

# Course Project Description

CS 6301 Special Topics: Introduction to Robot Manipulation and Navigation

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The University of Texas at Dallas

# Course Project

- Team Project (45%)
  - 2 - 3 students for a project
  - Project proposal (5%)
  - Project mid-term report (10%)
  - Project presentation (15%)
  - Project final report (15%)

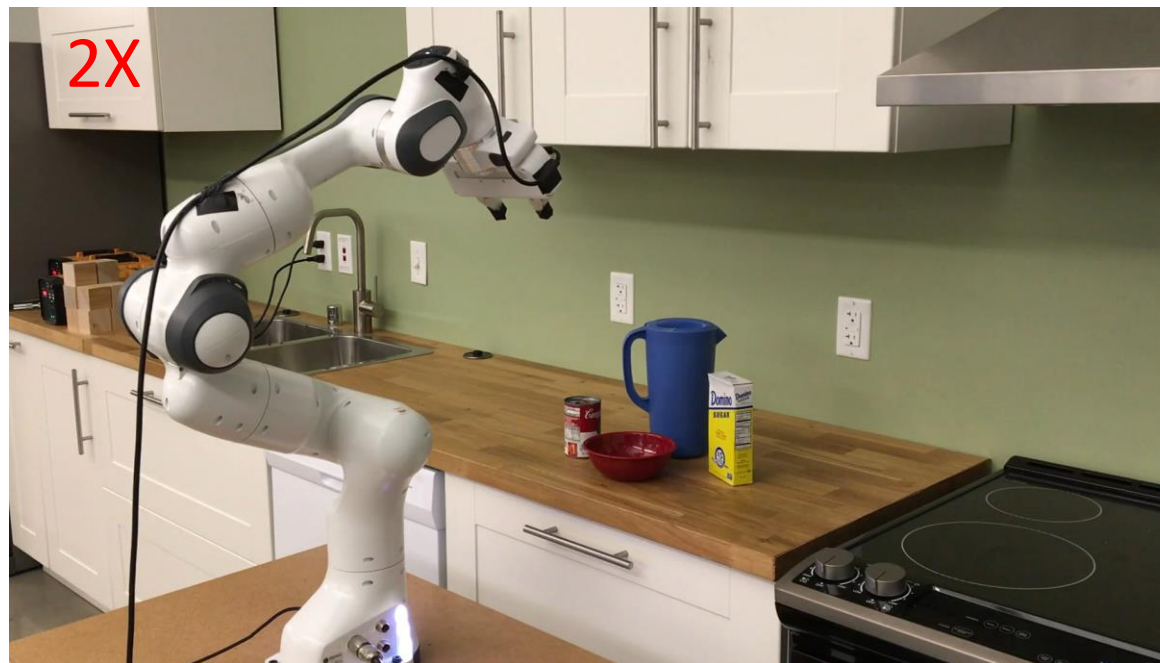
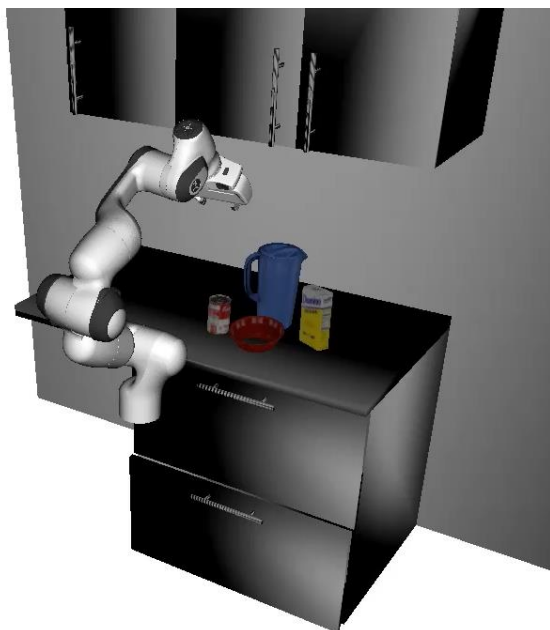
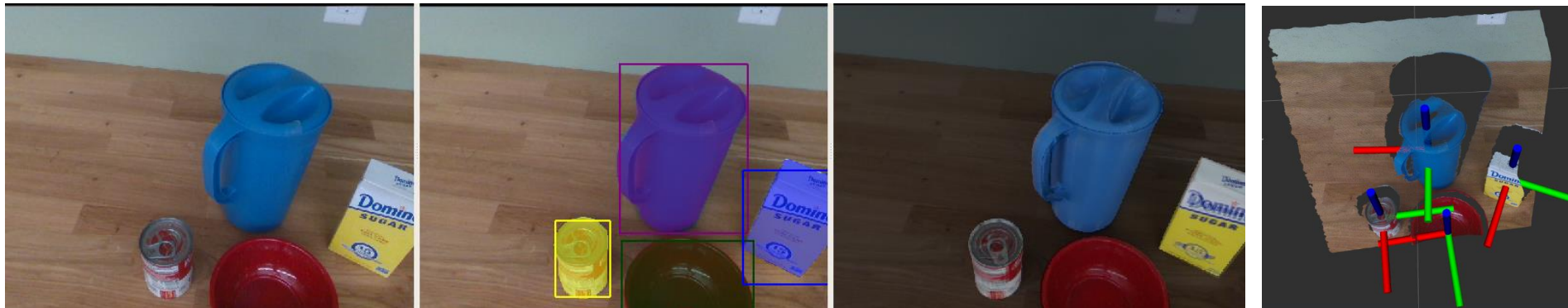
# Course Project Tracks

- Research-oriented
  - Proposal a new idea in robotics that has not been explored before
  - Implement the new idea and conduct experiments to verify it
- Application-oriented
  - Apply an existing algorithm or method to a new problem or a new application
  - E.g., if a method is proposed for domain A, explore applying it to a different domain
- Implementation-oriented
  - Select an existing algorithm or method, implement it and conduct experiments to verify the implementation
  - Cannot just use open-source code and run experiments with it

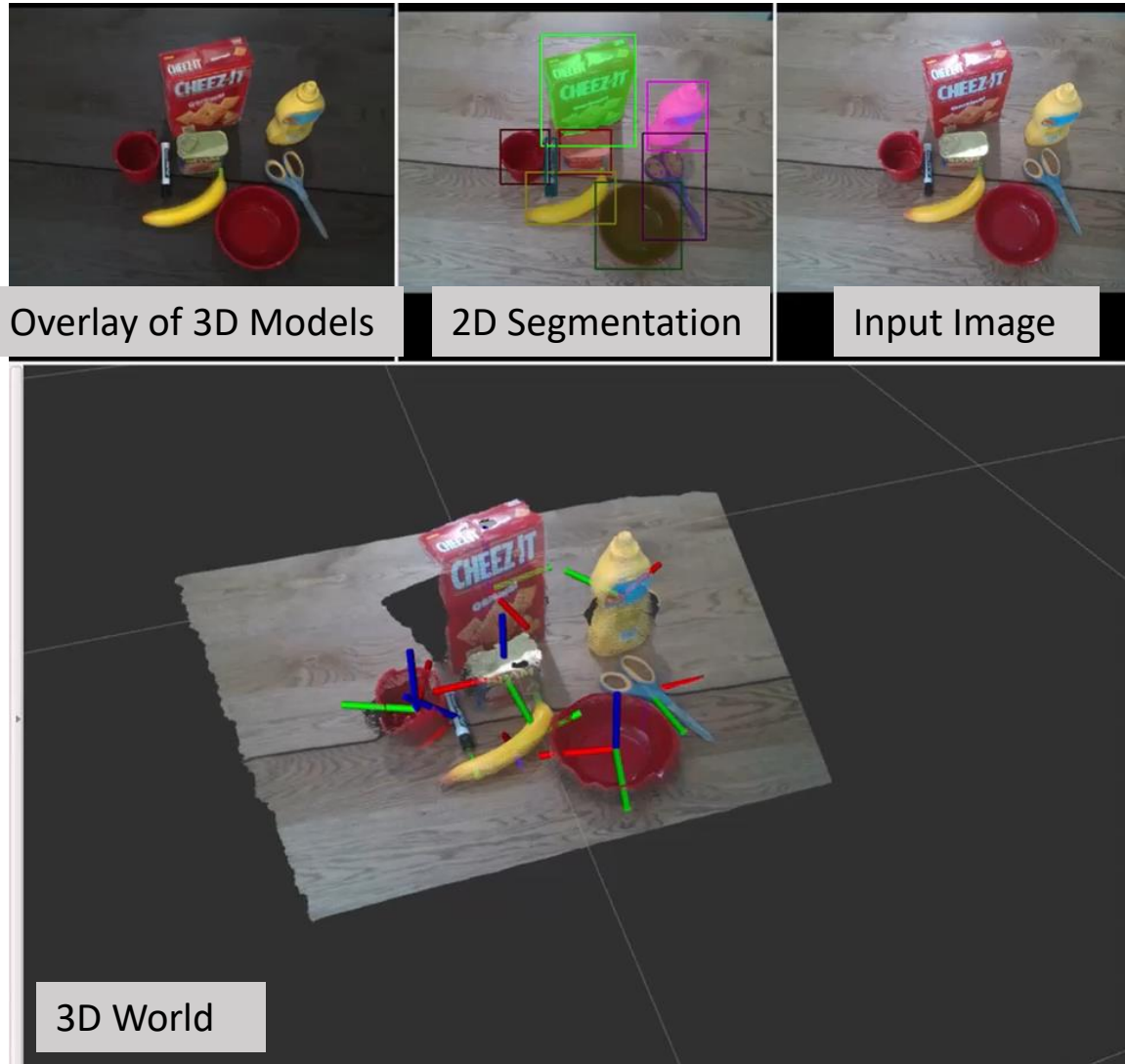
# Mandatory Requirements

- The project needs to have a robot
- The project needs to have robot manipulation

# Topic: Model-based Grasping



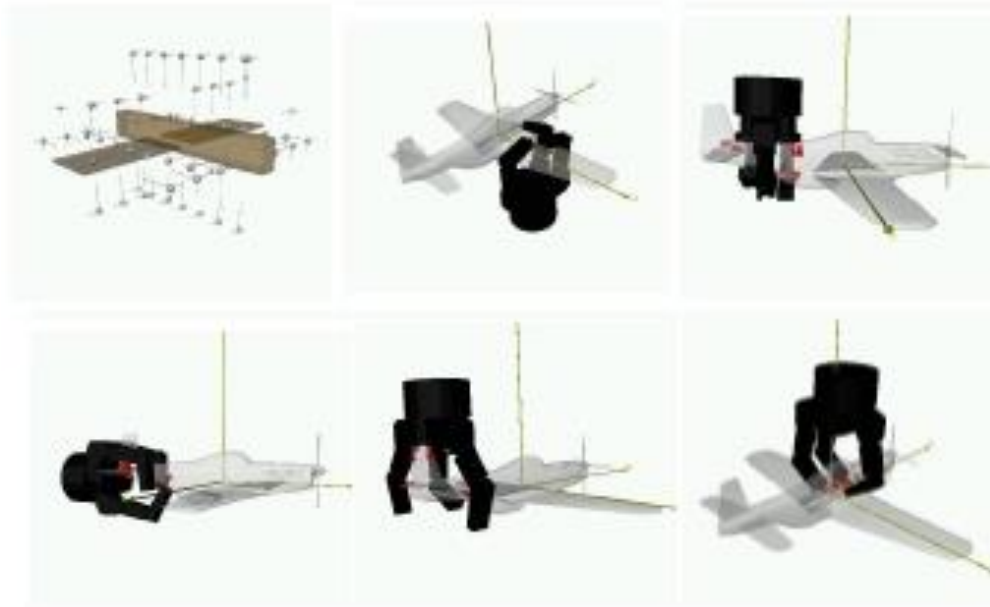
# Topic: 6D Object Pose-based Grasping



Self-supervised 6D Object Pose Estimation for Robot Manipulation. Deng et al., ICRA'20

<https://arxiv.org/abs/1909.10159>

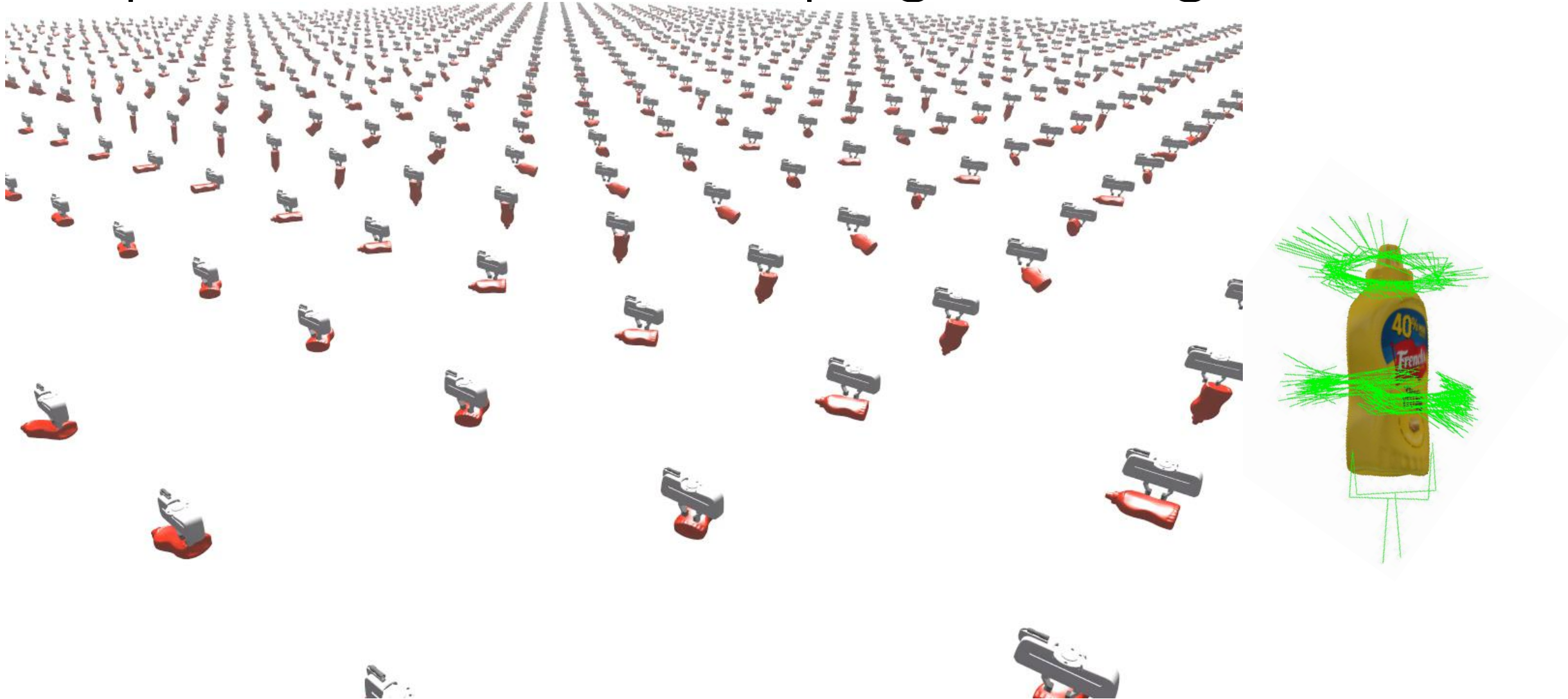
# Topic: Model-based Grasping Planning



Graspit! <https://graspit-simulator.github.io/>

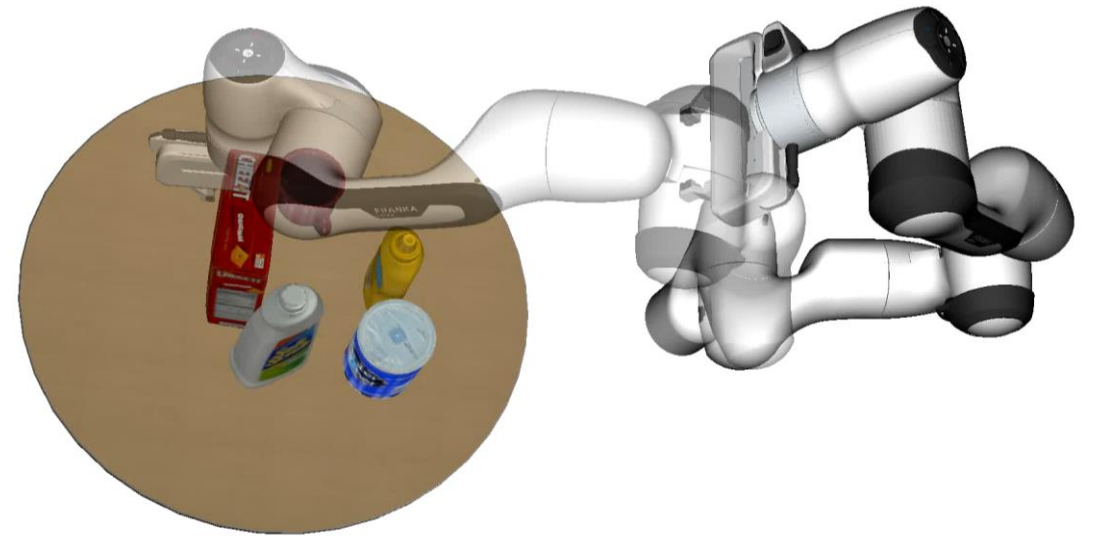
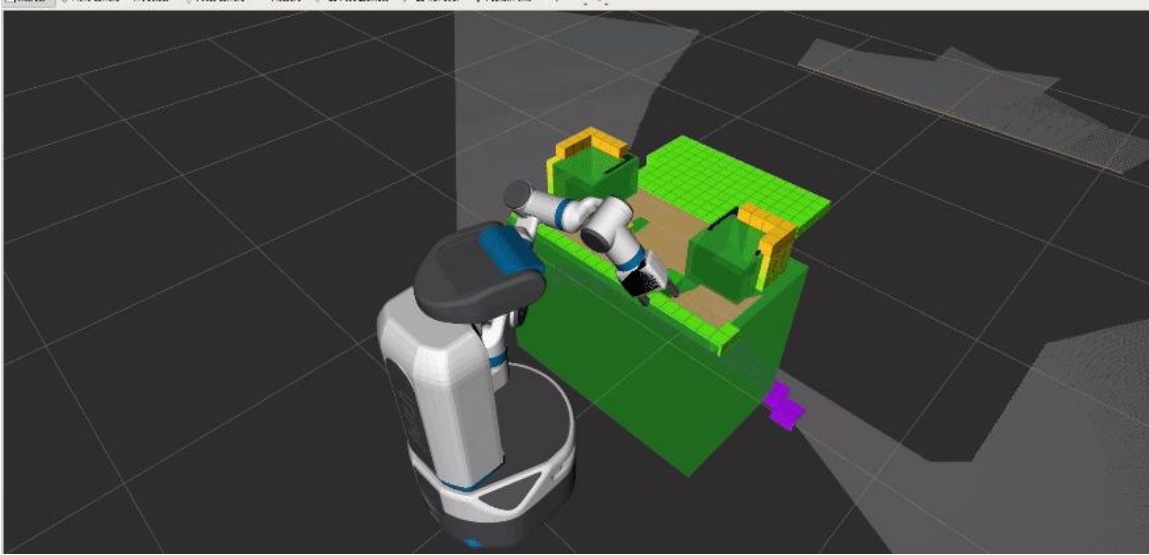


# Topic: Model-based Grasping Planning





# Topic: Model-based Motion Planning



<https://opensource.fetchrobotics.com/icra-challenge/2019/01/28/tutorial.html>

Moveit <https://moveit.ros.org/>

# Topic: Learning-based Top-Down Grasping



<https://ai.googleblog.com/2018/06/scalable-deep-reinforcement-learning.html>

**QT-Opt: Scalable Deep Reinforcement Learning for Vision-Based Robotic Manipulation.**  
Kalashnikov, et al., 2018 <https://arxiv.org/abs/1806.10293>

# Topic: Learning-based Top-Down Grasping



Sample Efficient Grasp Learning Using Equivariant Models. Zhu et al. RSS, 2022

[https://zxp-s-works.github.io/equivariant\\_grasp\\_site/](https://zxp-s-works.github.io/equivariant_grasp_site/)

# Topic: Learning-based 6D Grasping

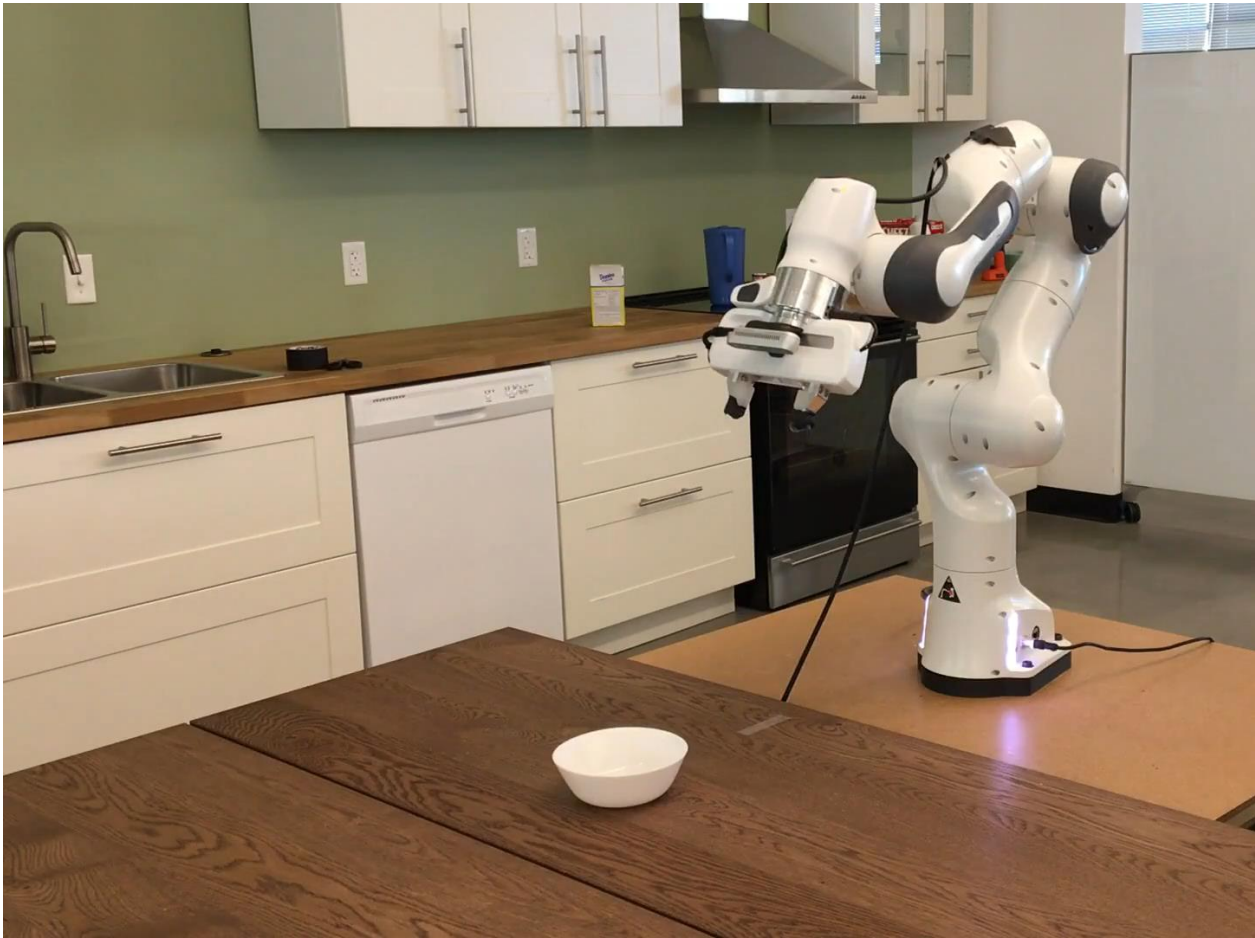


**6-DOF GraspNet: Variational Grasp Generation for Object Manipulation. Mousavian et al., ICCV'19**

<https://arxiv.org/abs/1905.10520>



# Topic: Learning-based 6D Grasping



**Goal-Auxiliary Actor-Critic for 6D Robotic Grasping with Point Clouds. Wang et al., CoRL'21**

<https://sites.google.com/view/gaddpg>

# Topic: Articulated Object Manipulation



<https://hyperplane-lab.github.io/vat-mart/>

VAT-Mart: Learning Visual Action Trajectory Proposals for Manipulating 3D ARTiculated Objects, Wu et al., ICLR'22

# Topic: Deformable Object Manipulation



Learning Latent Graph Dynamics for Visual Manipulation of Deformable Objects. Ma et al., ICRA'21.

<https://arxiv.org/abs/2104.12149>



# Topic: Mobile Manipulation



<https://www.youtube.com/watch?v=ZQknooga8A0>

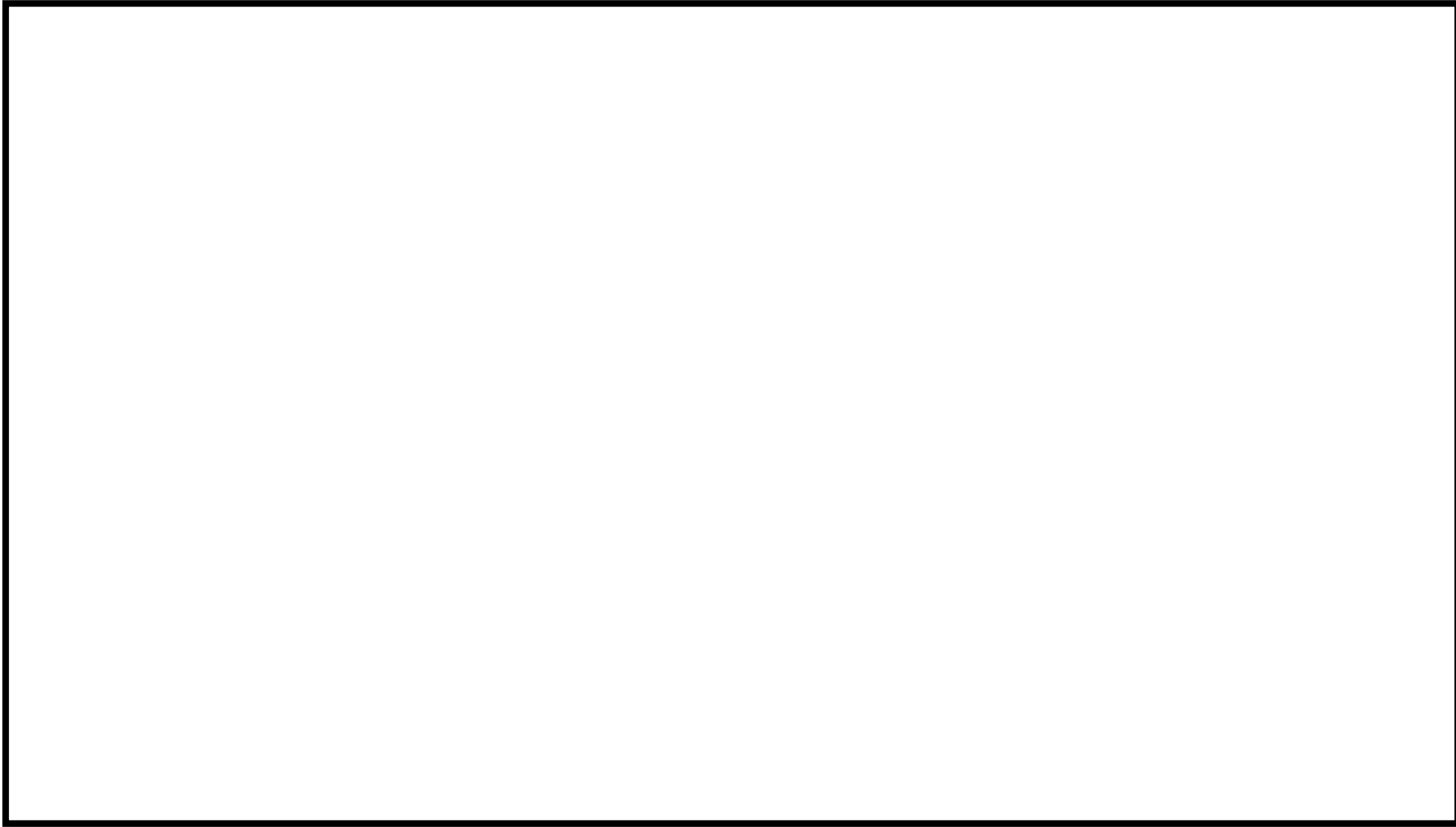
# Topic: Mobile Manipulation

- TidyBot



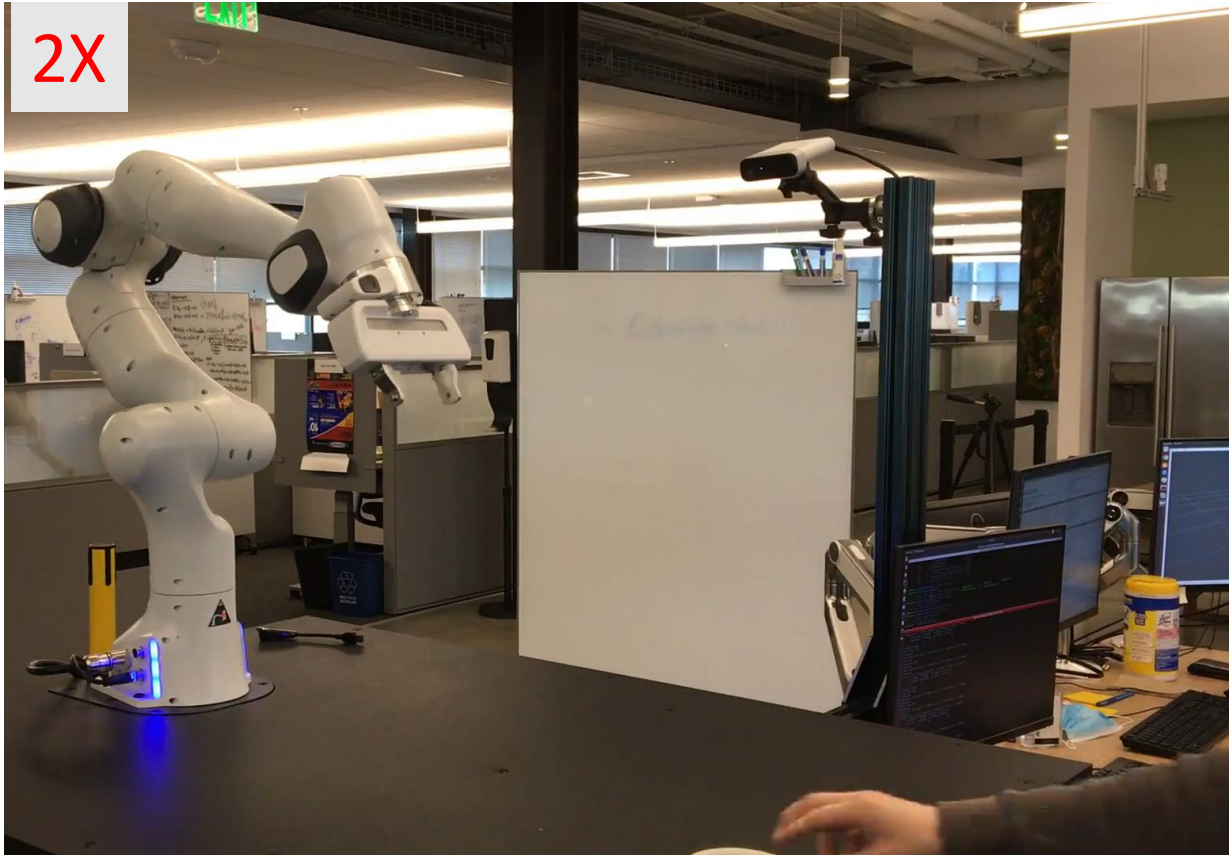
<https://tidybot.cs.princeton.edu/>

# Topic: Language-guide Manipulation



<https://say-can.github.io/>

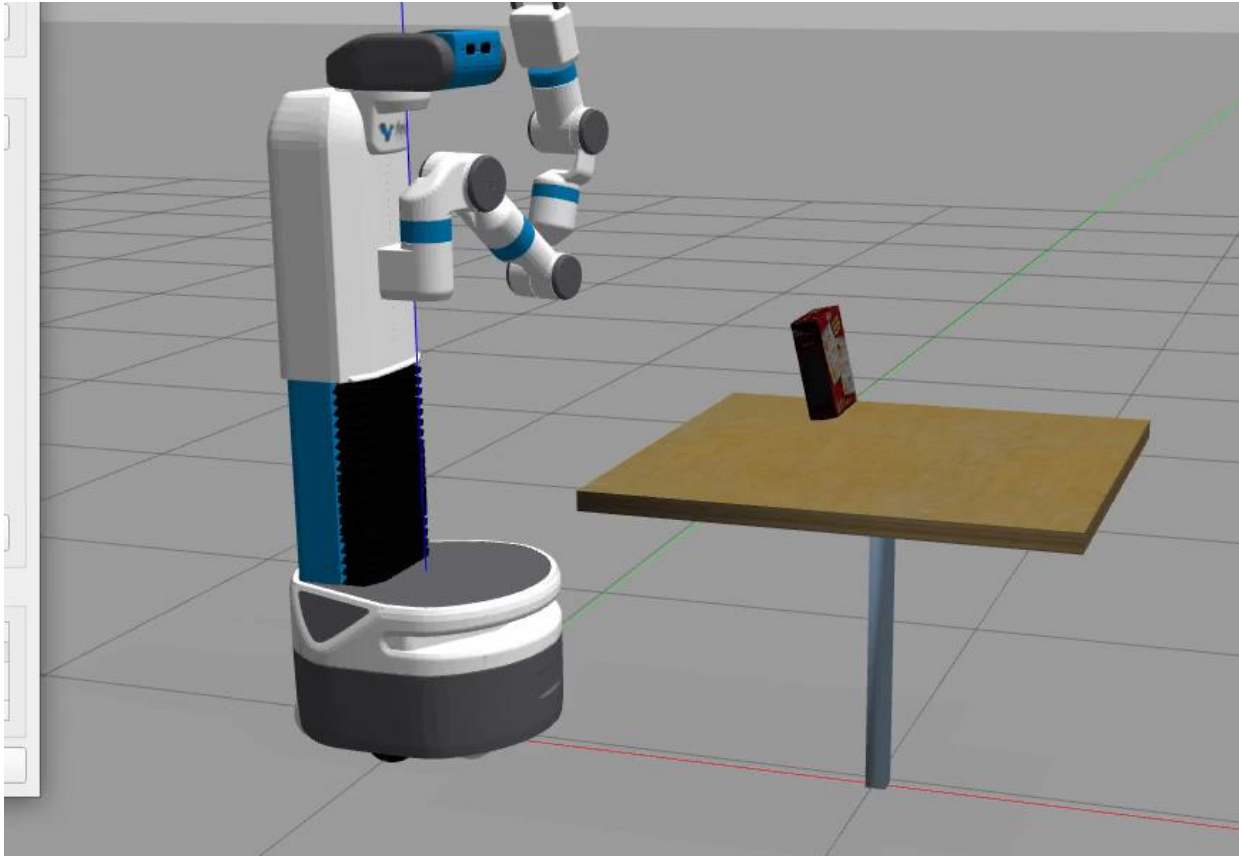
# Topic: Human-Robot Handover



**Goal-Auxiliary Actor-Critic for 6D Robotic Grasping with Point Clouds**  
Lirui Wang, Yu Xiang, Wei Yang, Arsalan Mousavian and Dieter Fox  
In Conference on Robot Learning (CoRL), 2021.



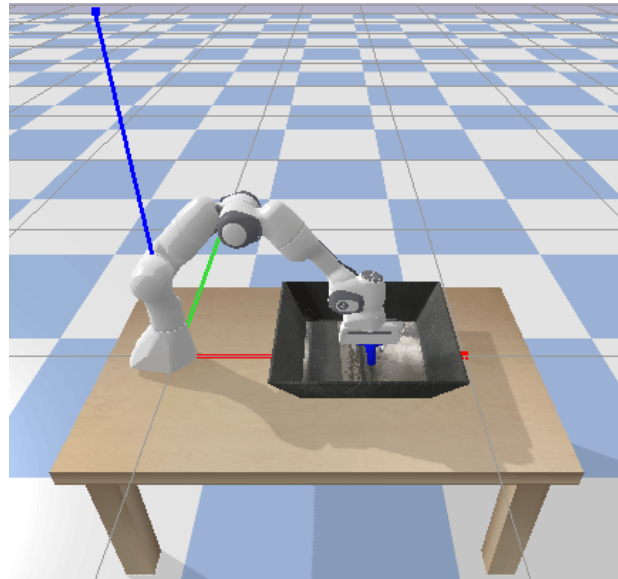
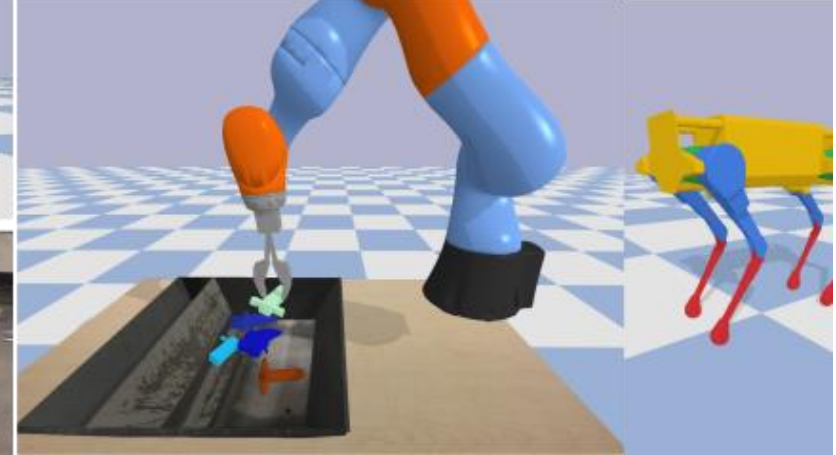
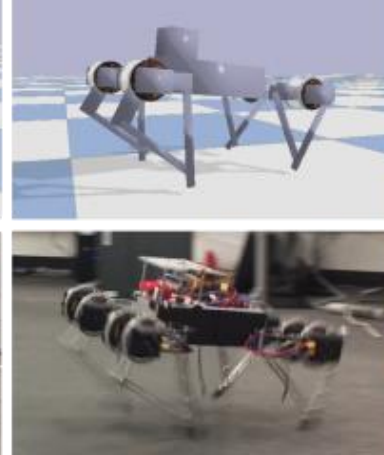
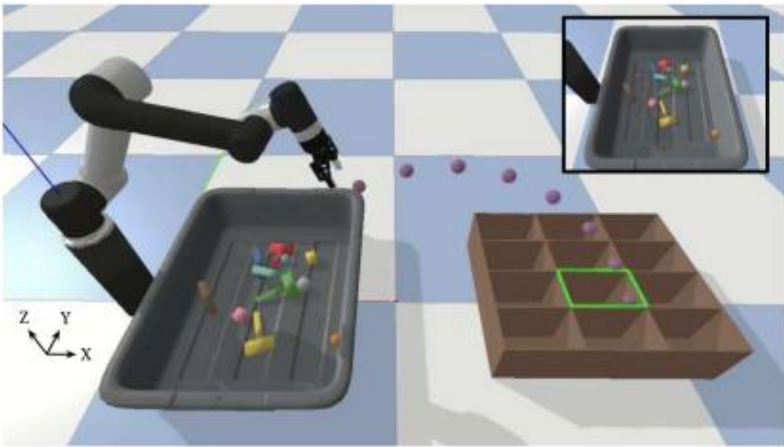
# Simulator: Gazebo



- Integrated with ROS

<https://gazebosim.org/home>

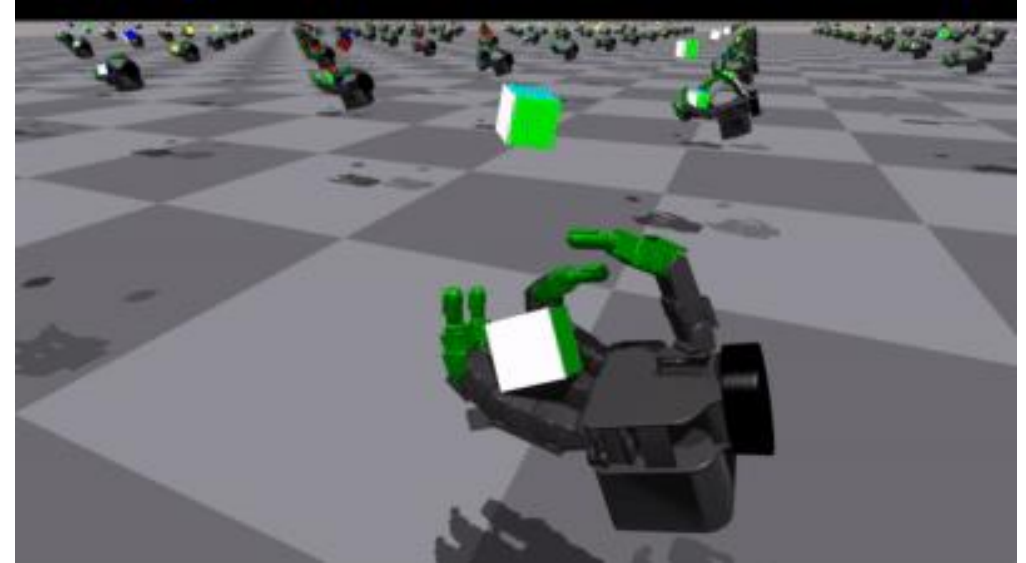
# Simulator: PyBullet



- Python interface

<https://pybullet.org/wordpress/>

# Simulator: NVIDIA Isaac Gym



- GPU acceleration
- Parallelization of thousands of environments

<https://developer.nvidia.com/isaac-gym>

<https://github.com/NVIDIA-Omniverse/IsaacGymEnvs>



# Simulation Environment: iGibson

## Fully-**Interactive** and Photorealistic

**15** scenes  
annotated from  
real-world homes

Support **12000+**  
scenes from  
CubiCasa5K and  
3D-Front



## Physical Interaction with Articulated Objects

More than 500 object  
models

Sourced from open  
source datasets and  
cleaned up

Articulated objects can be  
operated by agents



<https://svl.stanford.edu/igibson/>

# Simulation Environment: ManipulaTHOR



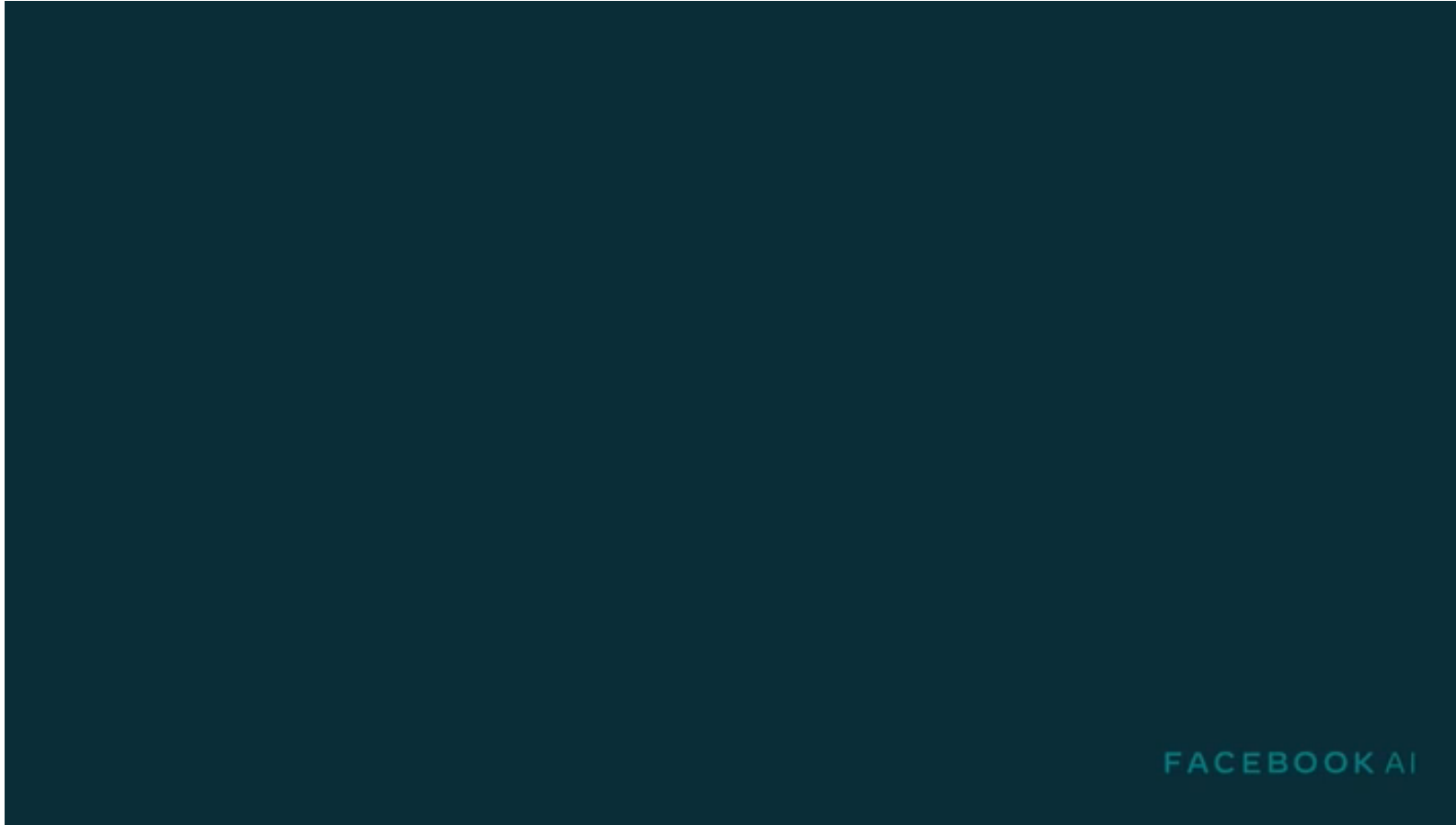
iTHOR



RoboTHOR

<https://ai2thor.allenai.org/manipulathor>

# Simulation Environment: Habitat-sim



<https://github.com/facebookresearch/habitat-sim>

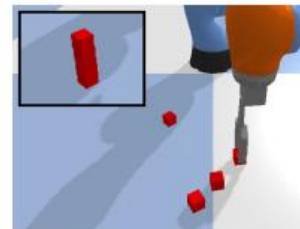
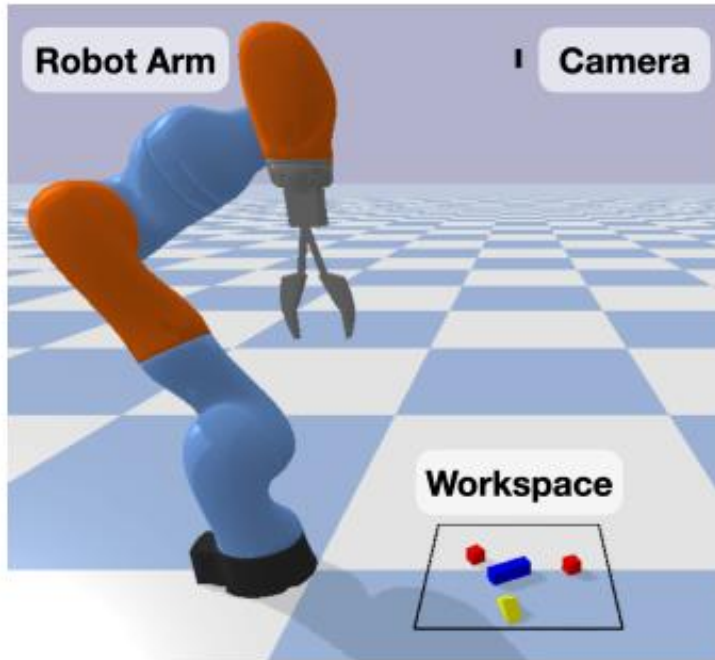
# Simulation Environment: SAPIEN



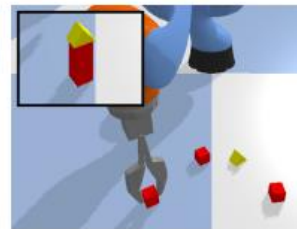
<https://sapien.ucsd.edu/>



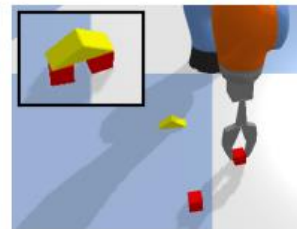
# Simulation Environment: BulletArm



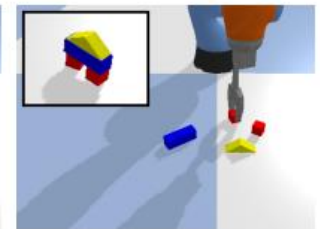
(a) Block Stacking



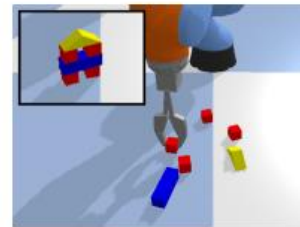
(b) House Building 1



(c) House Building 2



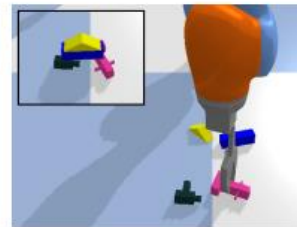
(d) House Building 3



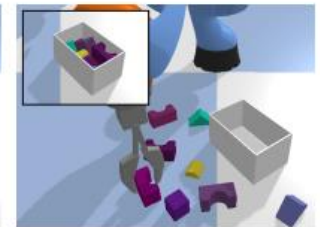
(e) House Building 4



(f) Improvise House Building 2



(g) Improvise House Building 3



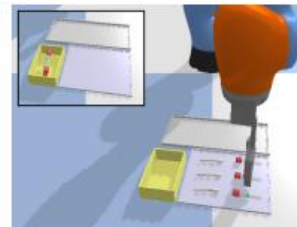
(h) Bin Packing



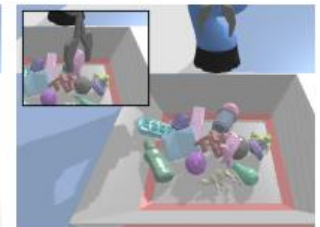
(i) Bottle Arrangement



(j) Box Palletizing



(k) Covid Test



(l) Object Grasping

BulletArm: An Open-Source Robotic Manipulation Benchmark and Learning Framework. Wang et al. 2022

<https://arxiv.org/abs/2205.14292>

# Propose Your Projects

- Which topic to work on?
  - Grasping? Language-guided Manipulation? Mobile Manipulation?
- What specific problem to work on within the chosen topic?
  - Model-based grasping? Motion planning? RL for grasping? Etc.
- Which simulation environment to use?
  - Gazebo with ROS? iGibson? Isaac Gym? Etc.
- Which track is your project?
  - Research-oriented? Application-oriented? Implementation-oriented?

# Discussion