



Learning Cross-Category Generalizable Part Manipulation Policy from Point Cloud Observations

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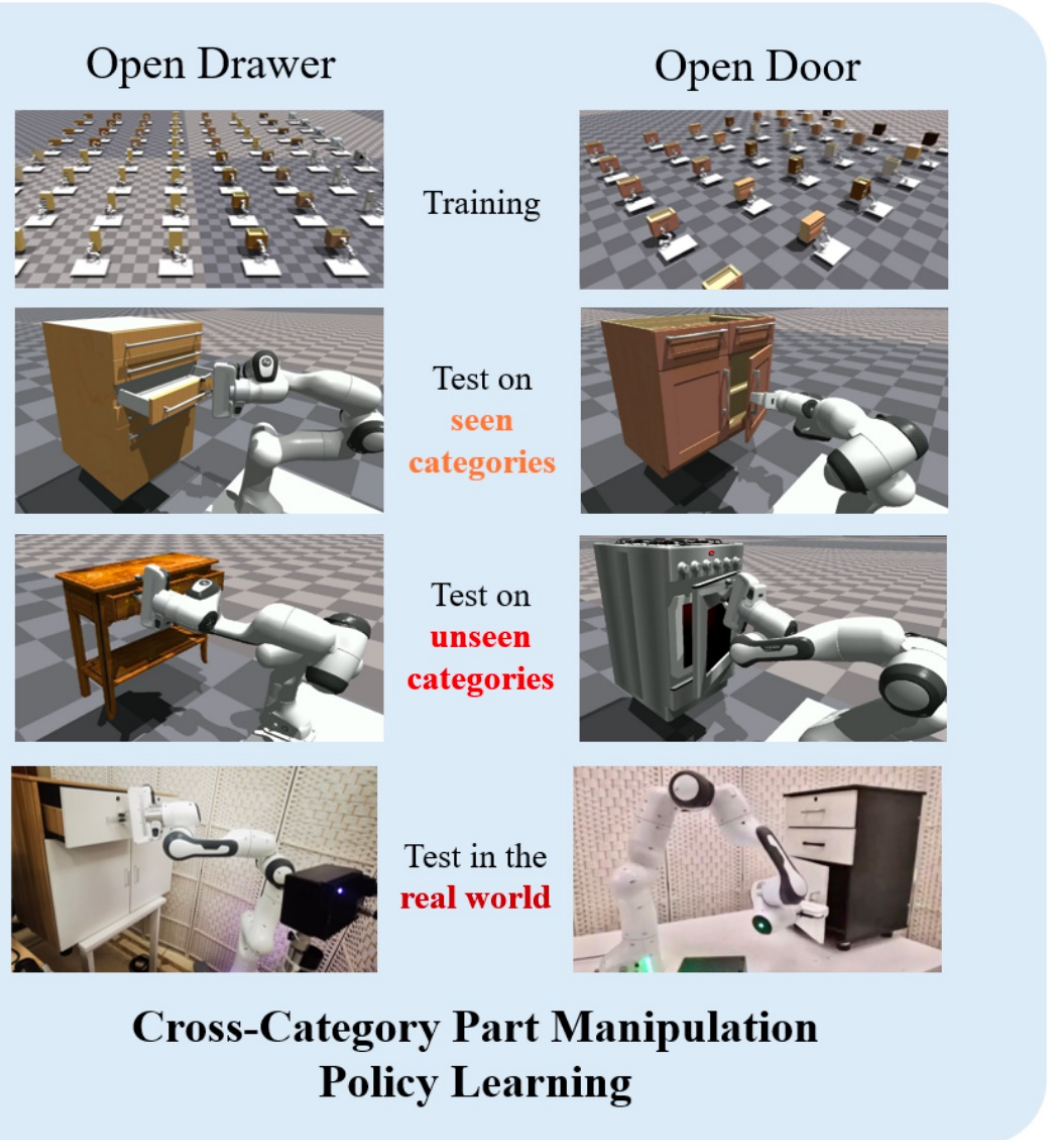
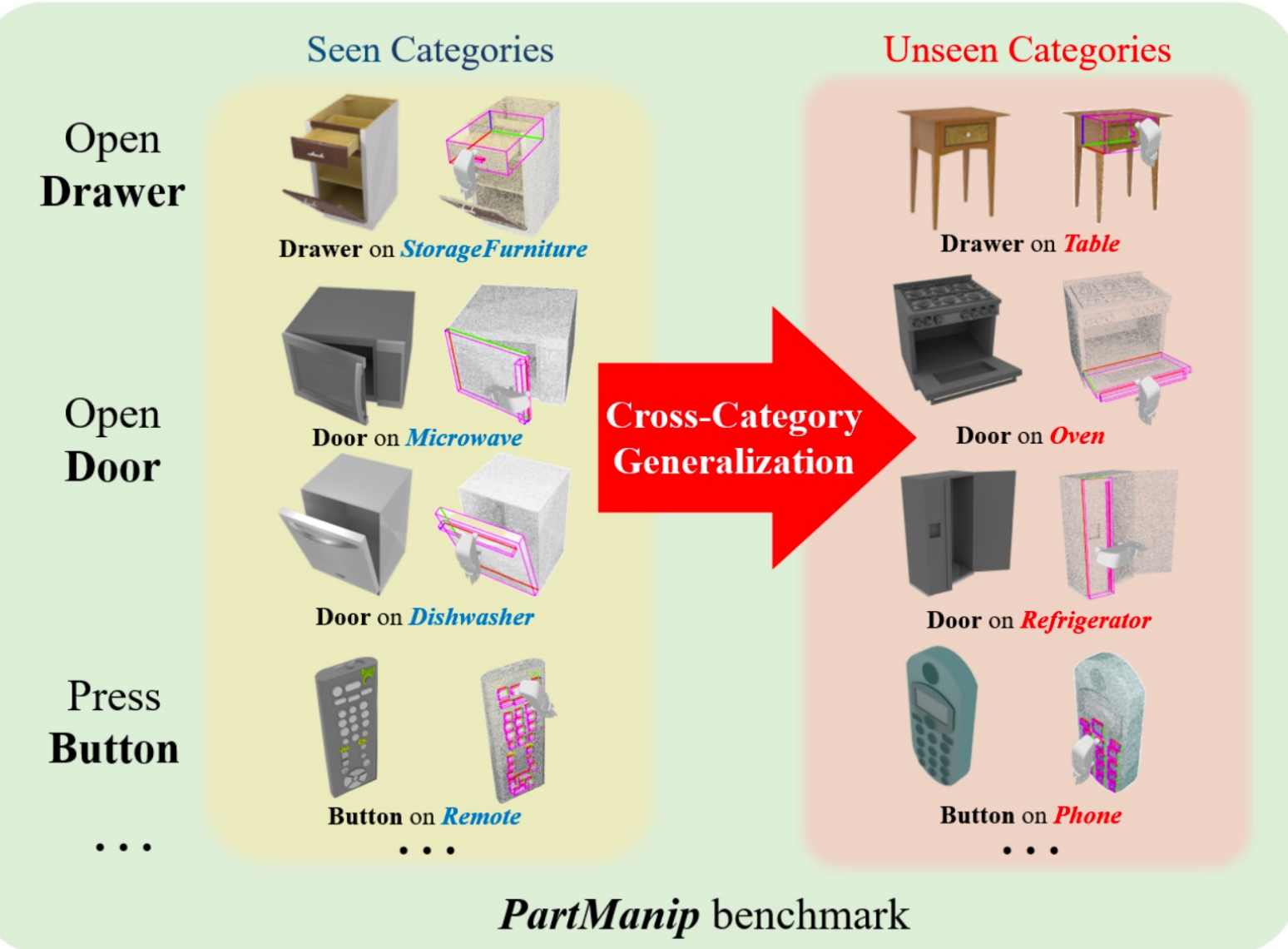
Motivation

Key insight: We humans can successfully manipulate certain types of **parts** across **different objects** in a similar way.
➔ In this work, we tackle **generalizable part-based** manipulation policy learning.



Goal: Learning cross-category Manipulation skills via Generalizable and Actionable **Parts (GAParts)**.

Tasks: Cross-category Open/Close Door, Open/Close Drawer, Press Button, Grasp handle



Contribution

Benchmark: The first **large-scale**, part-based, cross-category object manipulation benchmark, PartManip, is composed of 11 object categories, 494 objects, and 1432 tasks in 6 task classes.

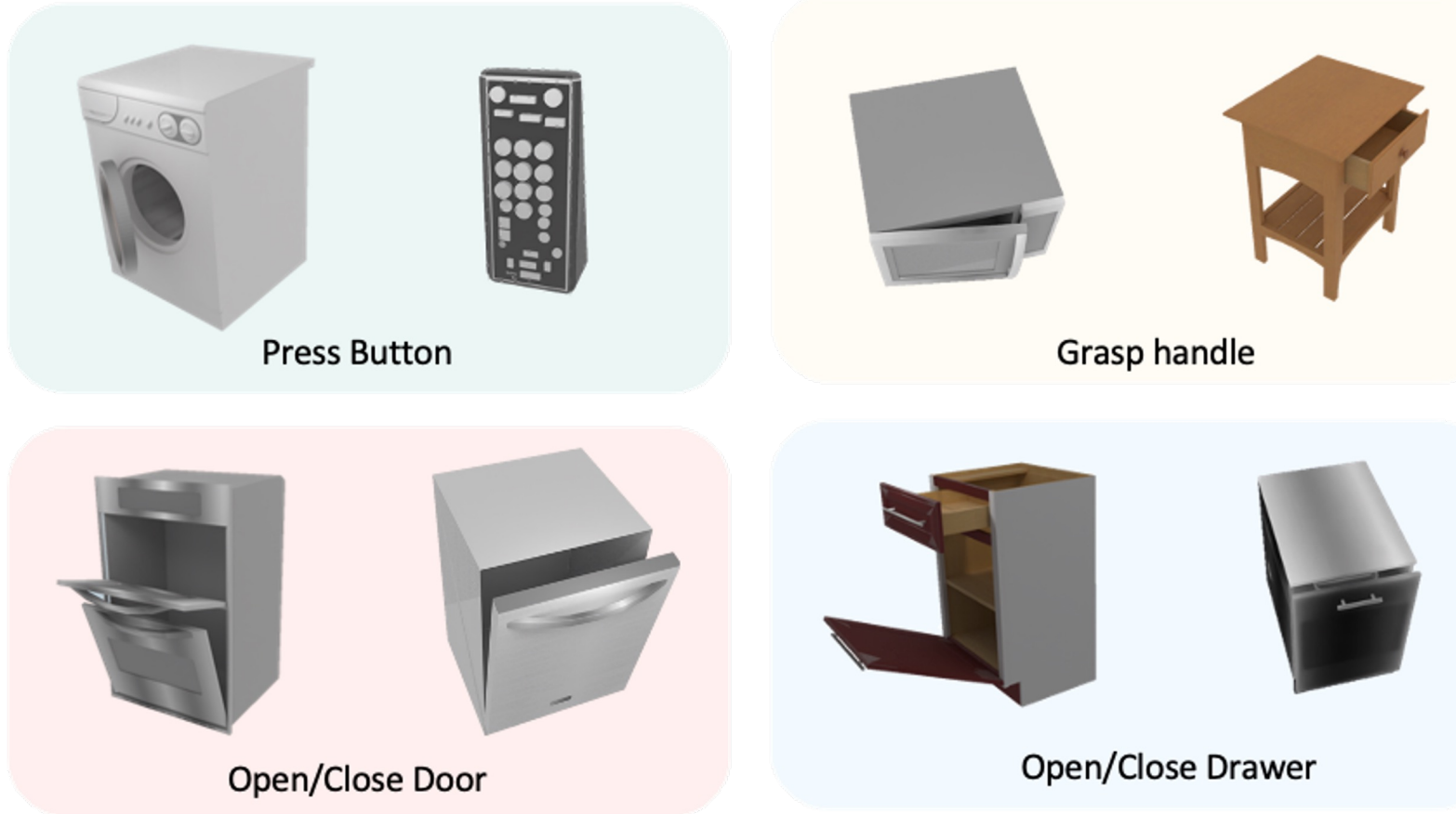
Manipulation: first train a state-based expert with our proposed part-based canonicalization and part-aware rewards, and then distill the knowledge to a vision-based student

Benchmark

Benchmark Statistics

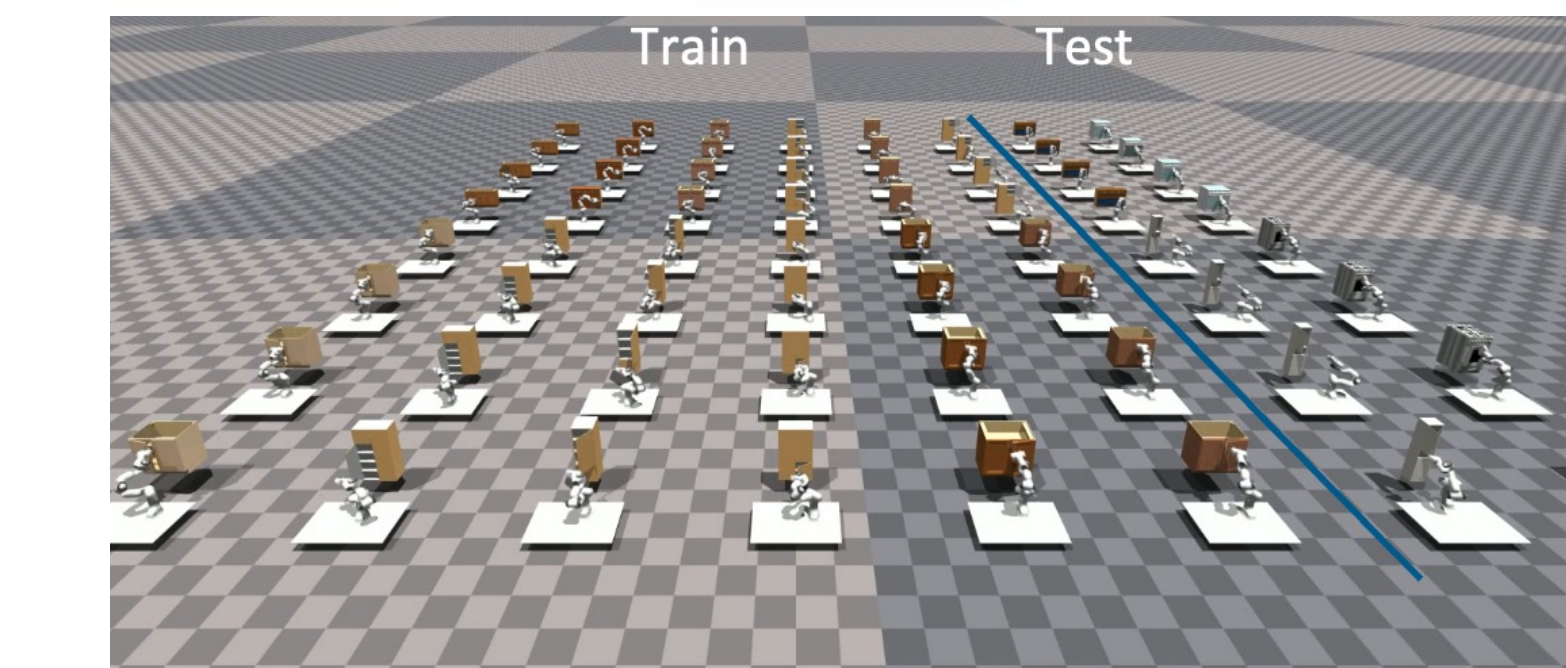
494 objects
11 object categories
Six tasks
1432 different parts

Object Categories in PartManip

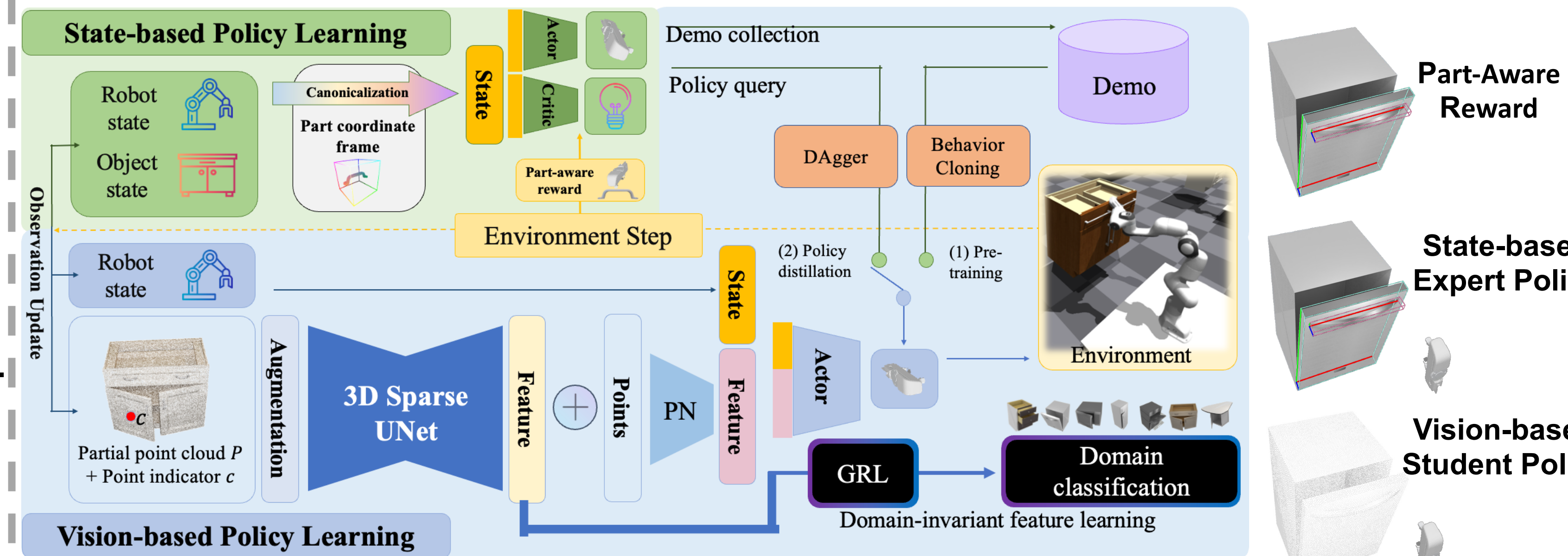


Cross-category Generalization

Training: **Seen Categories**
Testing: **Unseen Categories**



Methods



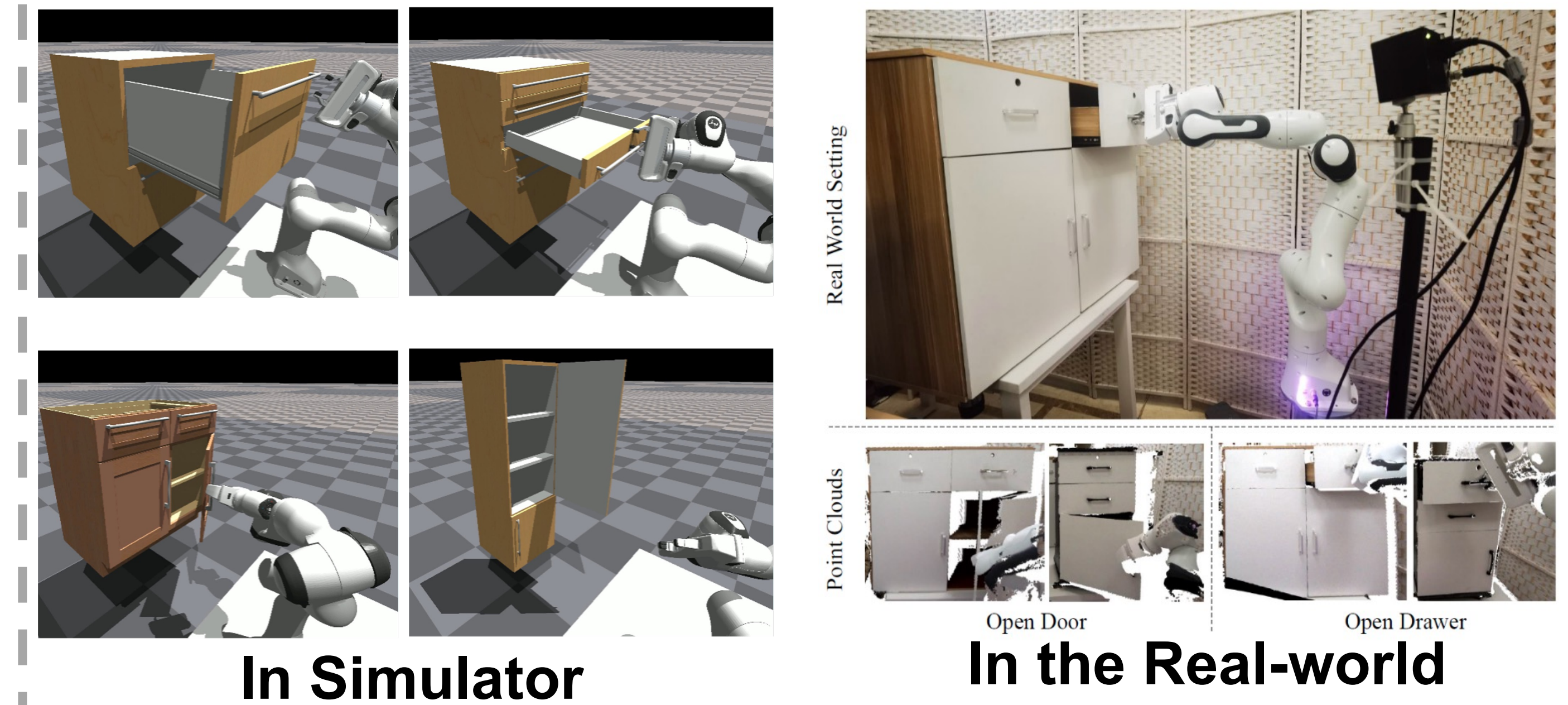
Results

Success rate (%)	OpenDoor			OpenDrawer		
	Training	Val-Intra	Val-Inter	Training	Val-Intra	Val-Inter
PPO [35]	4.5±3.8	4.9±3.5	0.2±0.2	8.9±2.8	11.3±2.8	3.3±1.6
ILAD [48]	13.3±4.9	6.3±2.5	5.0±4.1	18.7±3.6	18.3±2.9	3.3±2.9
Where2act [24]	25.4±0.1	23.4±0.0	15.2±0.1	39.6±0.2	37.2±0.2	20.5±0.1
SilverBullet3D [26]	54.6±2.5	49.9±1.0	26.9±2.2	77.7±3.3	60.0±2.0	31.2±5.1
Shen et. al [38]	1.5±0.6	0.3±0.6	2.3±4.0	9.7±0.5	18.0±2.2	2.7±1.9
Wu et. al [46]	45.9±2.3	34.1±3.8	17.8±1.4	70.5±2.2	53.3±3.3	28.5±2.4
Dubois et. al [5]	35.4±4.4	25.1±2.1	1.3±1.0	61.4±4.3	38.3±2.0	2.7±1.6
Ours	68.4±1.1	57.2±0.4	49.1±1.5	82.3±2.1	78.7±2.0	54.7±4.2

Comparison with Baselines.

Success rate (%)	Canon	DAGger	Augm	S-Unet	Pretrain	DomAdv	Opening Door			Opening Drawer		
							Training	Val-Intra	Val-Inter	Training	Val-Intra	Val-Inter
State-based Expert	✓						67.8±3.4	50.2±1.9	23.4±3.9	71.5±2.1	62.5±2.3	37.5±5.2
Vision-based Student		✓		✓			4.5±3.8	4.9±3.5	0.2±0.2	8.9±2.8	11.3±2.8	3.3±1.6
		✓		✓			0.8±0.5	0.4±0.2	0.0±0.0	5.9±2.3	3.9±0.6	1.0±0.2
		✓		✓			60.3±0.7	49.2±1.1	31.5±2.9	70.9±0.6	62.0±1.1	42.7±1.8
		✓		✓			66.8±2.7	50.2±1.7	28.8±2.1	77.4±2.7	61.9±3.0	36.4±3.3
		✓		✓			60.0±1.7	54.4±2.3	40.2±3.9	69.7±2.4	69.8±2.5	49.0±2.1
		✓	✓	✓			65.5±1.5	55.9±2.7	41.7±2.5	74.6±3.4	63.8±4.7	49.1±3.4
		✓	✓	✓	✓		61.1±3.3	55.0±1.2	37.8±2.9	71.9±3.3	72.2±3.5	50.3±2.6
		✓	✓	✓	✓	✓	71.2±1.8	57.0±0.7	37.2±1.2	82.0±3.3	73.8±2.9	48.8±4.5
		✓	✓	✓	✓	✓	68.4±1.1	57.2±0.4	49.1±1.5	82.3±2.1	78.7±2.0	54.7±4.2

Ablation Study.



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