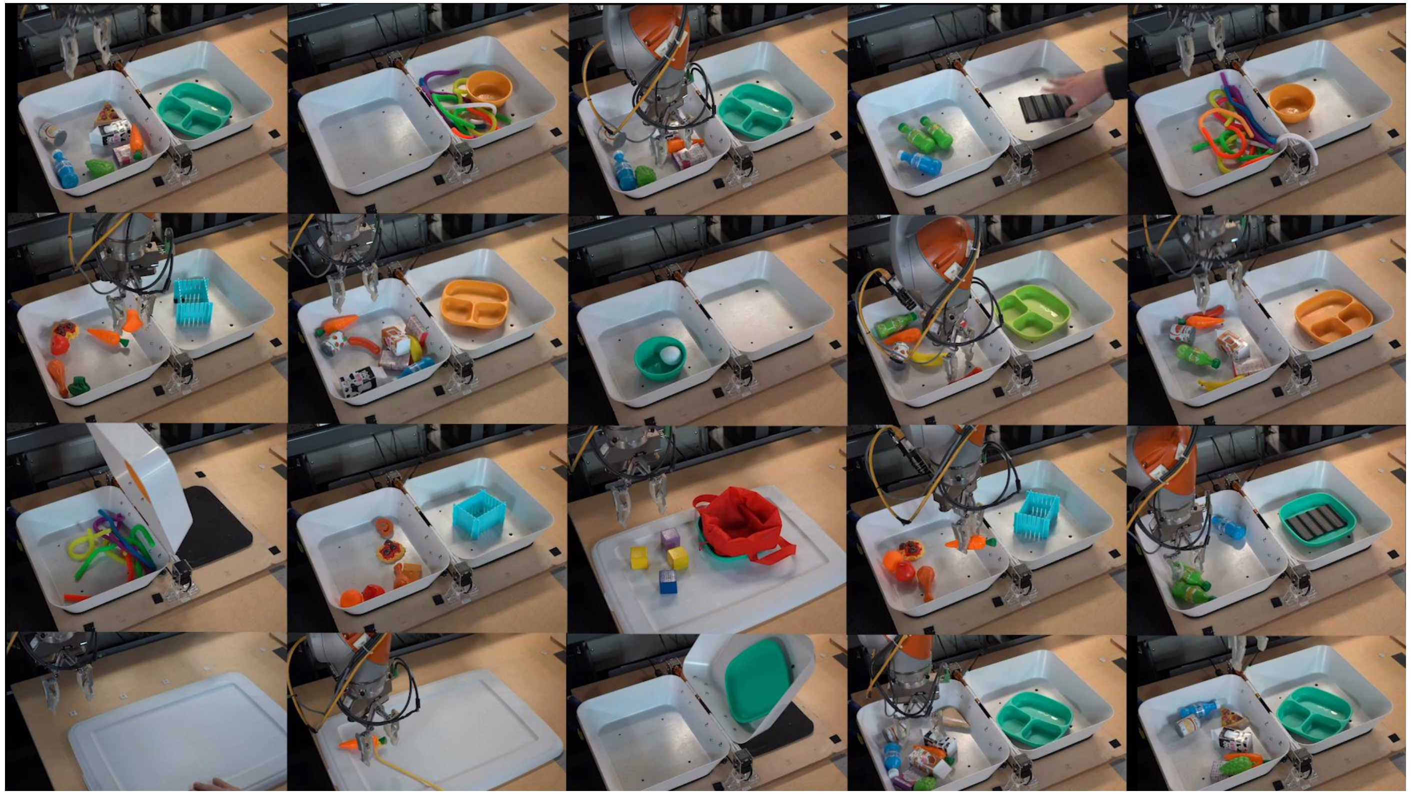
Robot Learning

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

- Reinforcement learning
  - Learning from trial and error

- Imitation learning
  - Learning from demonstrations

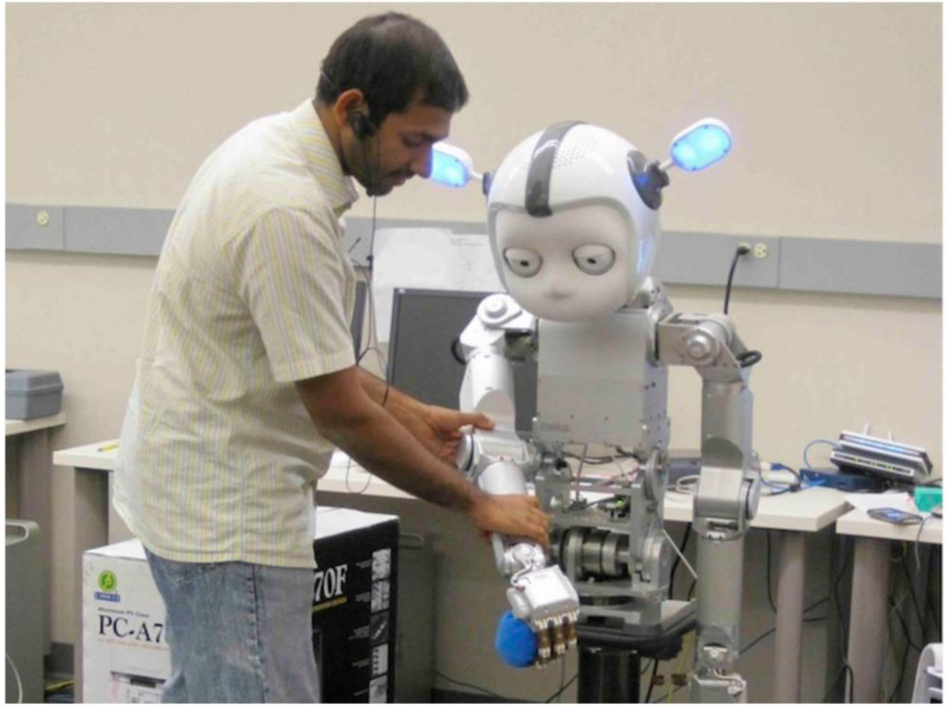
Reinforcement Learning



https://ai.googleblog.com/2021/04/multi-task-robotic-reinforcement.html

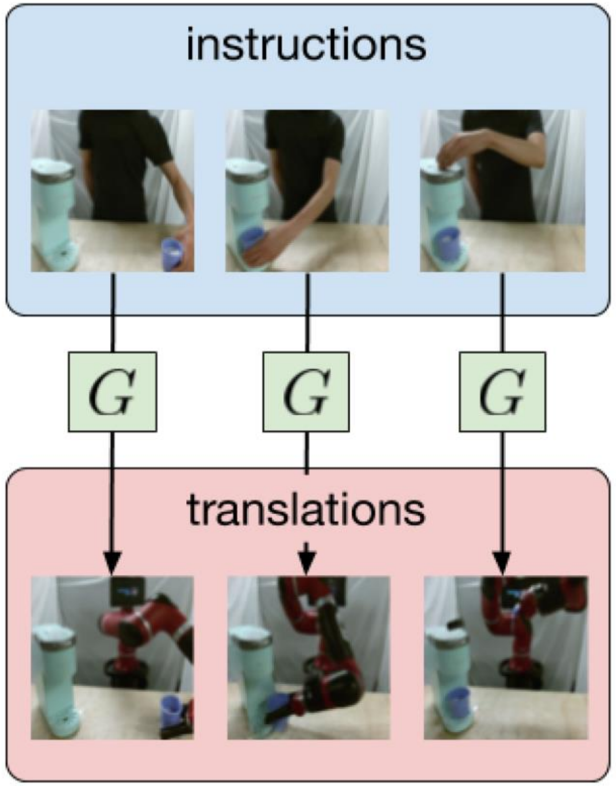
Kinesthetic Teaching

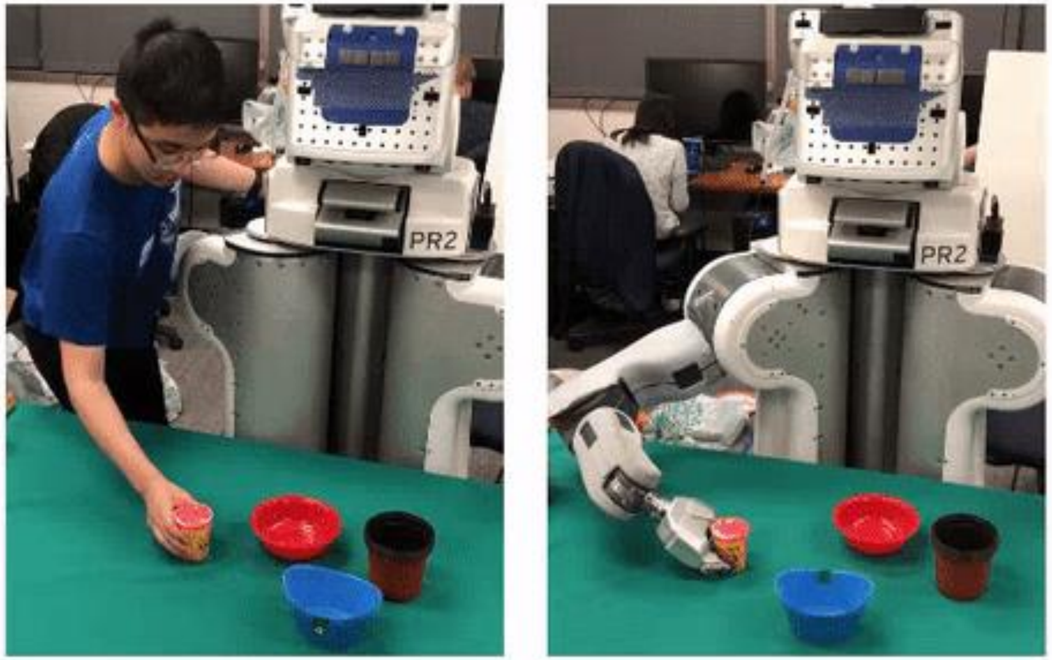
- A human teacher physically guides the robot in performing the skill



Keyframe-based Learning from Demonstration. Akgun et al., International Journal of Social Robotics , 2011.

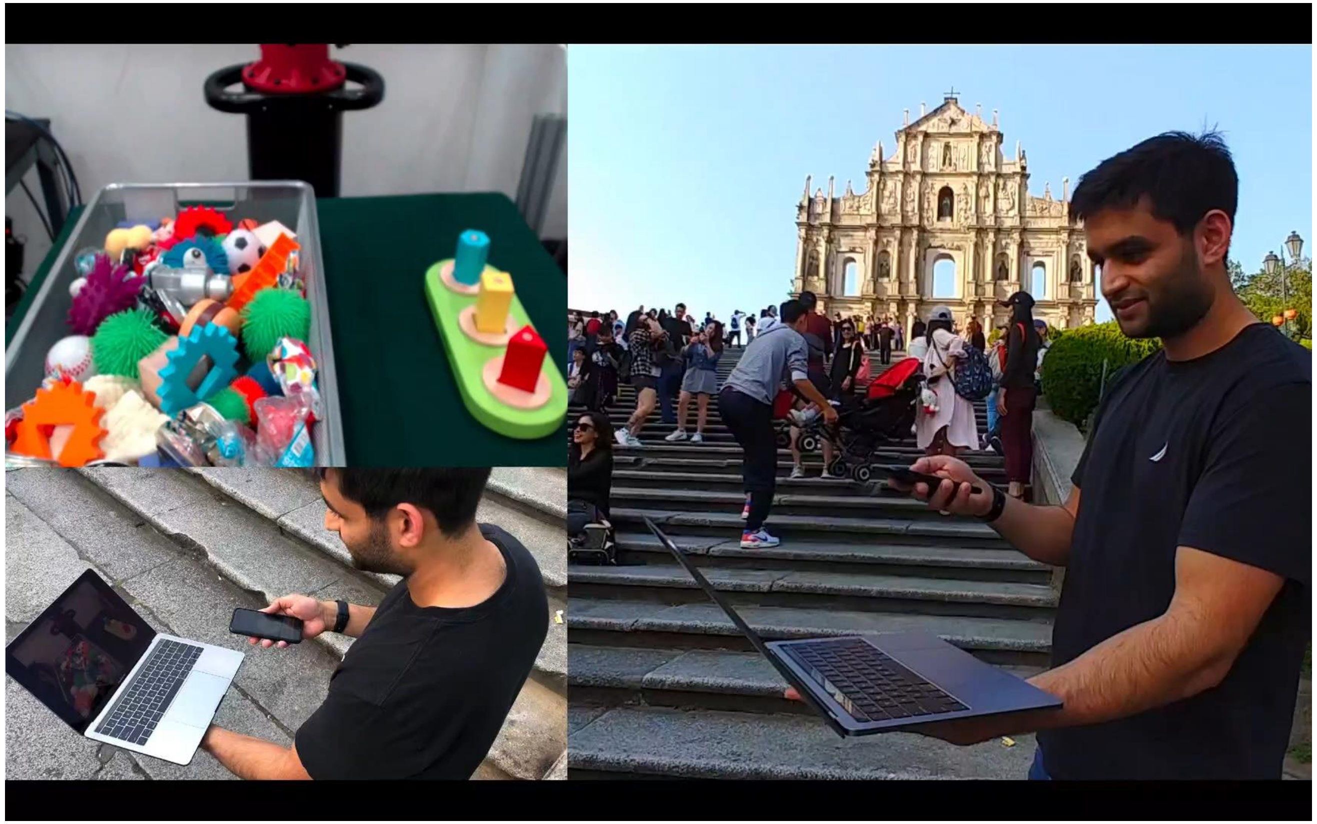
Watching Human Demonstrations





AVID: Learning Multi-Stage Tasks via Pixel-Level Translation of Human Videos. Smith et al., arXiv'20.

Demonstrations from Teleoperation



RotoTurk: https://roboturk.stanford.edu/realrobotdataset#dataset

Demonstrations from VR

- Use VR in teleoperation to generate demonstrations

Deep Imitation Learning for Complex Manipulation Tasks from Virtual Reality Teleoperation. Zhang et al., in arXiv'18.

Demonstrations from VR

https://techxplore.com/news/2017-11-startup-robots-puppets.html

TRI Robotics Example

TOYOTA
RESEARCH INSTITUTE

Summary

- Teleoperating robots with VR
- Robot learning with VR

Further Reading

- Section 13.3, Virtual Reality, Steven LaValle