Introduction to Robotic Manipulation

Session 1

Todays Agenda

Course Introduction

Staff Introduction

Logistics

The Mechanics of Manipulation

Course Objectives

Introduction to Robotic Manipulation

- Fundamentals
- Modern research lines

Exposure to important concepts in:

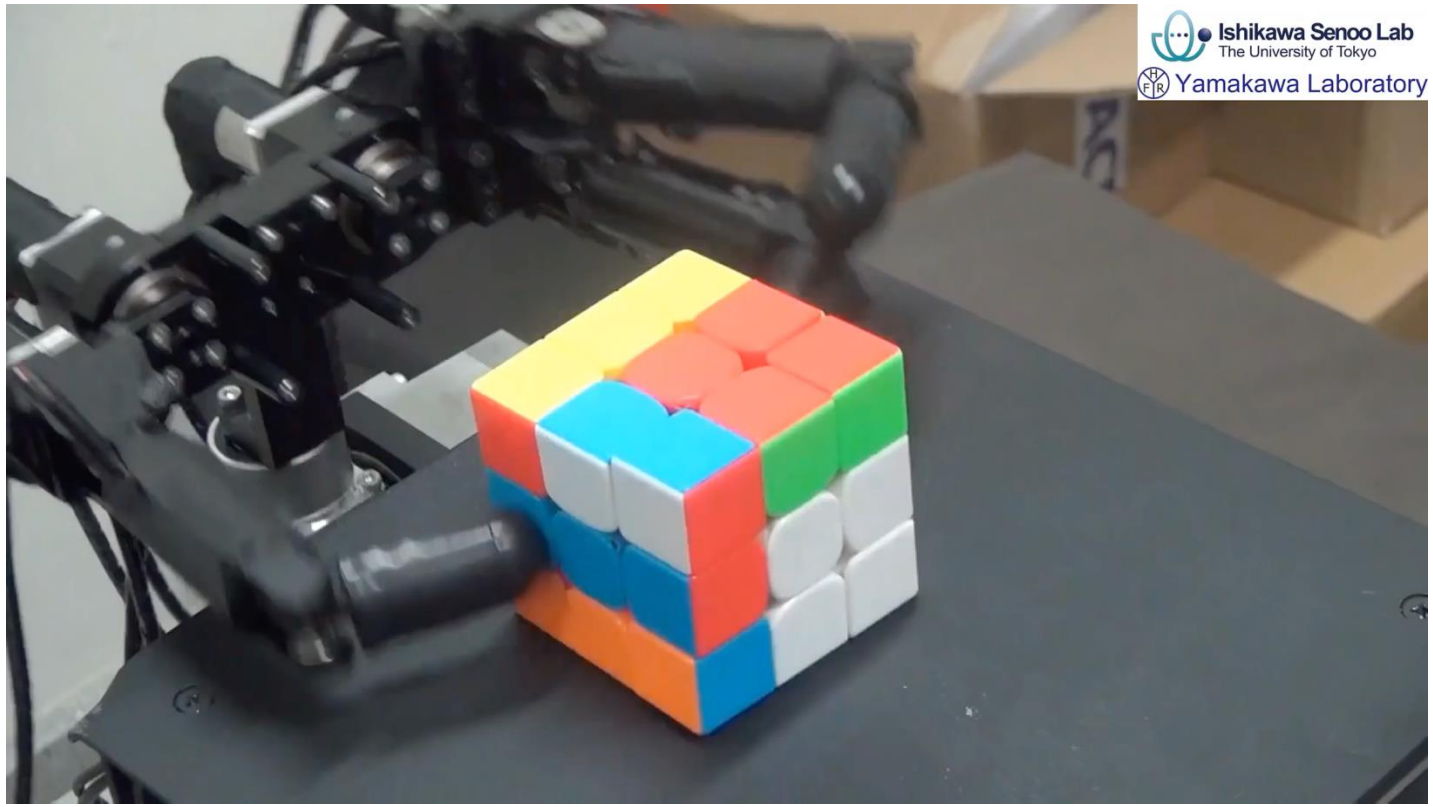
- Modeling
- Controls
- State-estimation
- Planning/AI

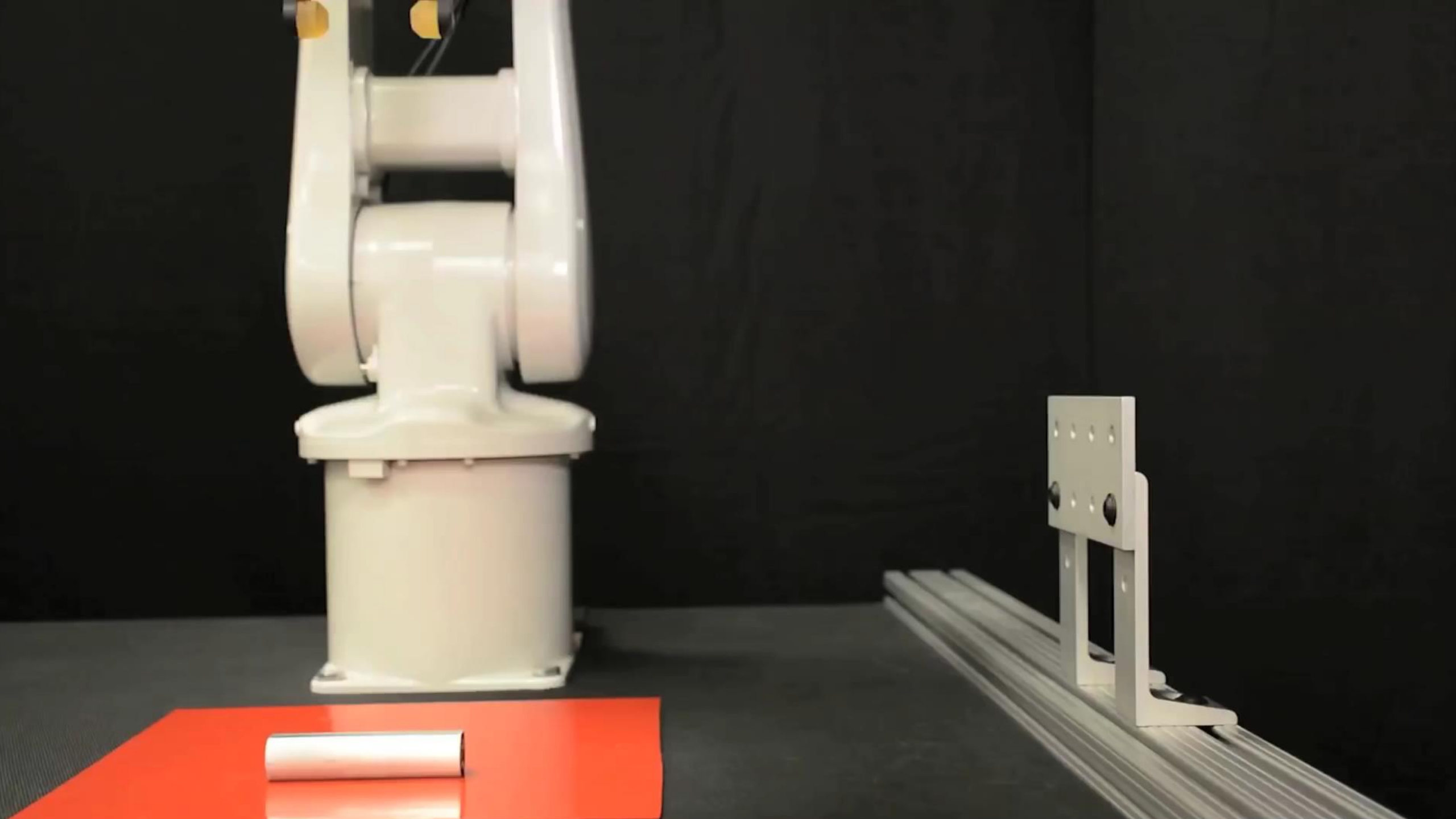
What is Manipulation?

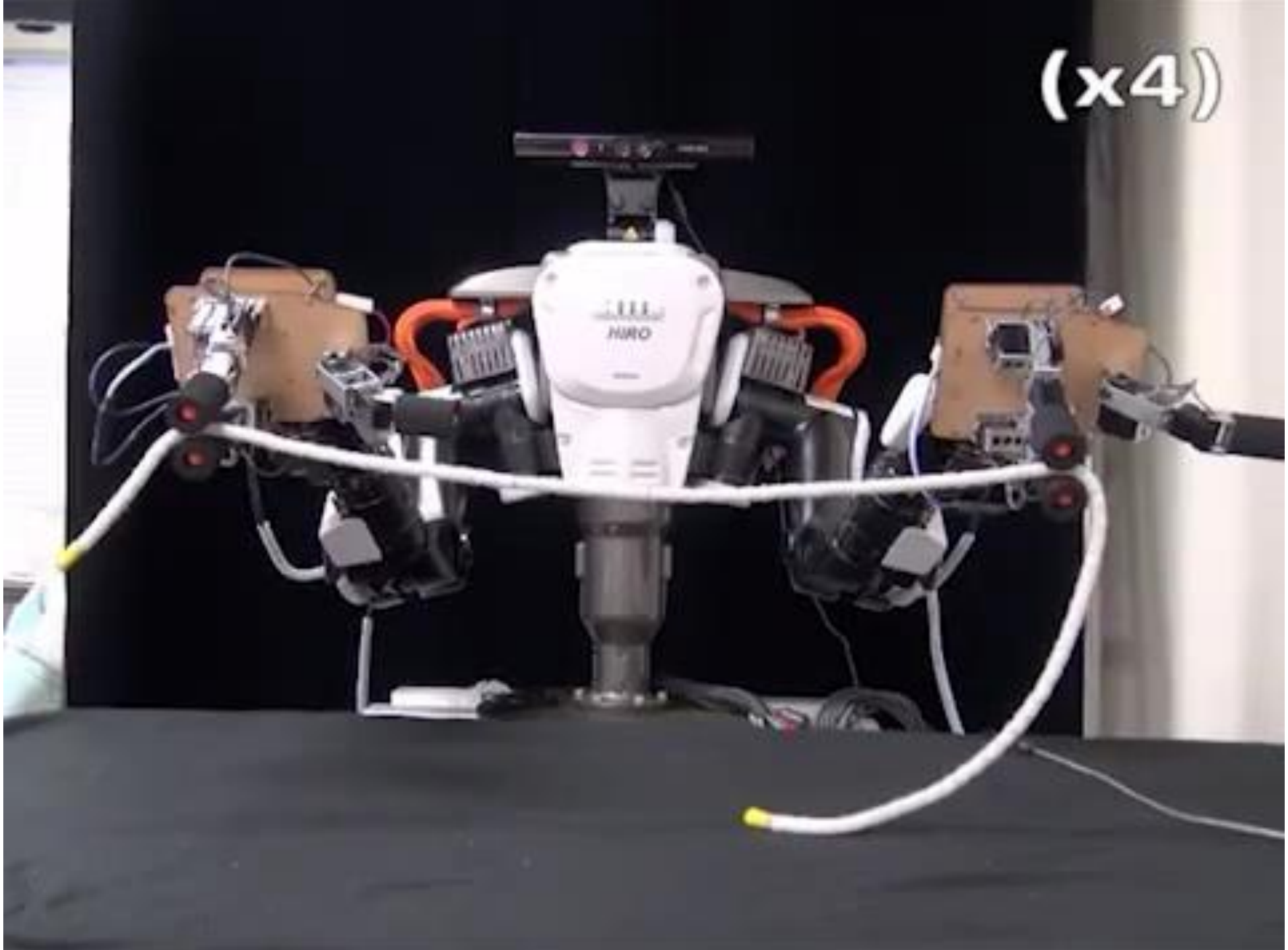
An agents control of its environment through selective and purposeful contact.

Remarkable human manipulation

Robotic Manipulation Examples



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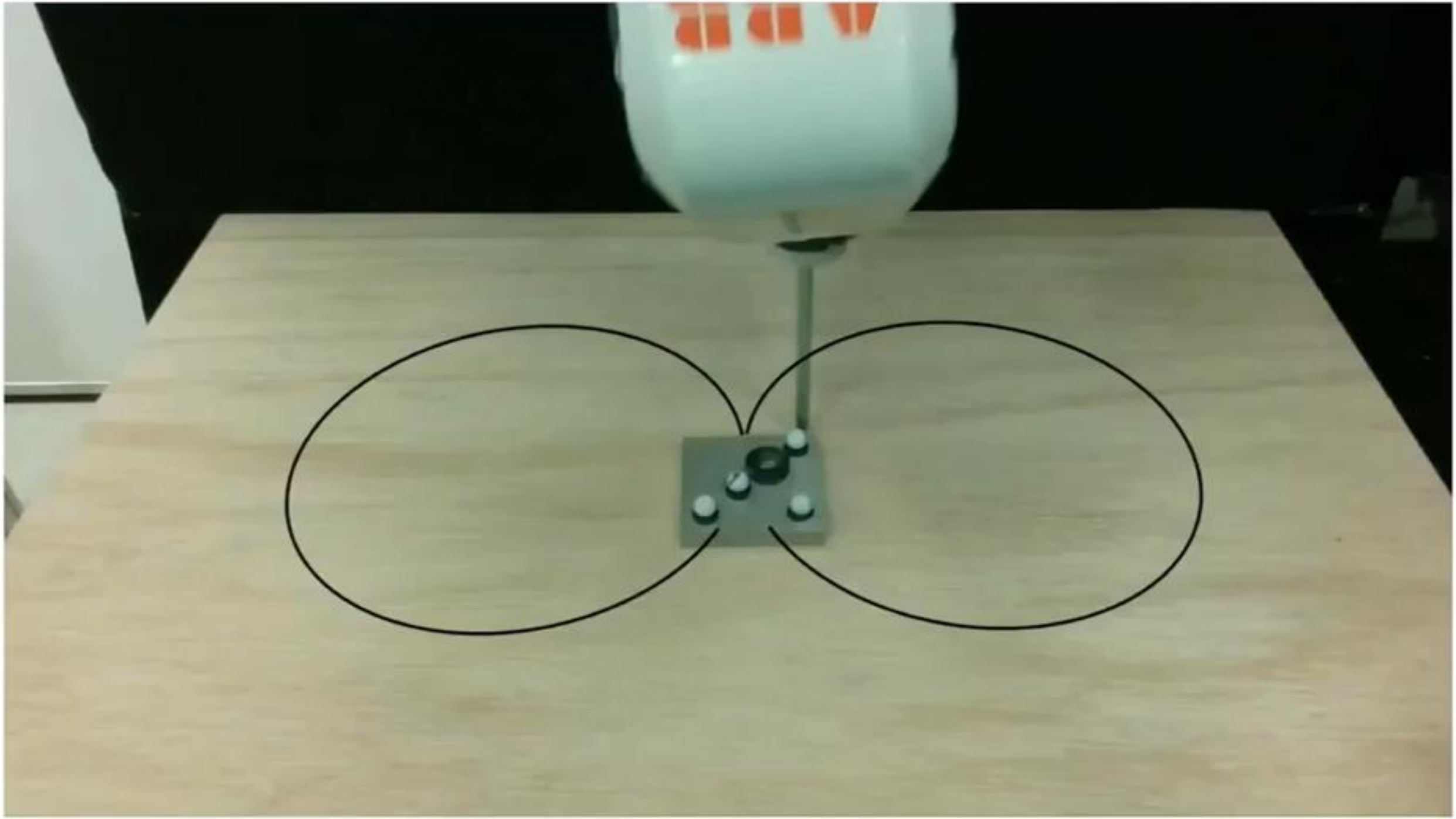
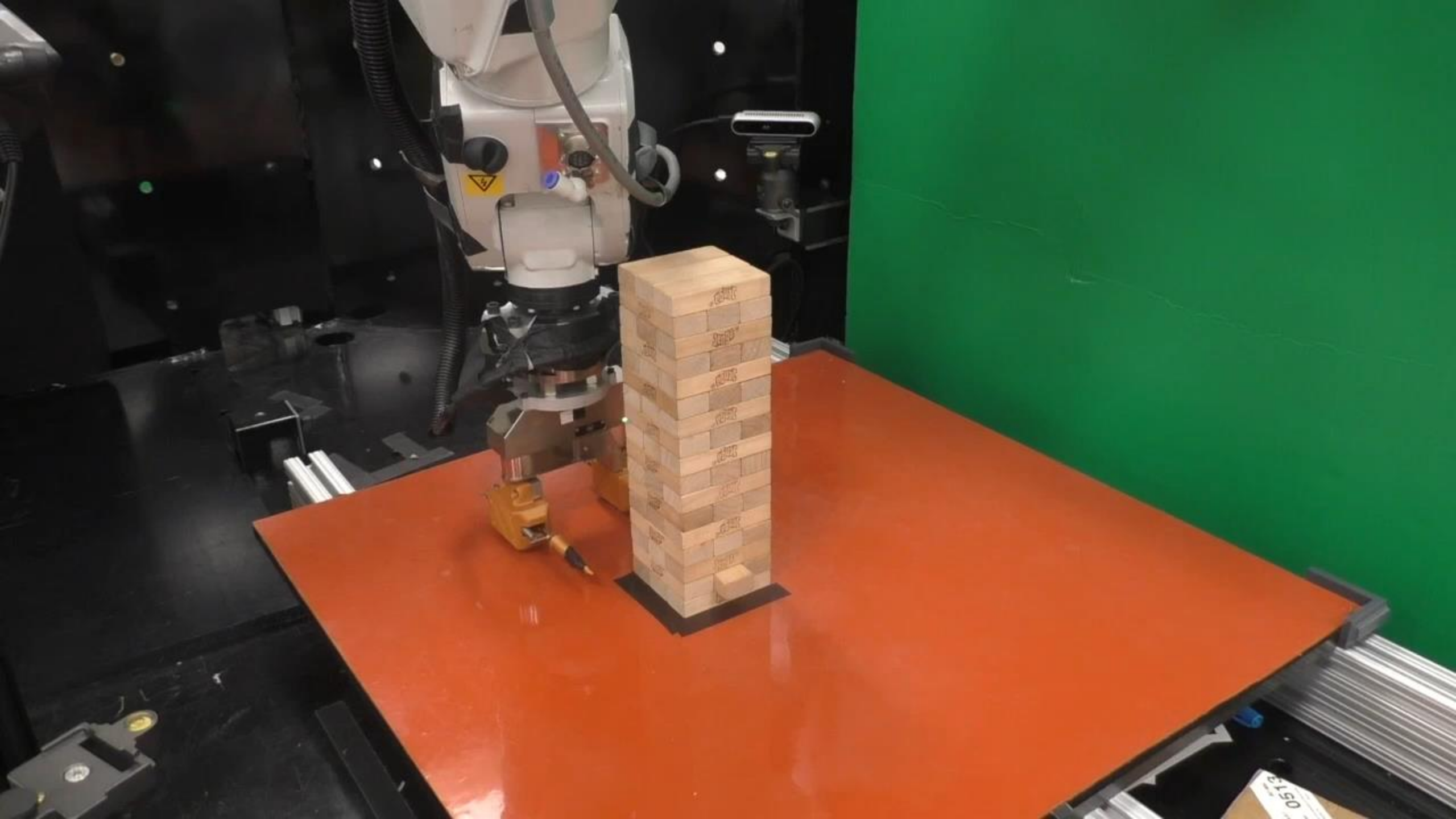




Course Material Overview

Mechanics for Manipulation

Perception for Manipulation

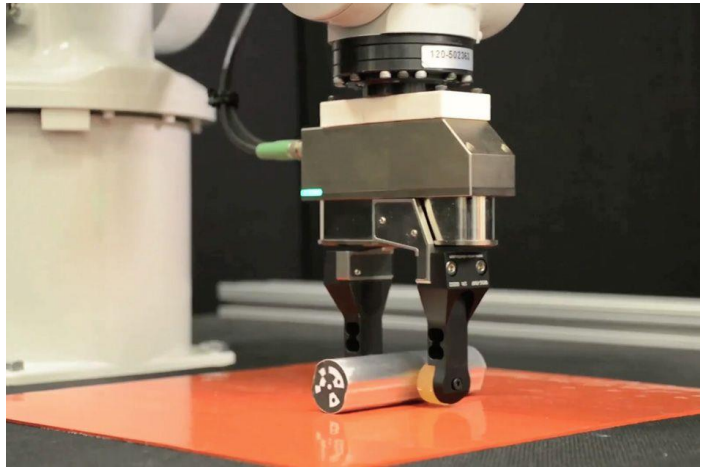
Planning for Manipulation

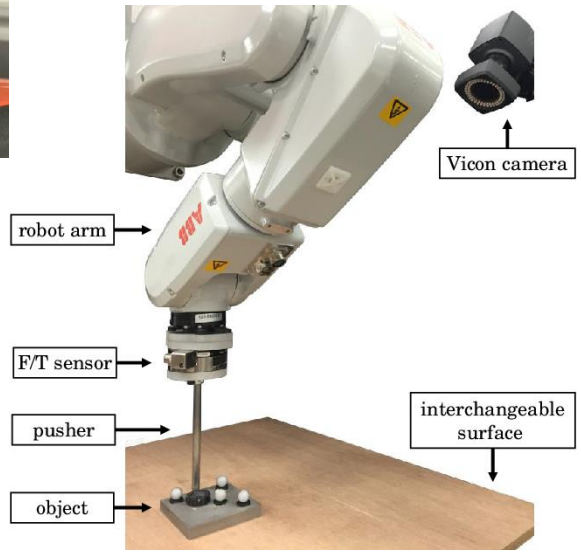
Controls for Manipulation

Mechanics of Manipulation

Study contact mechanics in the context of 3 important manipulation skills:

- Grasping
- Pushing
- Bouncing





Perception for Manipulation

Our focus will be on combining vision and touch for:

- Object localization / State-estimation
- Model-based grasping and pushing with visual feedback
- Handling Uncertainty from perceptual feedback

Planning and Controls

Topics we will discuss include:

- Model predictive control through contact
- Planning with uni-lateral and complementarity constraints
- Learning and using manipulation primitives

Your background -- ideally

- Linear Algebra – necessary
- ME/EECS 567: Robot Kinematics and Dynamics – recommended
- Optimization -- recommended
- Python – your HW

Python Requirements

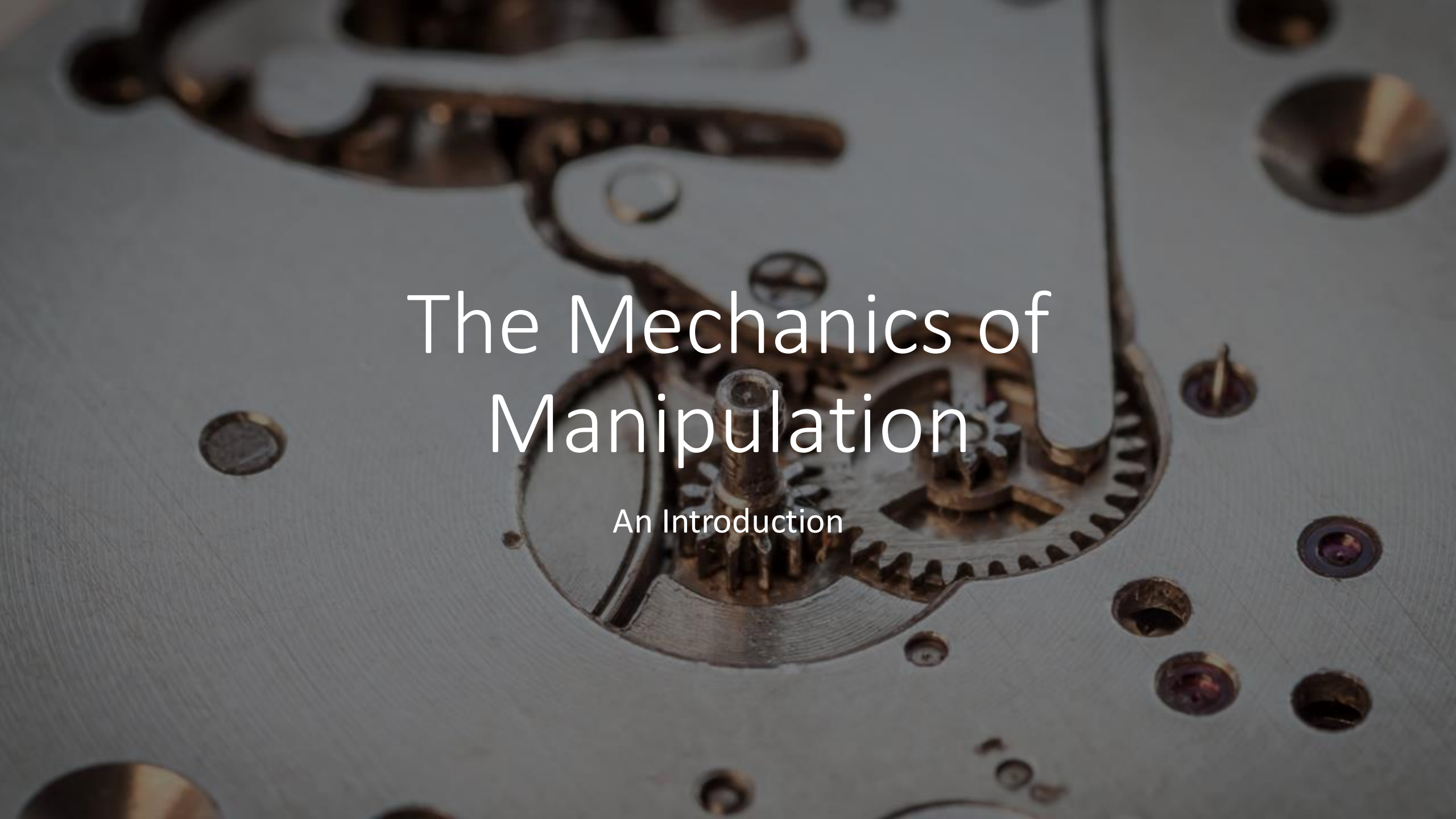
- Procedural programming basics – writing functions
- Numpy – standard library for numerical computations (think MATLAB)
- Linear algebra (matrix manipulation, dot products etc.)
- We will have 2 Python introduction lectures
- We will write most of the code, you'll be "filling the blanks"
- Limited support over piazza

Lectures and Materials

- Our course is recorded on zoom
- Lectures will use a combination of slides and notes written on slides
- Slides will mostly follow notes, but deviate for research slides
- Course notes are online: https://nima-fazeli.github.io/manipulation/
- Join the class on Piazza – we'll circulate a link over email

Your expected workload

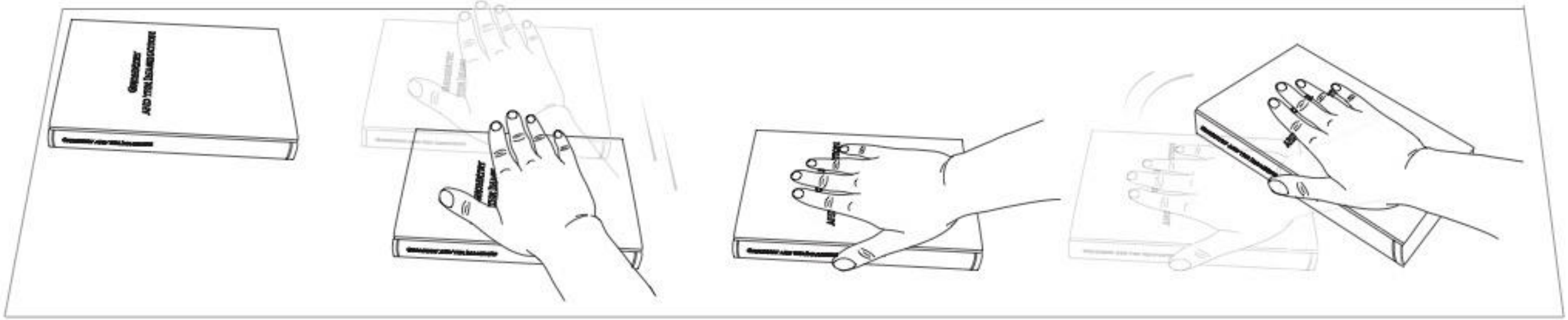
- Good news? No exams!
- We will have 7 HW assignments – no late submissions
- Assignments will be out every 2 weeks on Thursdays
- First assignment will be a refresher on Python skills
- A course project – we'll discuss more down the line
- Quiz every 2 weeks – over canvas, multiple choice lecture reviews



The Mechanics of Manipulation

An Introduction

Why contact mechanics?



Our assumptions – Rigid-body Mechanics

Our assumptions – Non-penetration

State Space

Configuration Space

Reference Frames

Reference Frames

Forces and wrenches

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