Embodied AI Tasks in ManiSkill and Visual Learning Challenges

Building and Working in Environments for Embodied AI (part VI)

CVPR 2022 Tutorial

UC San Diego







ManiSkill Benchmark and Challenge Generalizable Manipulation Skill Benchmark with

Large-Scale Demonstrations

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Overview

- We are going to talk about:
 - What kind of manipulation tasks are difficult?
 - Imitation learning, RL, and classical robotics, which one can solve embodied AI tasks better for now?
 - Preview of ManiSkill Challenge 2022

Outline

- ManiSkill Benchmark
- Summary of ManiSkill Challenge 2021
- Preview of ManiSkill Challenge 2022

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Generalizable Manipulation Skills

- After learned to manipulate a category of objects, human can manipulate unseen objects of the same category, despite the large topological and geometric variations.
- We refer to such ability to interact with unseen objects within a certain category as generalizable manipulation skills.



Object-Level Generalization



Generalize Over Object Geometry / Topology / Appearance

Object-Level Generalization

- Require to discover knowledge about object structure
 - Part? Keypoint? Skeleton? ...



Generalize Over Object Geometry / Topology / Appearance

• A benchmark for learning generalizable manipulation skills



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- And it features
 - Four manipulation tasks targeting at distinct challenges of *short-horizon physical* manipulation skills



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 - Ego-centric 3D visual inputs from a panoramic camera mounted on a robot
 - Large-scale demonstration datasets





Manipulation Skills with Distinct Challenges

Tasks feature distinct object motions and manipulation skill properties





 Motion Constrained by Revolute Joint



 Motion Constrained by Prismatic Joint

Push Chair

- Motion Constrained by Plane
- Complex Underactuated System
- Dual-arm Collaboration



Generalization Over Diverse Objects

We manually processed 162 objects over 4 categories Large topology, geometry, and appearance variations (Including objects that cannot be procedurally generated)



3D Visual Inputs from Panoramic Camera: Point Cloud / RGBD Image



Demonstrations Provided

~36,000 demo trajectories in totalOver 1.5 million 3D video frames



Training-Evaluation Protocol

• For each task

- Agent is trained on training environments (with training objects)
- Evaluated on test environments (with test objects)
- Metric is mean success rate



Interesting Research Problems

- How to design better networks for physical manipulation?
 - Recent experiments: SparseConvNet achieves better training and test performance
 - Many 3D Shape Analysis techniques can be utilized
 - Keypoint Extraction? Part Discovery? ...
- How to combine offline demo with online learning?

 $\circ\,$ What if multiple modalities in demo?

How to mitigate the occlusion issues during manipulation?
 Active perception?

...

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ManiSkill Challenge 2021

- Total Awards: 20,000 USD
- Challenge Award Ceremony held on ICLR 2022
 Workshop on Generalizable Policy Learning in the Physical World
- The workshop has also received many works on generalizable policy learning.
 - <u>https://openreview.net/group?id=ICLR.cc/2022/Workshop/GPL#a</u>
 <u>ccept-poster-</u>

ManiSkill 2021

SAPIEN Open-Source Manipulation Skill Challenge

Learning to manipulate unseen objects with visual inputs **3** tracks for researchers on CV, RL, and robotics



ORGANIZERS



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Three Competition Tracks

- Demonstrations provided, and 3 tracks to choose from:
 - **No interaction track:** Learn from demonstration only, no interaction with the environment. (welcome, 3DV experts!)
 - No external annotation track: Interaction allowed on top of demonstrations, no additional data and environment annotations. (welcome, RL experts!)
 - No restriction track: Do whatever you want to solve the problem. (welcome, robotics experts!)

Competition Summary

• Timeline

- o 07/29/2021: Registration opens
- \circ 08/09/2021: Submission opens
- o 08/20/2021: Evaluation starts
- $\circ~$ 01/14/2022: Challenge ends
- 40+ registered teams
- 7 teams have received the final awards
- Awards worth \$20,000 given to winners (sponsored by Qualcomm AI)

Which track is the hardest?

- Metric: 0.5 train set perf + 0.5 test set perf
- For each track, we average scores across tasks (by best performing team). Std represents task difficulty variation for each track



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Train-Test Performance Difference By Track



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ManiSkill Challenge 2022

- Follow the form of the 2021 challenge
 - $\circ\,$ Focus on object-level-generalizability
 - \circ Three tracks

• We will add new tasks and provide a **much faster** system.

ManiSkill Challenge 2022

• ManiSkill 2021

4 tasks for articulated object manipulation

• ManiSkill 2022

- $\circ\,$ ~10 tasks for rigid body
- \circ 5 tasks for articulated body
- $\,\circ\,$ 5 tasks for deformable body

Deformable Body Tasks



ManiSkill Challenge 2022

- Launch in July, 2022
- Please watch the twitter of our group account for further updates:



https://twitter.com/HaoSuLabUCSD

QA & Links & Contact

- SAPIEN & ManiSkill: <u>https://sapien.ucsd.edu</u>
- Group page: <u>https://cseweb.ucsd.edu/~haosu/</u>
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