Introduction to Course Project

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Quiz (10 pts)

- (5 pts) What is the difference between motion planning and obstacle avoidance?

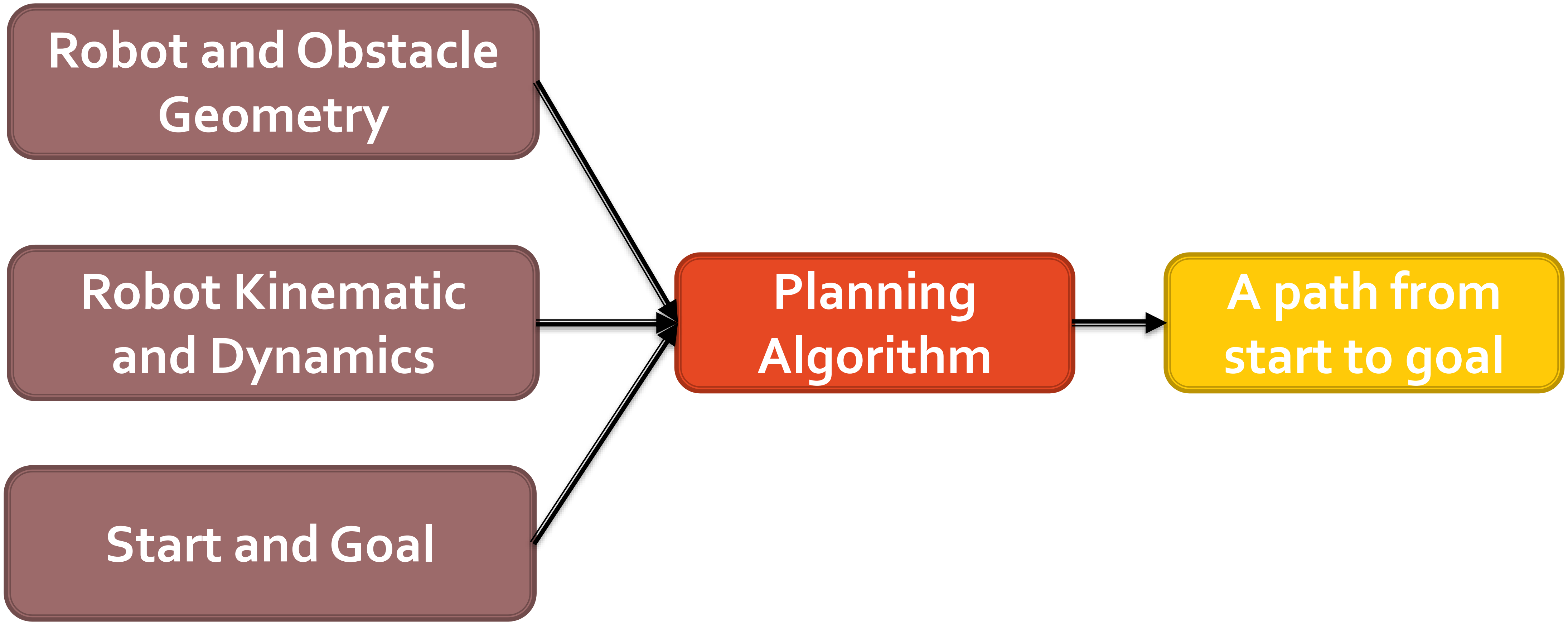
- (5 pts) Please describe the basic problem statement of motion planning – you can draw a graph to illustrate.

More than Obstacle Avoidance

- Path planning
  - Low-frequency, time-intensive search method for global finding of a (optimal) path to a goal
- Obstacle avoidance (aka "local navigation")
  - Fast, reactive method with local time and space horizon

- Distinction: Global vs. local reasoning

Basic Problem Statement

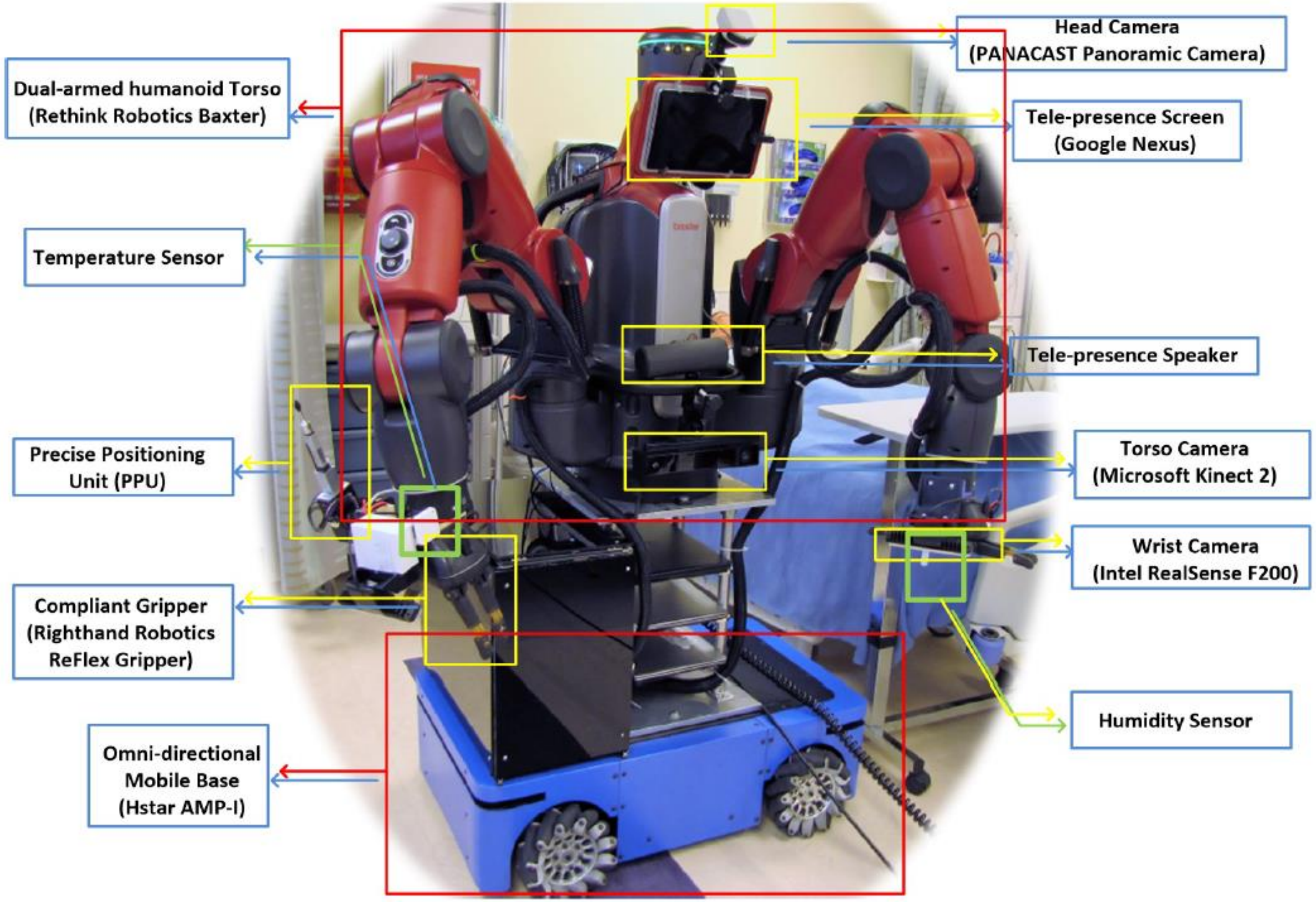


Overview

- Platform
- Course projects

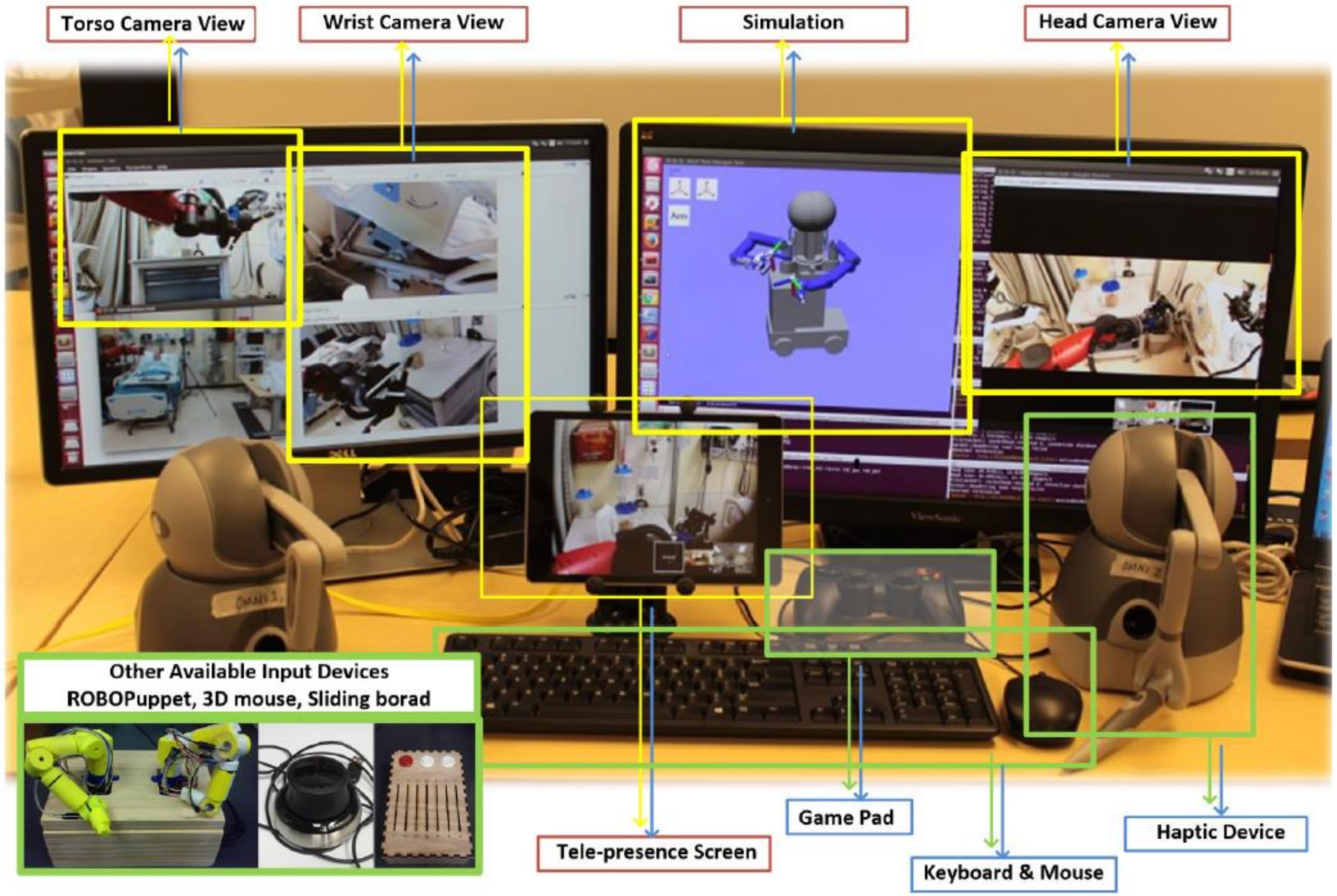
Tele-nursing robotic intelligent nursing assistant (TRINA)

- Major components
  - Baxter robot
  - Mobile base
  - Compliant grippers
  - 3D cameras



Operator Console

- Simulation mode
- Physical mode
- GUI
  - Various input devices
  - Multi-perspective camera views



Motion capture system

- Hardware
  - 10 cameras – Vero 2.2
  - Max frame rate = 330 Hz
  - Resolution 2048 x 1088 = 2.2 MP
  - Covered space = 17 ft X 21 ft
  - 8 on railing + 2 on ground (for closer view)
- Software
  - Nexus – human motion capture and analysis
  - Tracker – moving object tracking

Teleoperation of TRINA from Mocap System

Course Project

Overview

- Collaborative projects (5-6 students)
  - Mentored by me, TA and experienced students
  - Under-going Human-inspired robotics (HIRo) lab projects
- Small projects (1-2 students)
  - On the motion planning of surgical robots and swarm robots
  - In case you prefer working with fewer people

Successful projects needs ...

- Functional robot platform
  - Debugging hardware is a pain!
  - May be stuck by technical details of a software
- Experienced members in the team
  - Starting from sketch takes much longer time
- Commitment of every team members
  - Your project grade may be ruined if the team fall apart
- Healthy team dynamics
  - Your leader is knowledgeable, reasonable, and helpful
  - Your partners are trustworthy

How important your team can be

- A good project team means
  - Successful project outcome (30% of course grade)
  - High-quality group literature review (10% of course grade, as part of the assignment)
  - Help you study the course material and prepare for quiz

Make a wise decision when you start

- Find the team right for you
  - Project survey form allow you to fill in preferred teammates
  - Talk to project contact to see whether you like and project and have the right skill set
  - Talk to your classmates and find the ones you like to work with

- It may be a good idea to choose a small project
  - You have full control of the project progress
  - You can work at your comfortable pace

Project category

- Standard projects
  - Physical Human-robot interaction
  - Manipulation
  - Navigation
  - Motion coordination

- Small projects

Physical human-robot interaction (pHRI)

Human intent and object affordance

- Human intent
  - Gaze, body posture, motion, verbal communication

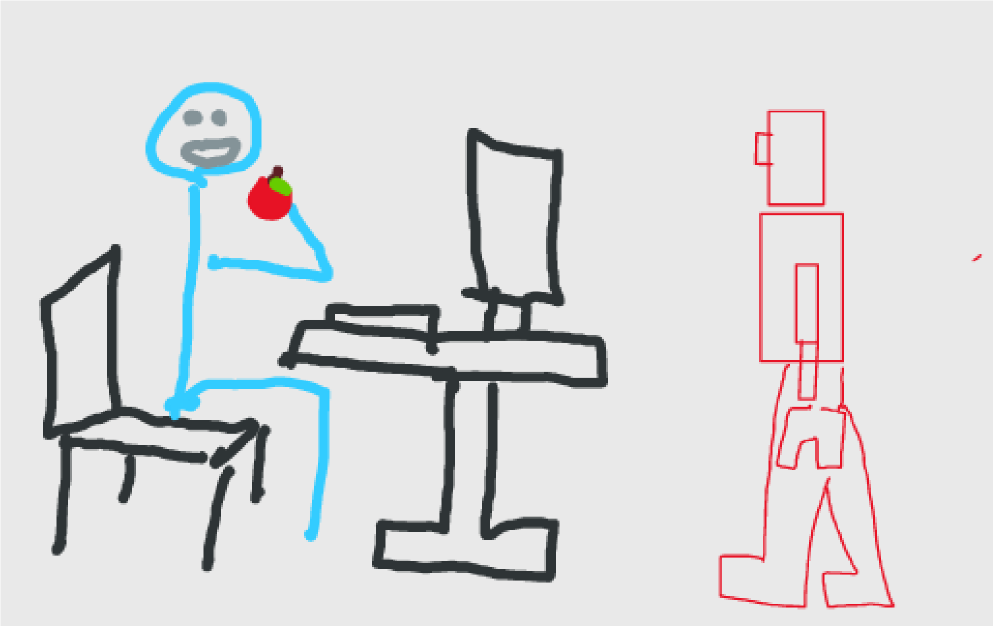
- Object affordance

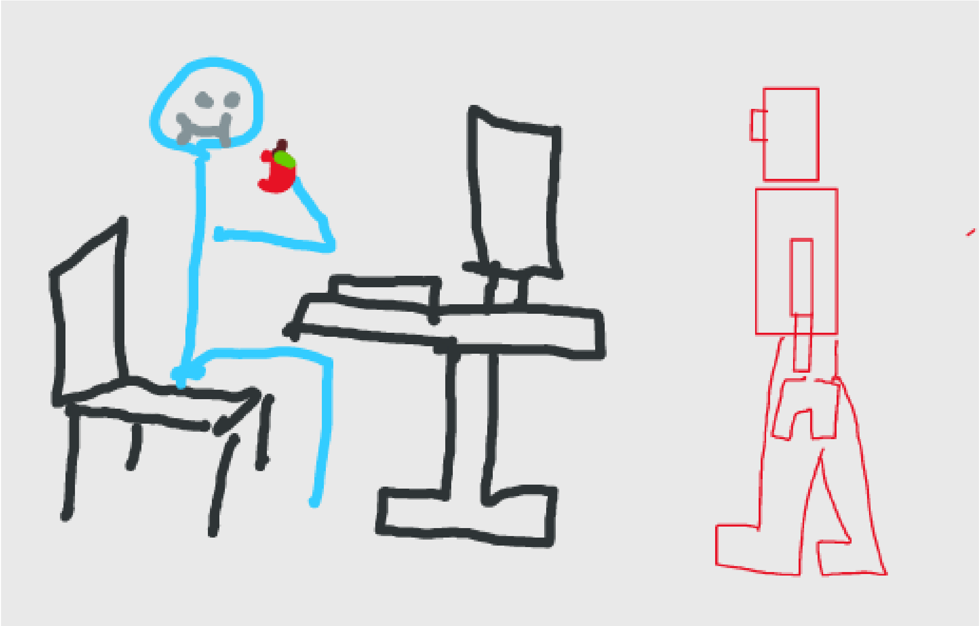
Not a trivial problem

- Goal
  - **Fluent** and **natural** human-robot object handing-over
- Human-robot object handing-over is not a trivial problem
  - Infer human intent
  - Identify object affordance
  - Planning feasible and natural motion
  - Handle exception

Example

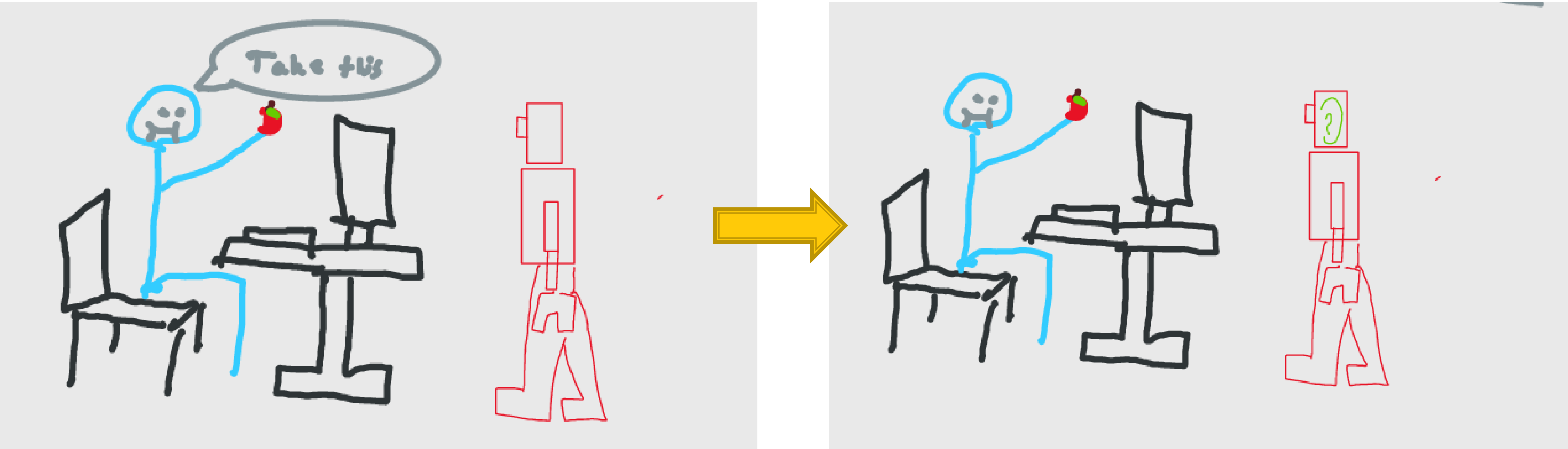
- Robot observing human manipulation





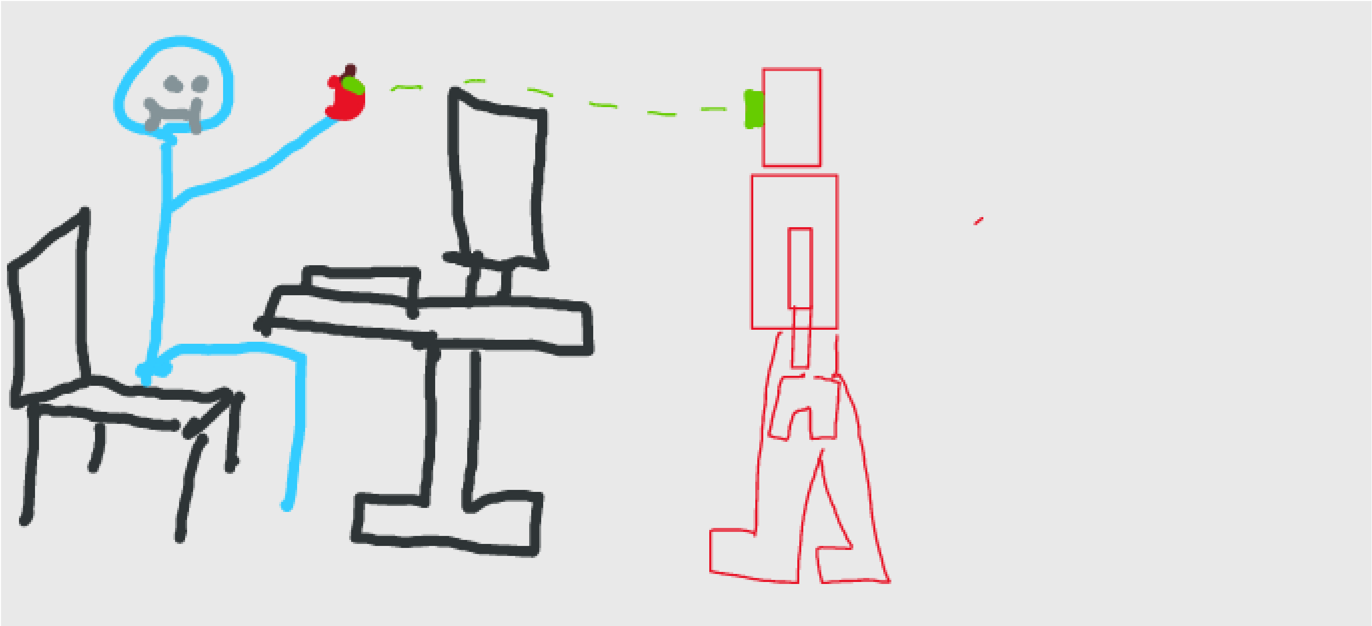
Example

- Communicate Intent



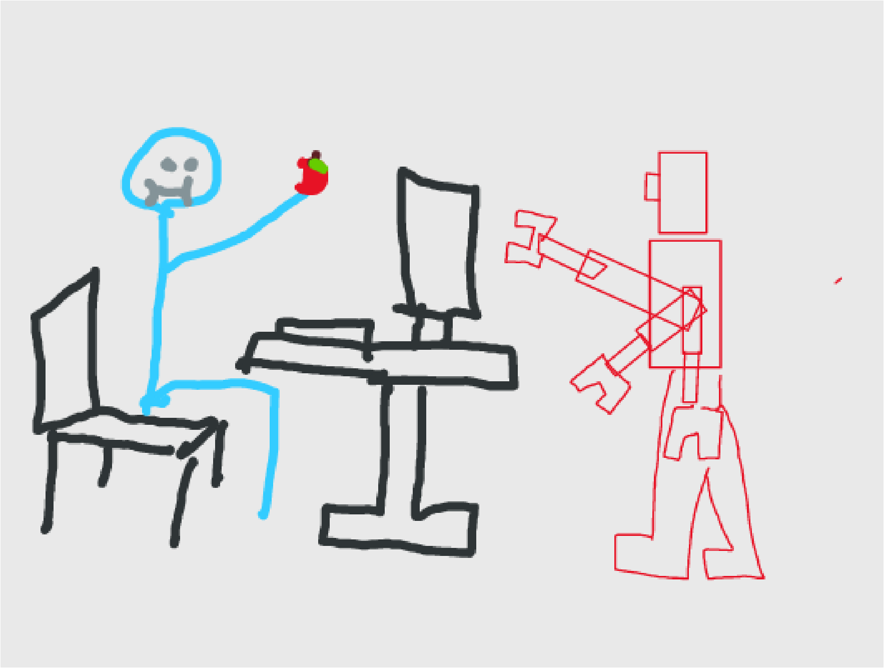
Example

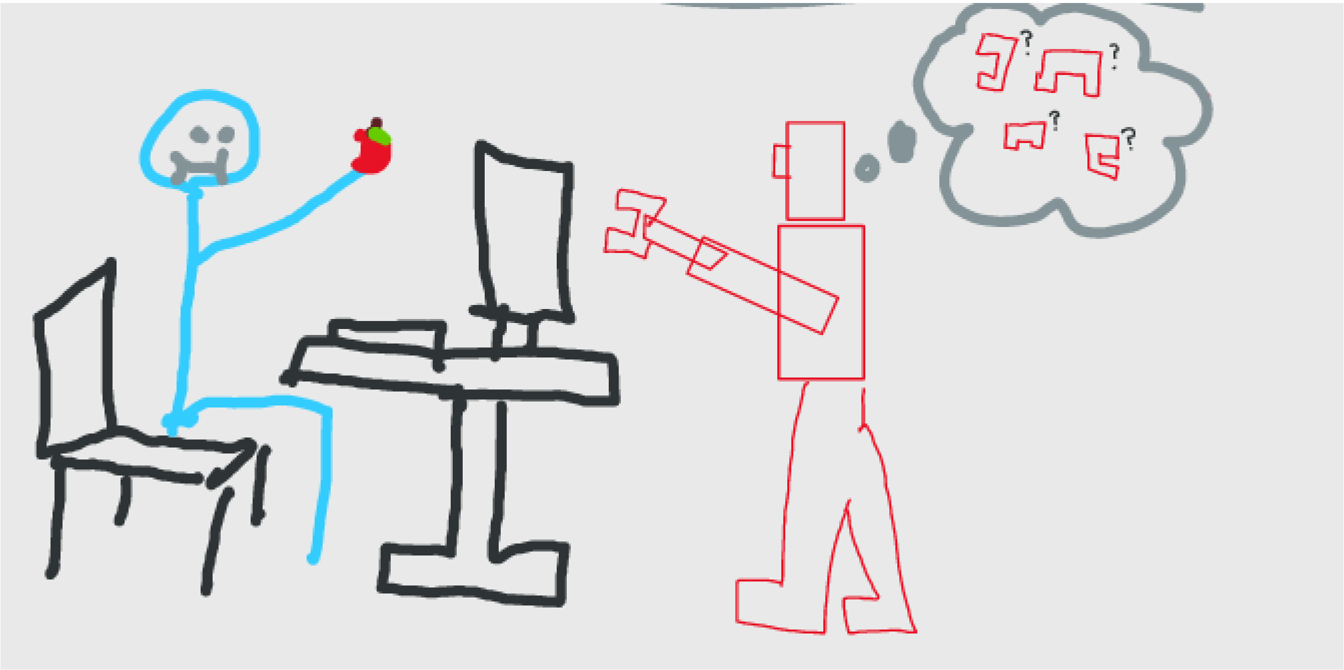
- Identifying and tracking object



Example

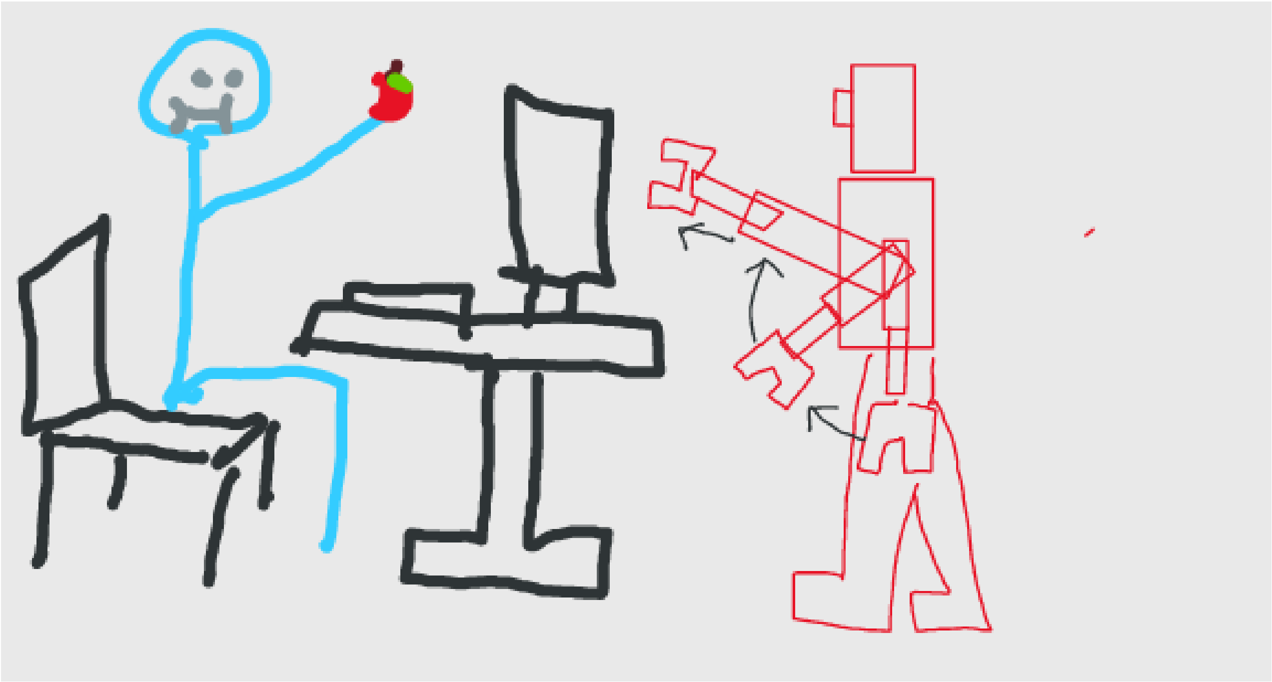
- Planning reaching and grasping





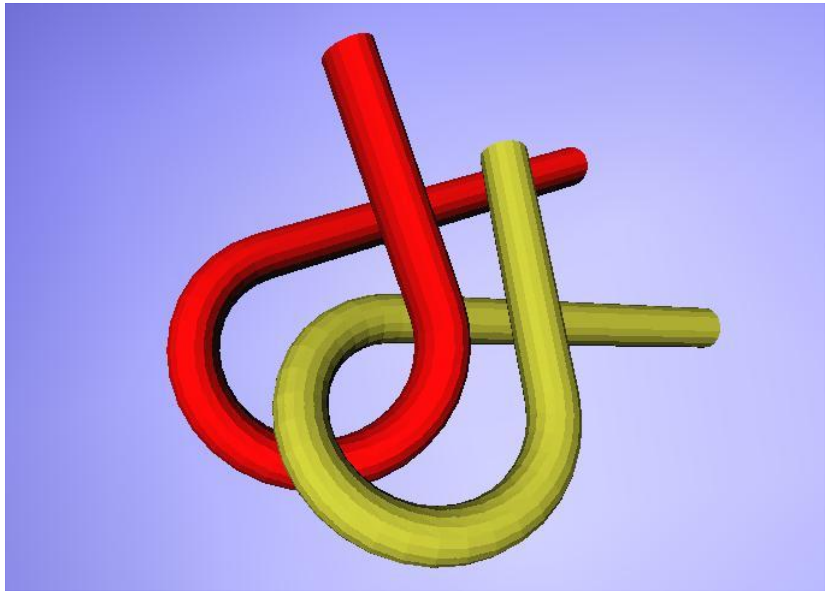
Example

- Trajectory control

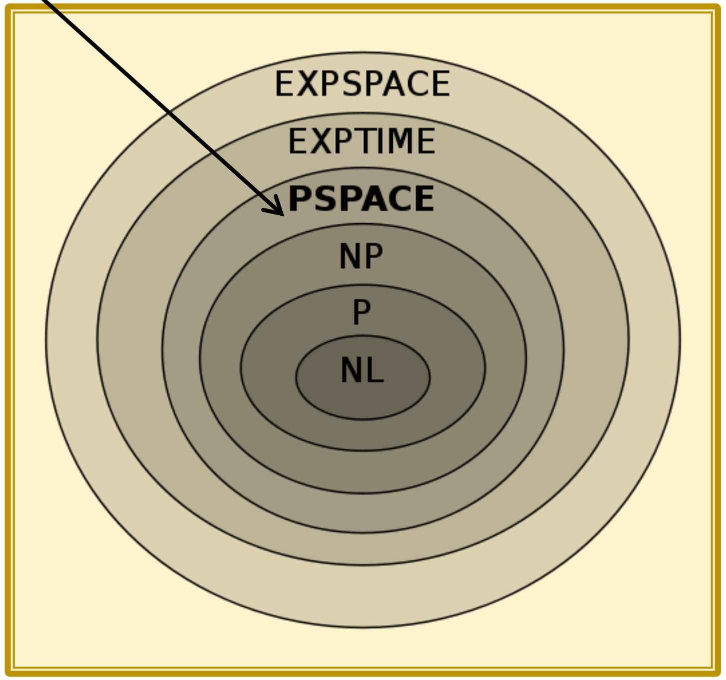


Example

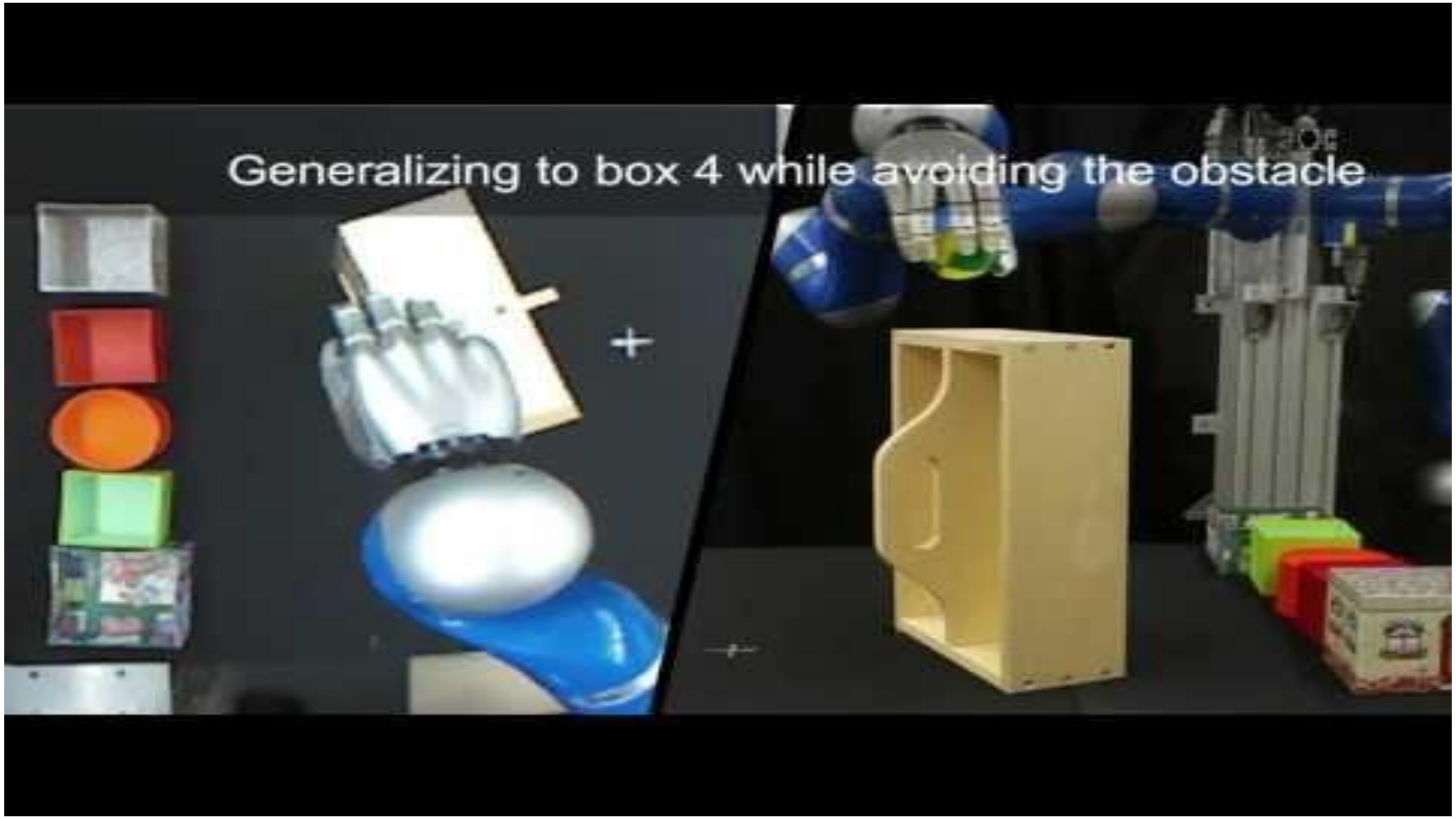
What if motion planning is too hard?



Basic Motion
Planning Problems



Combining motion planning with robot learning

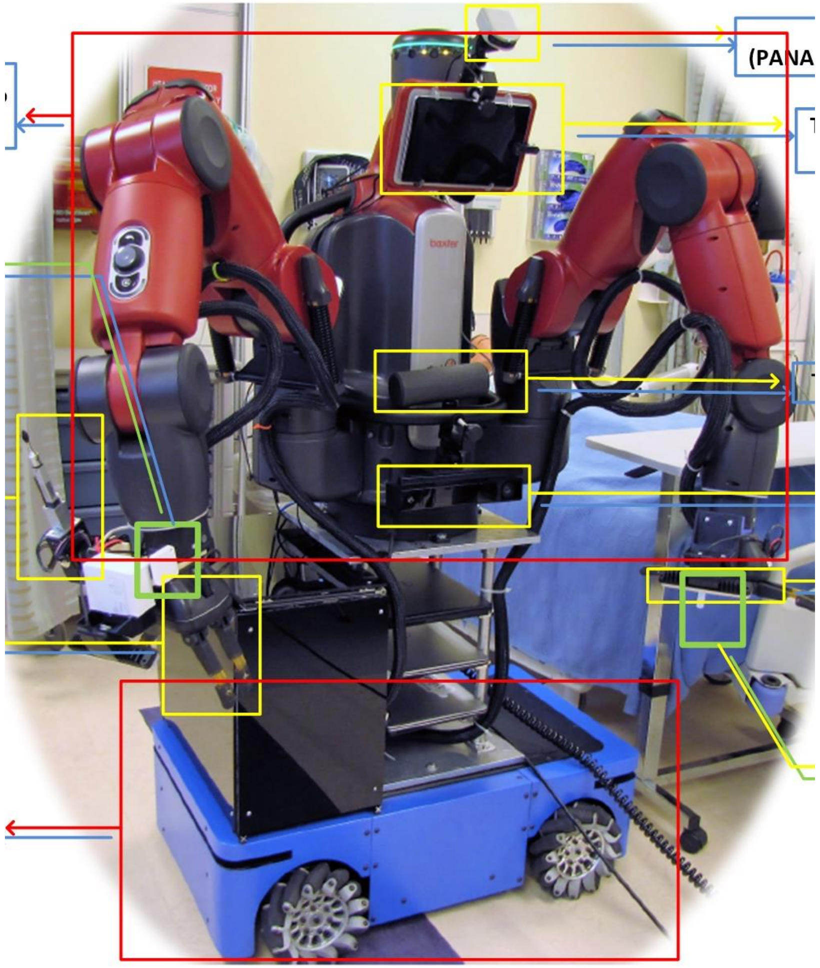


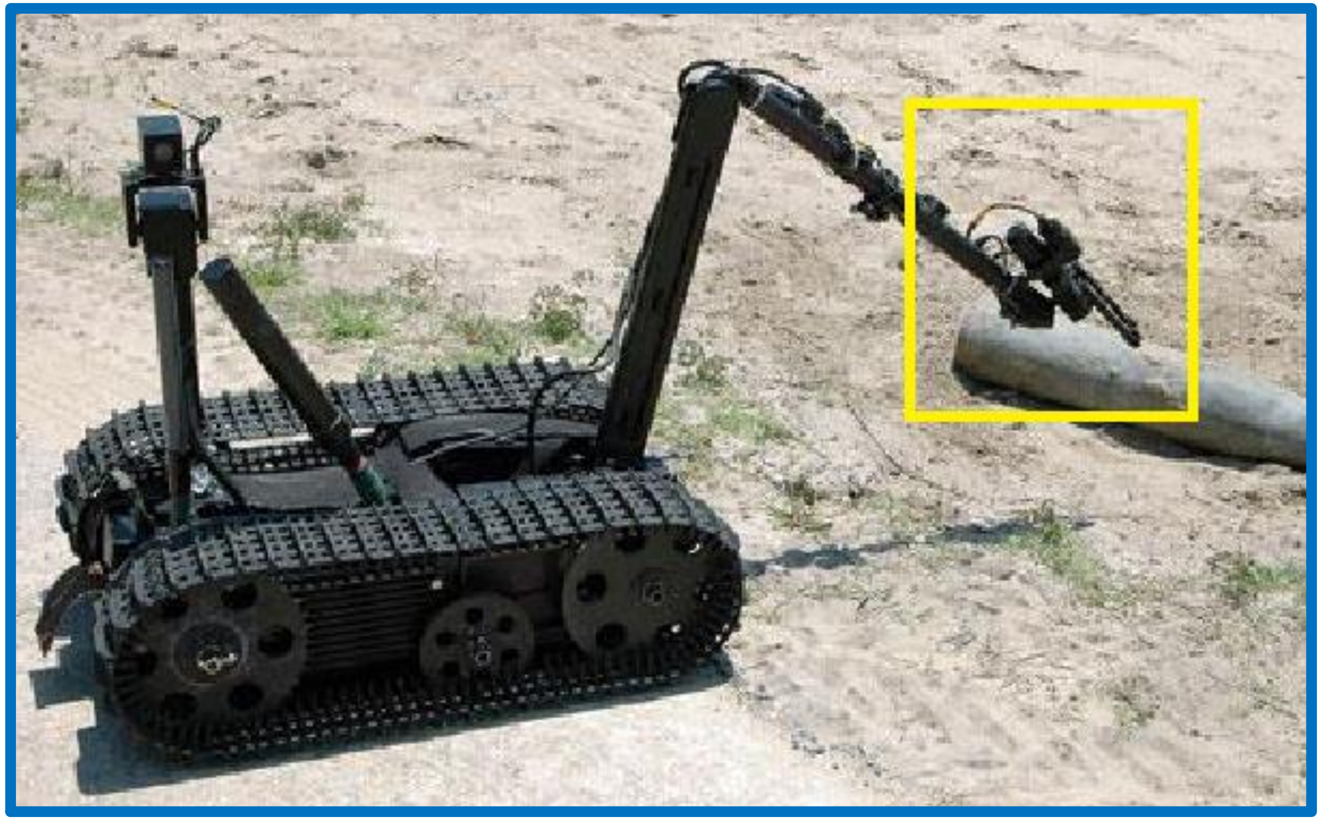
Project 1 – Coordinated motion of mobile manipulator nursing robot

- Project status
  - TRINA software allows direct teleoperation of mobile base

- Need to do
  - **Safe navigation** of omni-directional mobile base using LIDAR sensor
  - **Combining learning and motion planning** to determine when and how to move mobile base, to facilitate the manipulation task being performed
  - **Teleoperate** mobile base motion using mocap system (optional)

Coordinate manipulation end-effector with mobile manipulator





Project 1 – Coordinated motion of mobile manipulator nursing robot

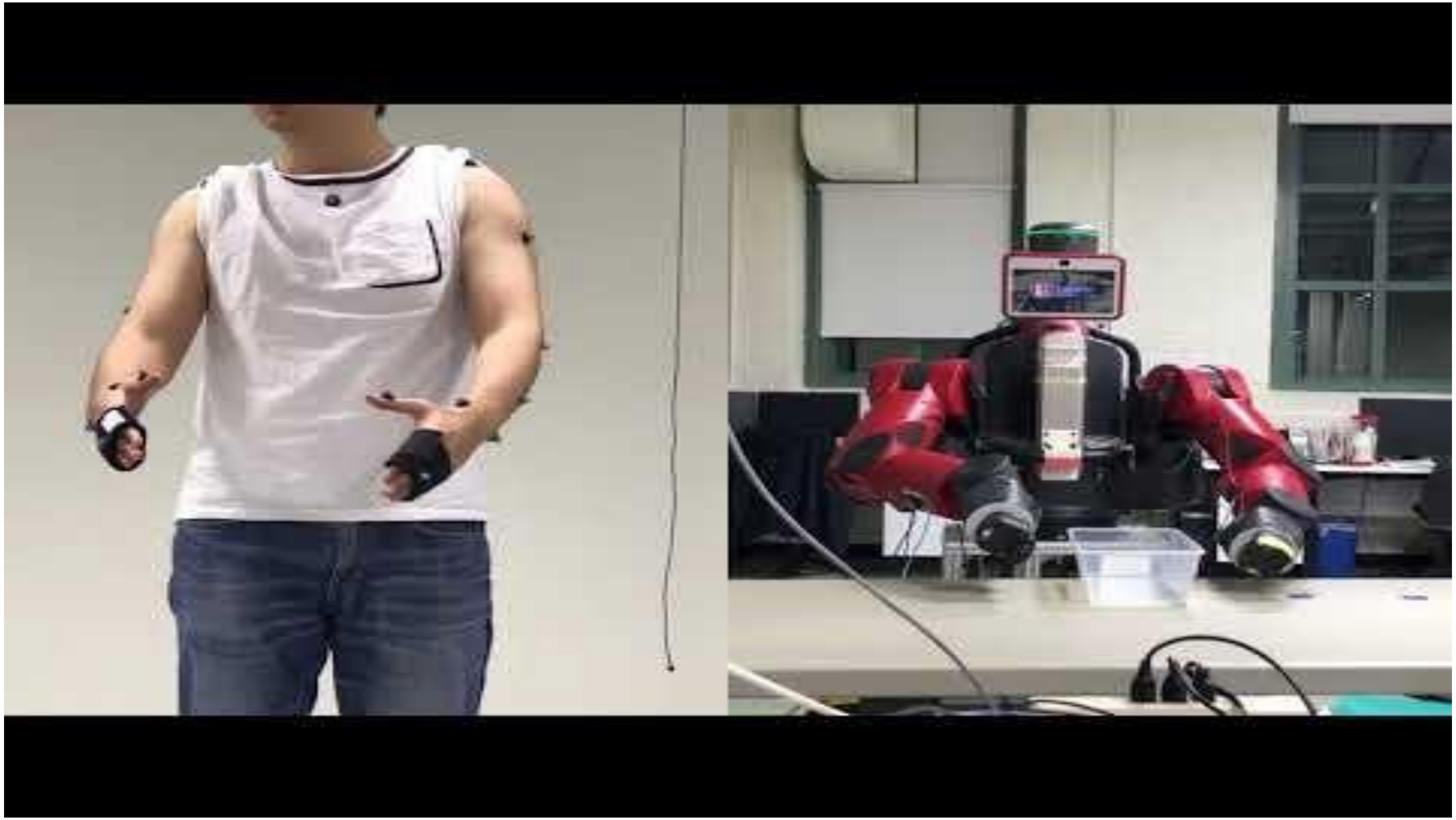
- Search for related work on
  - Mobile manipulator motion planning
  - Micro- and macro-structure coordination
- Project Contact
  - Sihui Li <sli16@wpi.edu>

Project 2 – Dexterous arm-hand and bimanual coordination

- Project status
  - TRINA software allows direct teleoperation of baxter robot arms and Reflex SF hand

- Need to do
  - Acquire object affordance by object identification and classification
  - Learning object affordance by observing human manipulation
  - Planning grasping motion based on object affordance

Project 2 – Dexterous arm-hand and bimanual coordination



Project 2 – Dexterous arm-hand and bimanual coordination

Project 2 – Dexterous arm-hand and bimanual coordination

- Search for related work on
  - Image processing for feature identification and object classification
  - Learning affordance from demonstration
  - Grasping planning for compliant gripper
- Project Contact
  - Yudong Yu <yyu6@wpi.edu > for using motion capture system
  - Sihui Li <sli16@wpi.edu> for setting up teleoperation of TRINA from mocap to perform bimanual reaching motion

Project 3 – Dexterous manipulation of multi-fingered robot hands

Project 3 – Dexterous manipulation of multi-fingered robot hands

Project 3 – Dexterous arm-hand and bimanual coordination

- Project status
  - TRINA software allows direct teleoperation of Baxter robot and Reflex SF hand

- Need to do
  - Plan coordinated reaching and grasping motion
  - Combine motion planning with learning reach-to-grasp motion from teleoperation

Project 3 – Dexterous arm-hand and bimanual coordination

- Search for related work on
  - Coordination of grasping with reaching
  - Grasping planning and learning for compliant gripper

- Project Contact
  - Duong Nguyen <dnguyen2@wpi.edu> - for ReFlex SF hand motion control and CaptoGlove

Project 4 – pHRI based human intent prediction and object affordance

- Project status
  - Setting up teleoperation of Baxter robot and Reflex SF hand
  - Preliminary work on
    - Phase estimation of physical human-robot interaction
    - Using Kinect for human skeleton and object tracking
- Need to do
  - Inference of human intent from gaze, body posture and etc.
  - Learning task and object affordance

Project 4 – pHRI based human intent prediction and object affordance

- Search for related work on
  - Human intent detection and inference
  - Human-robot handing over

- Project contact
  - Gunnar Horve (TA) <gchorve@wpi.edu>
  - Heramb Nemlekar <hsnemlekar@wpi.edu>
  - Max Merlin <mtmerlin@wpi.edu>

Project 5 – High-level motion planning in physical human-robot interaction

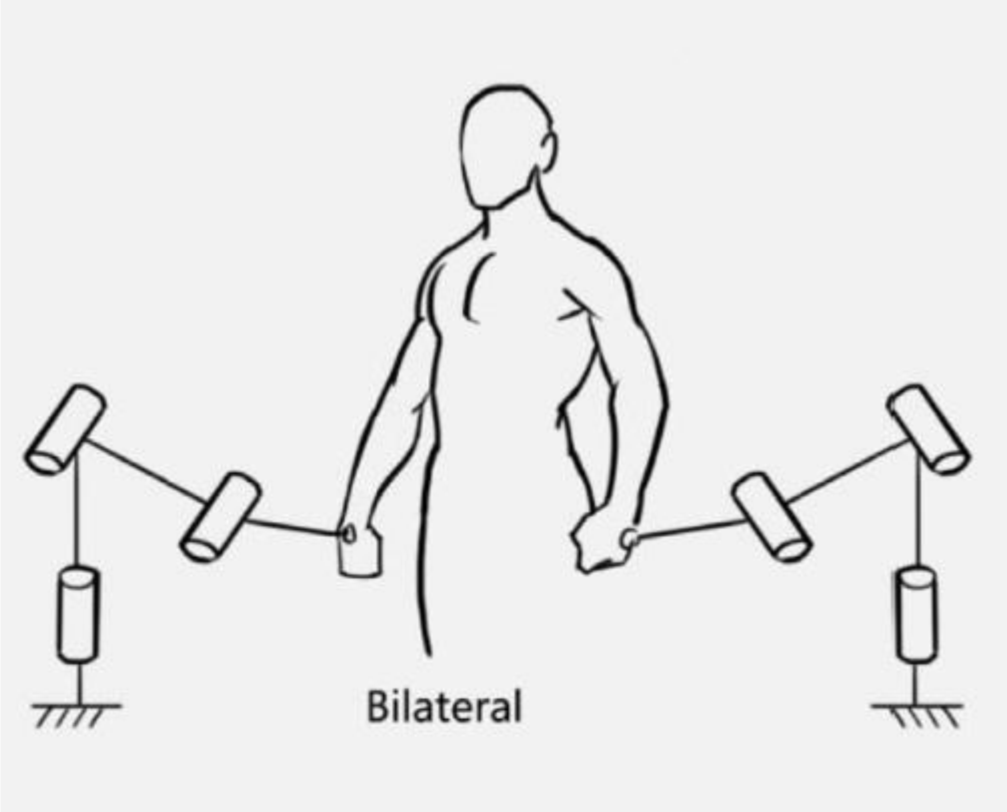
- Project status
  - Setting up teleoperation of Baxter robot and Reflex SF hand
  - Preliminary work on algorithms on learning motion primitives
- Need to do
  - Learning low level motion primitives from demonstration
  - High-level modeling and planning of human-robot handing-over

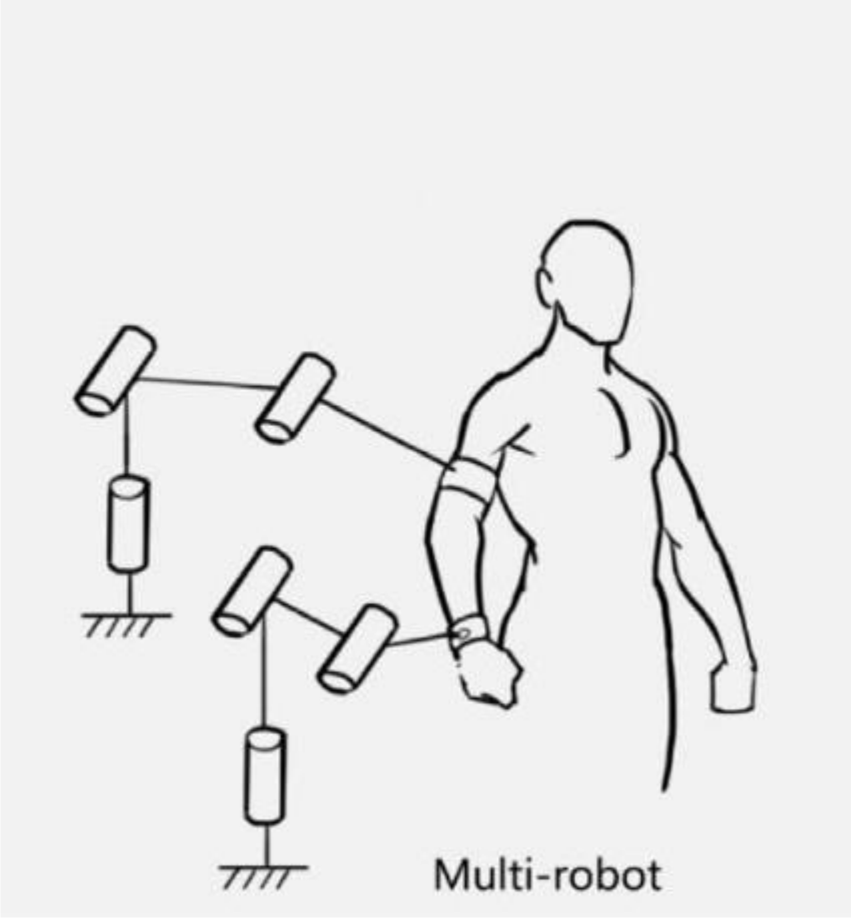
Project 5 – High-level motion planning in physical human-robot interaction

- Search for related work on
  - Learning dynamic movement primitives
  - Learning motion plan

- Project contact
  - Gunnar Horve (TA) <gchorve@wpi.edu>
  - Heramb Nemlekar <hsnemlekar@wpi.edu>
  - Max Merlin <mtmerlin@wpi.edu>

Project 6 – Online motion planning in dynamic virtual environment

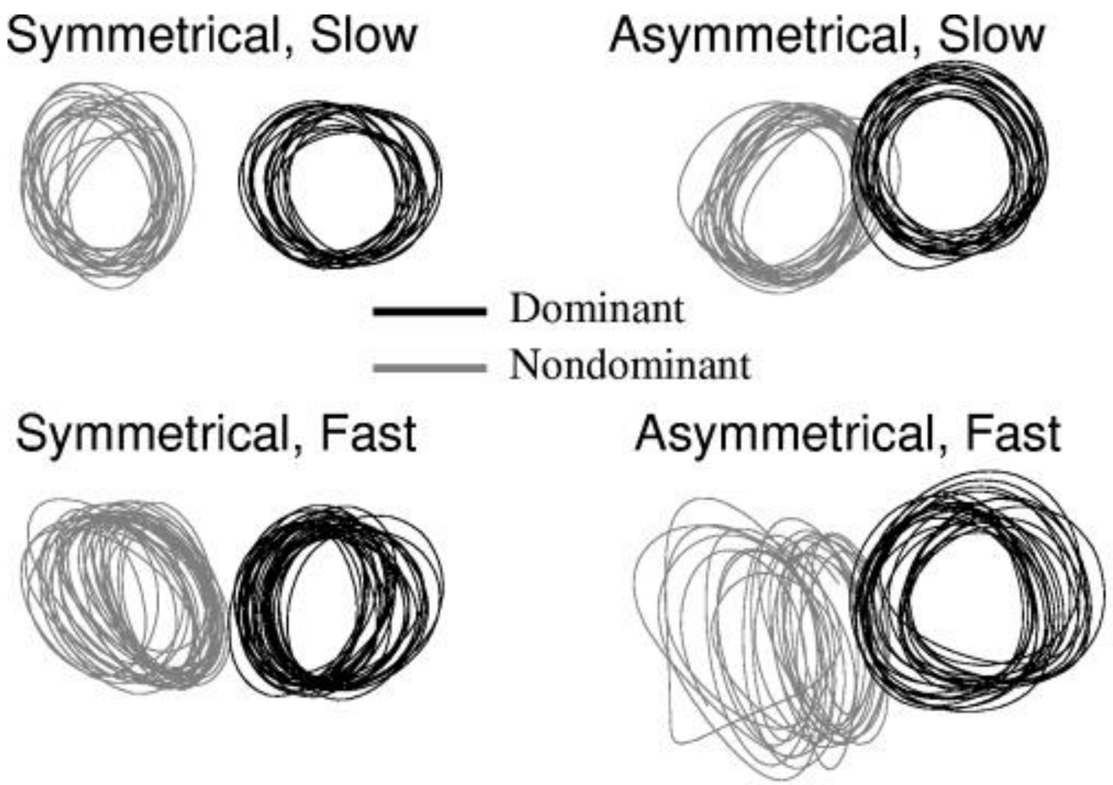


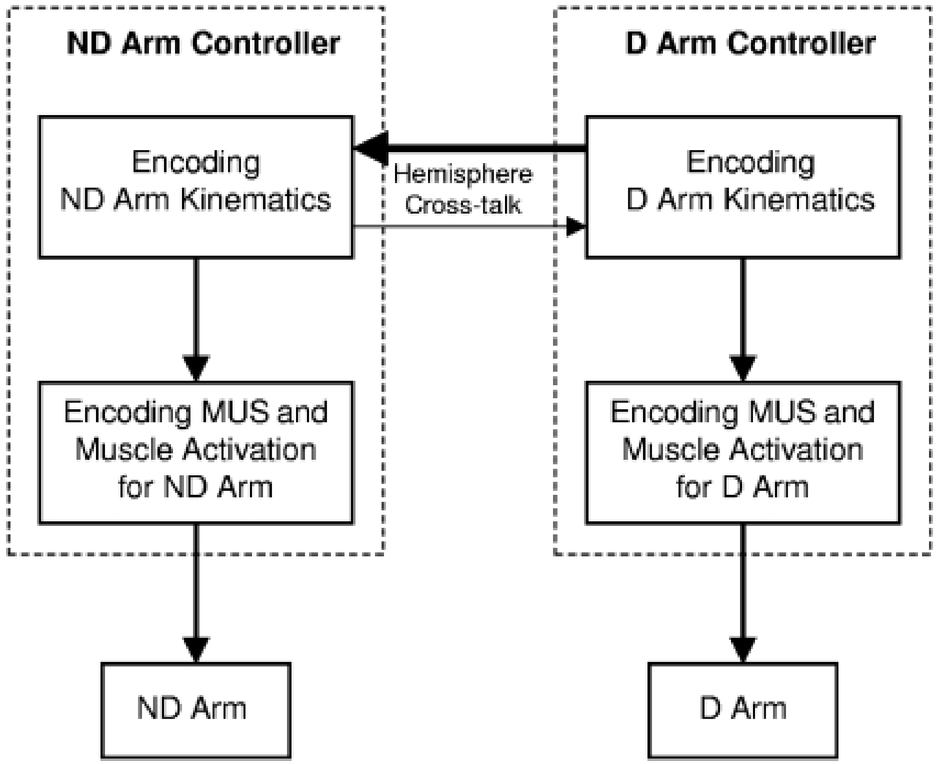


Background –Robot-assisted stroke rehabilitation

Background – Bilateral training for stroke rehabilitation

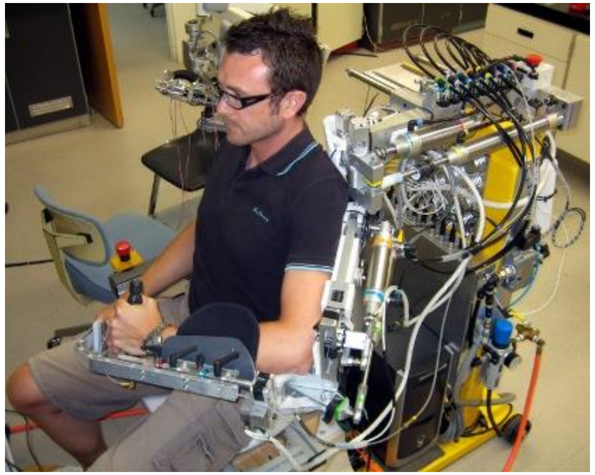
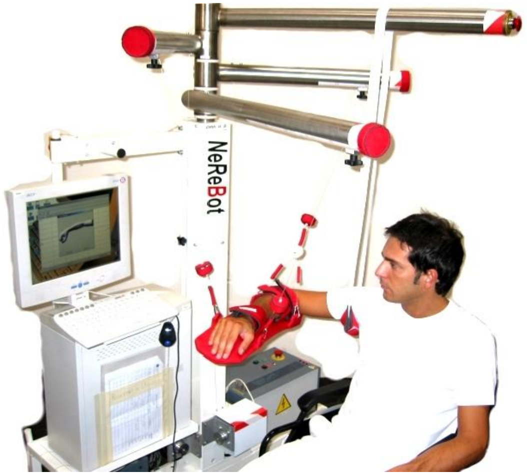
- Inter-arm coupling due to cross-hemisphere talk



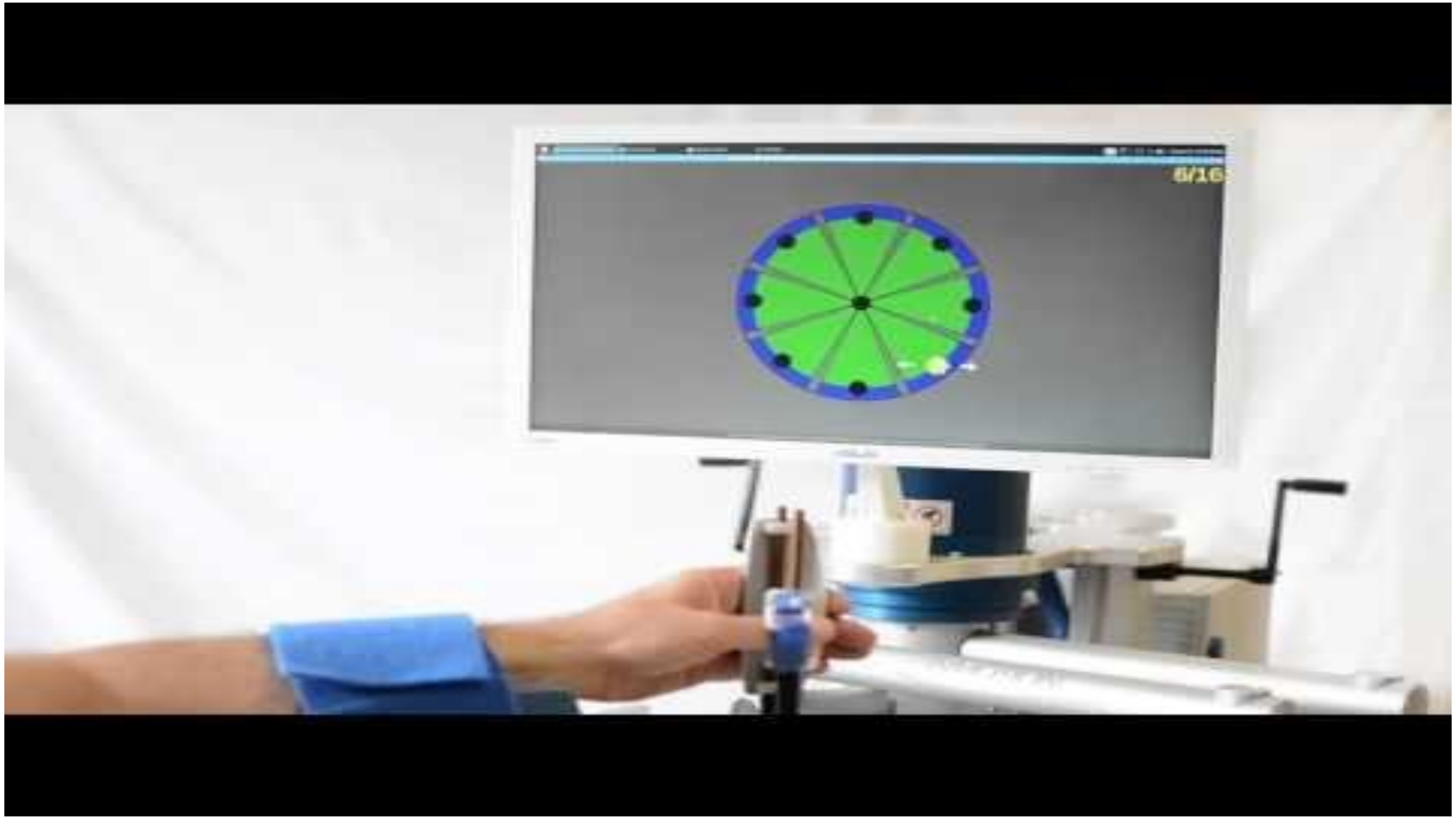


Background – Upper limb Rehabilitation Robots

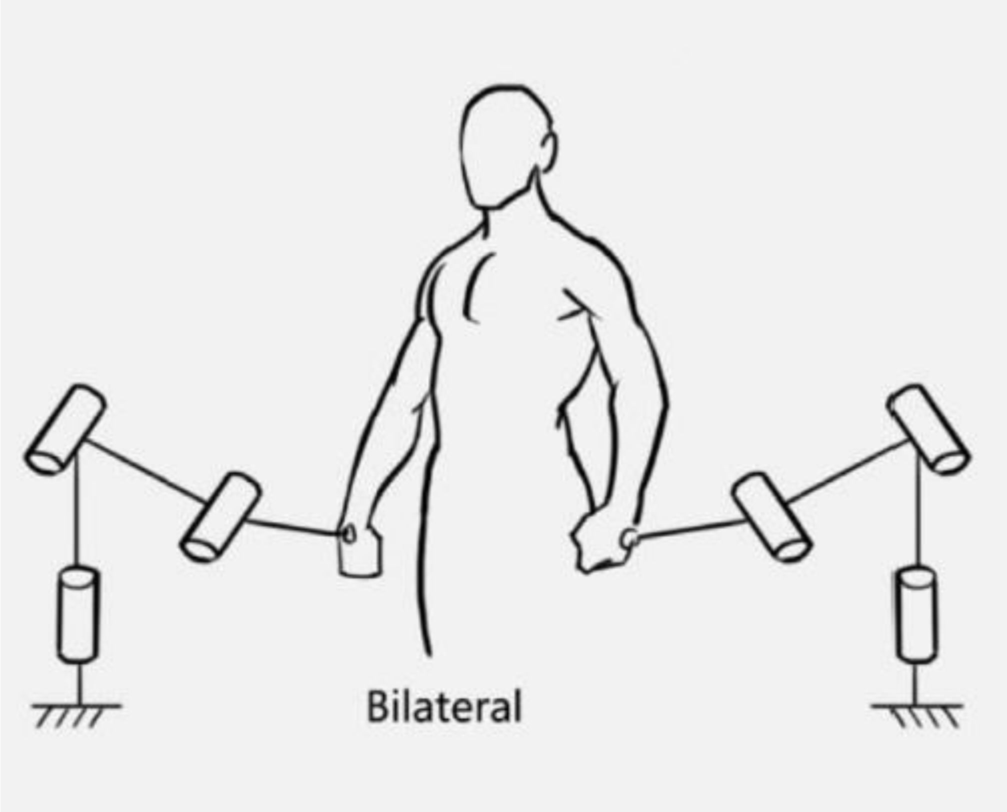


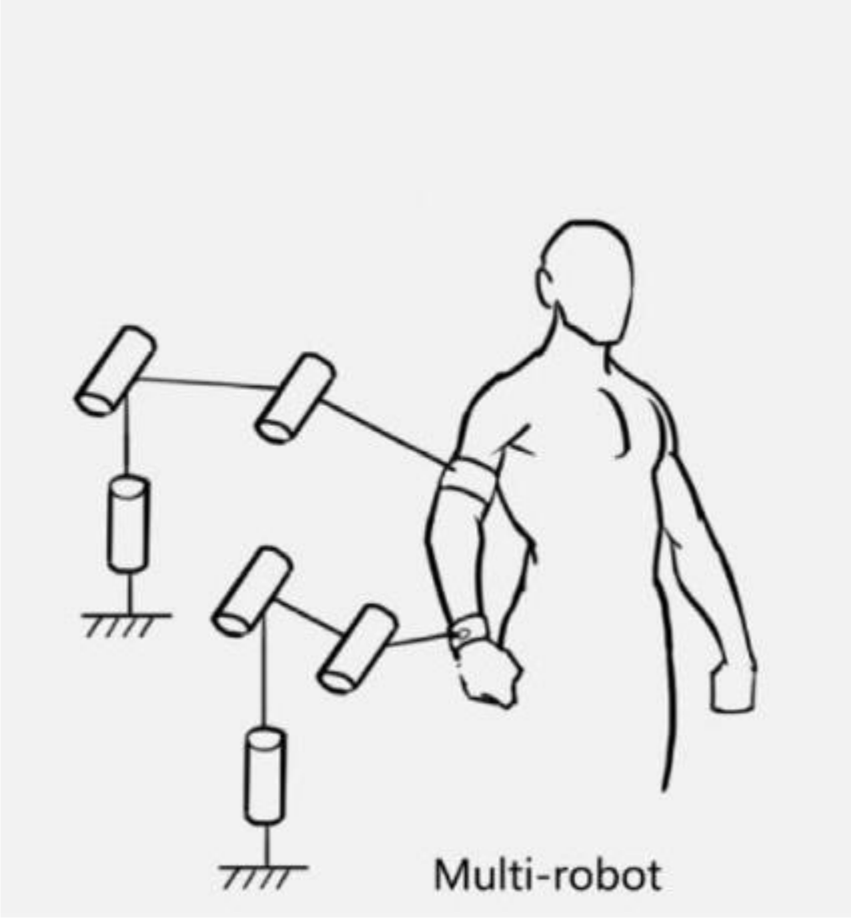




Integrated Rehabilitation System

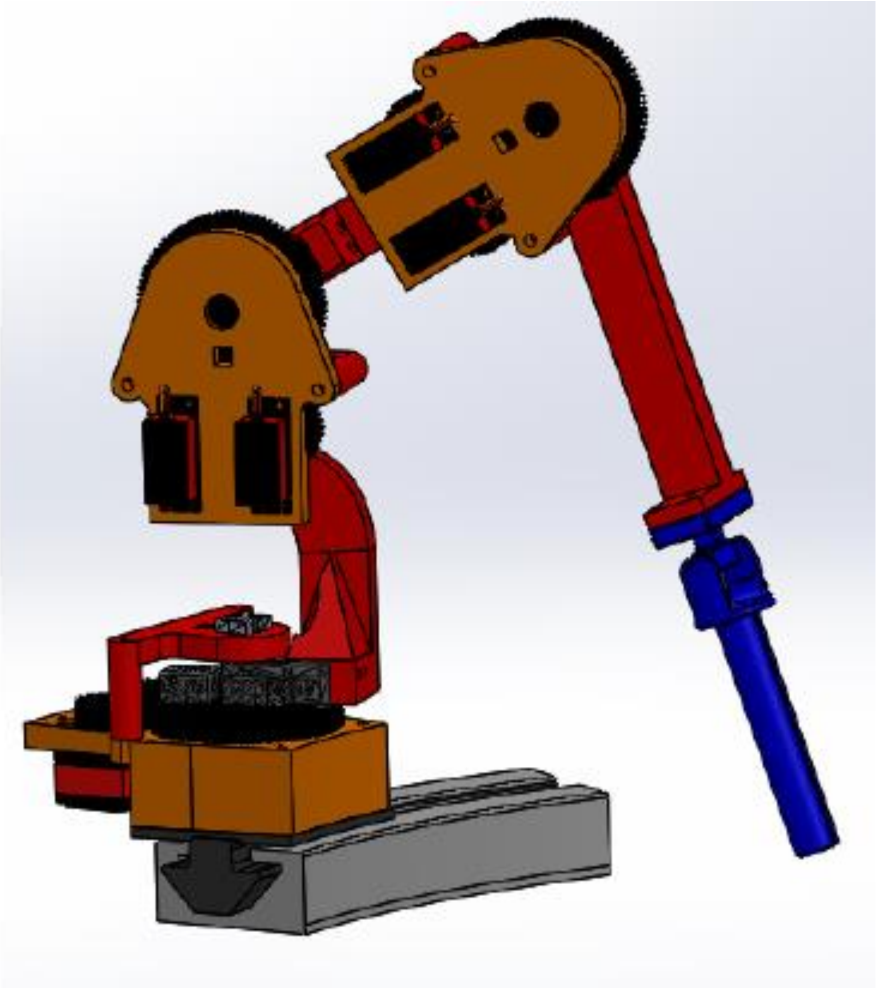


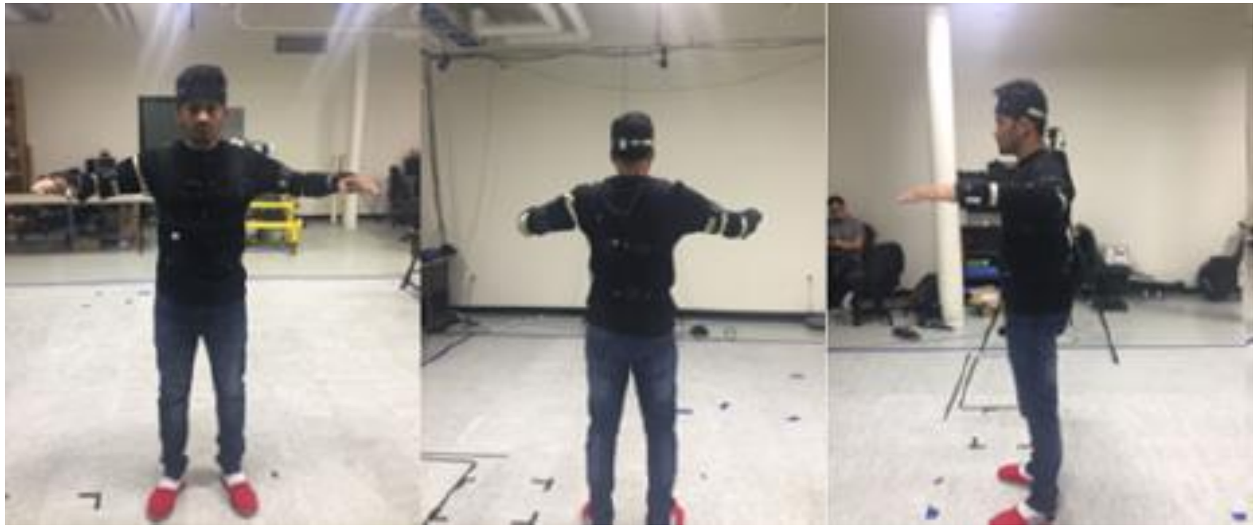
Development of highly-adaptive, low-cost home-based stroke rehabilitation system

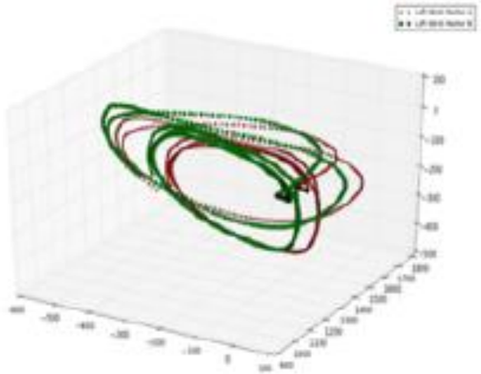




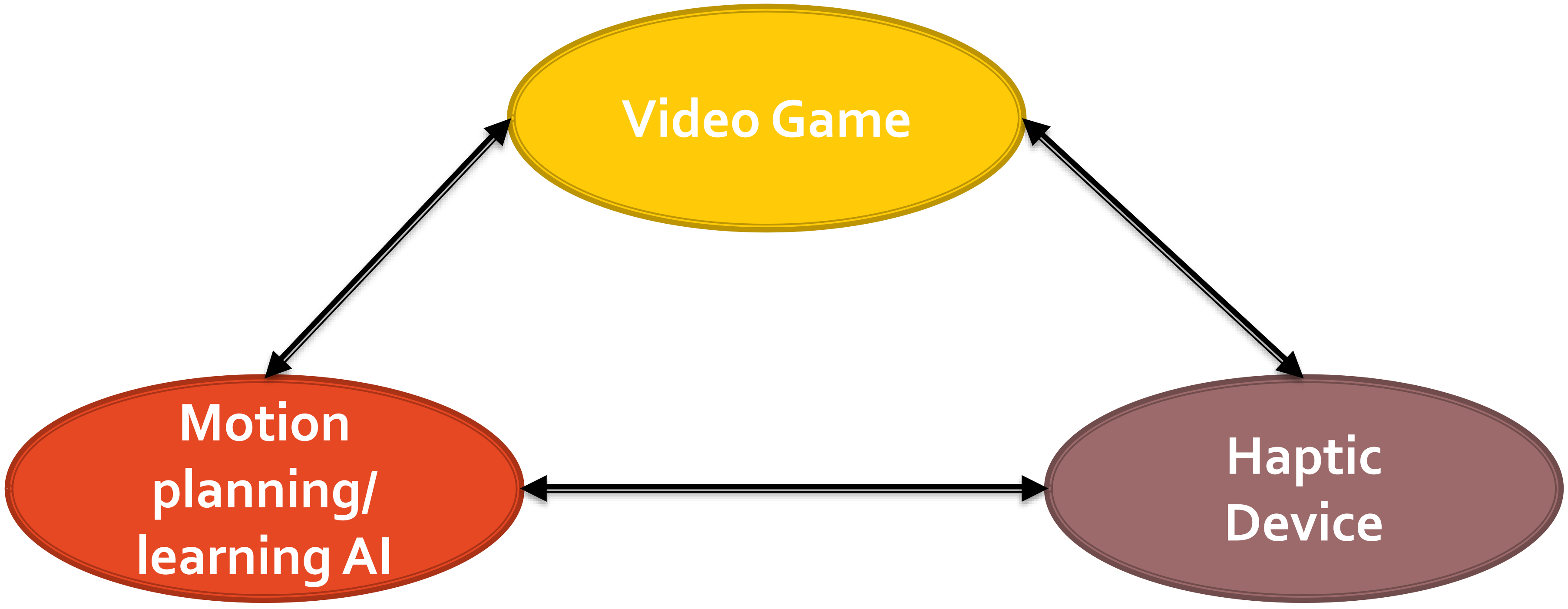
Preliminary work







Project 6 – Online motion planning in dynamic virtual environment

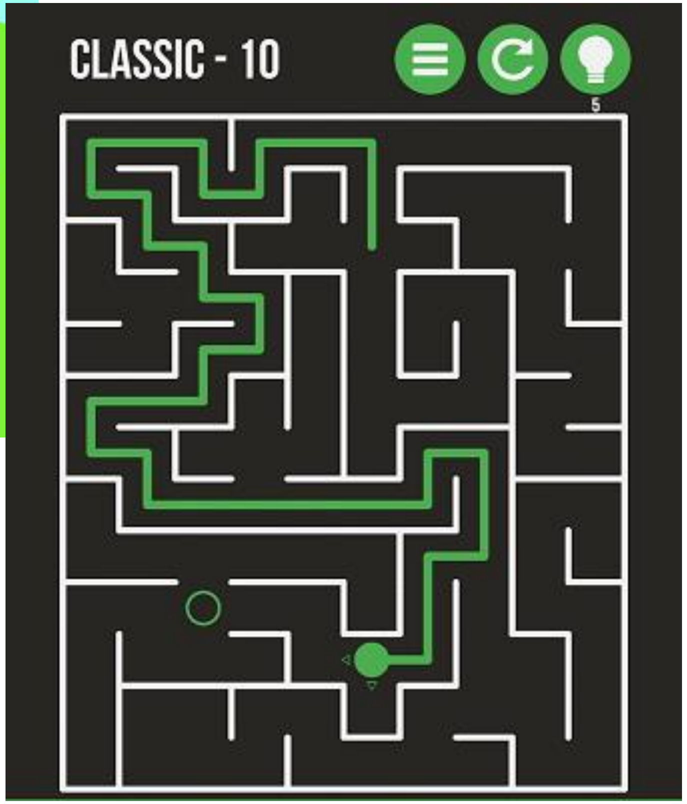


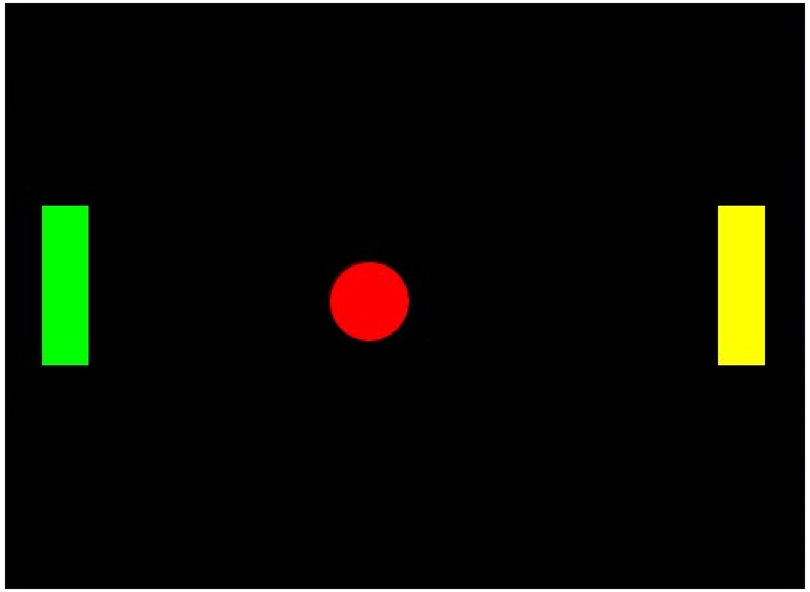
Project 6 – Online motion planning in dynamic virtual environment

- Project status
  - Build a pair of 3-DOF haptic devices
  - Interface with Pong game for bilateral rehabilitation

- Need to do
  - Develop AI for motion planning
  - Use motion learned from healthy arm to evaluate planned motion
  - Generate assistive force to guide the stroke arm

Planning motion in multi-agent, highly-dynamic virtual environment





Interesting questions

- How to create an AI that can play interactive video game?
- Can the AI-planned motion match natural human behavior?
- Can stroke patients recover faster by playing these games?

Project 6 – Online motion planning in dynamic virtual environment

- Project Contact
  - Nathaniel Goldfarb < nagoldfarb@wpi.edu >
  - Alexandra Valiton < arvaliton@wpi.edu >
  - Rishi Khajuriwala < rdkhajuriwala@wpi.edu >

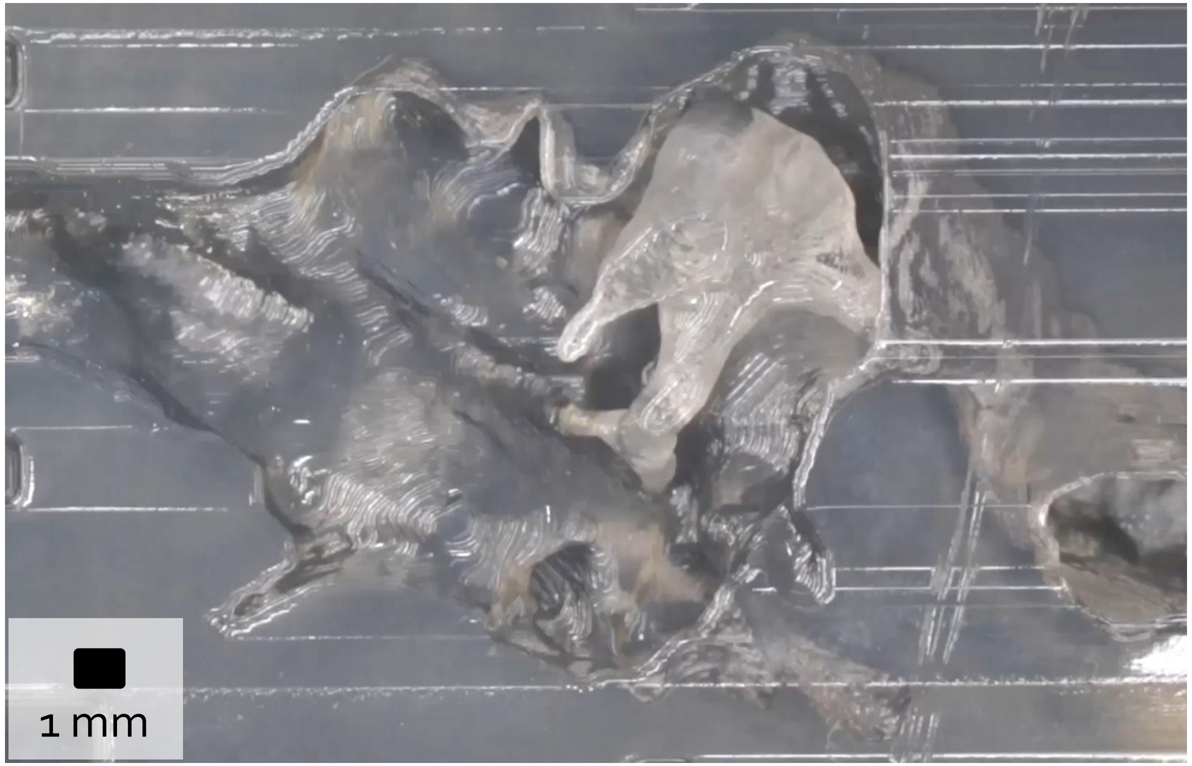
- Project presentation
  - Speaker: Nathaniel Goldfarb (PhD)
  - Jan 18, at Gatepark 1002

Small projects

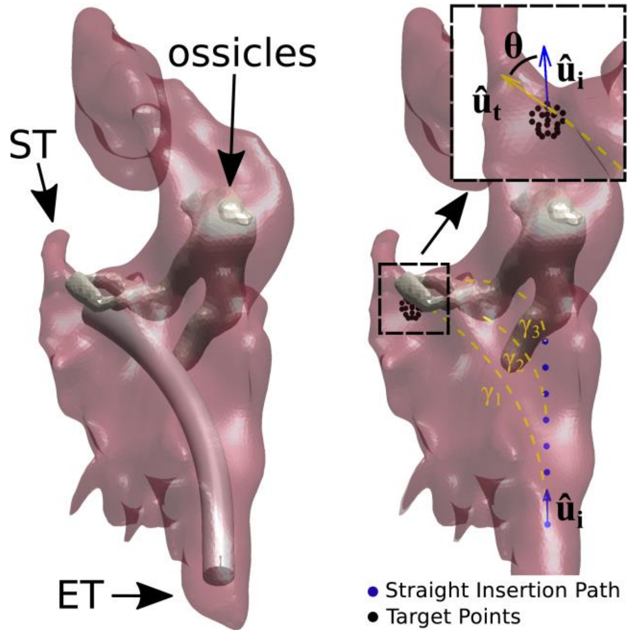
Coordinated swarm robot navigation (Small)

- Project description
  - Plan the coordinated motion of swarm robots that collaboratively move an object
- Question
  - How to coordinate swarm robots to follow a trajectory?
  - Can robot join and leave?
  - What if the object is deformable?
- Mentor
  - Prof Carlo Pinciroli < cpinciroli@wpi.edu >

Path planning for a continuum surgical robot (Small)



Continuum robotic probe inserted into an ear model



Planning the insertion into the ear cavity

Path planning for a continuum surgical robot (Small)

- Goals
  - Implement sampling-based path planning (RRT)
  - Implement obstacle detection to avoid collision with anatomical structures
  - Estimate the robot's reachable workspace by generating a high number of motions
- Required skills
  - Strong Matlab programming skills
  - Familiarity with robot kinematics and frame transformations
- Mentor
  - Prof Loris Fichera < lfichera@wpi.edu >

Important

- Project workshop held in lab today during office hour
  - 2-3 pm Today, CIBR lab at 85 Prescott
  - Talk to me, TA, and project contacts to get more information

- File your project selection form by Friday (Jan 19) noon
  - Talk to your classmates to find good teammates
  - You can always update your form before submission deadline

End

A hard problem