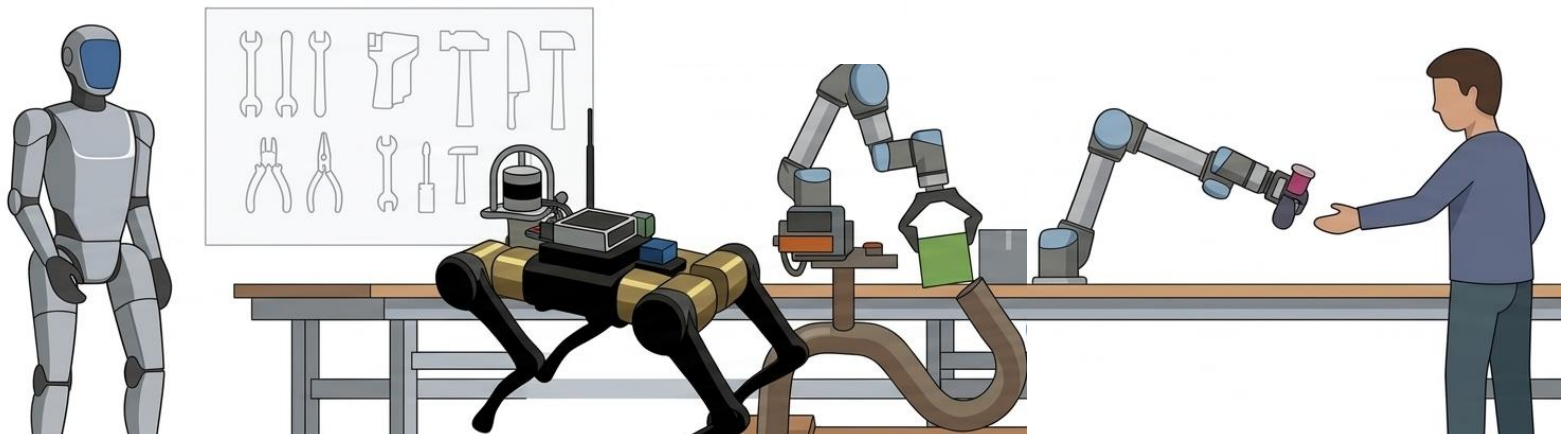
KAIST

RIRO LAB
Robust Intelligence & Robotics Lab

Robust Intelligence 강인지능 Robotics Lab 로보틱스 랩

Research Highlight



Dr. Daehyung Park
Associate Professor
School of Computing, KAIST

Name Daehyung Park

Affiliation School of Computing, KAIST

Degree Robotics Ph.D., Georgia Tech.

Research Interest Robotics, LfD, TAMP, NLG/NLU

Professional Activities

- Director, Korean Robotics Society (2025~Present)
- Demo Chair, CoRL (2025)
- Program Chair, RiTA (2024)
- Organizer, Workshop at Humanoids (2024)
- Organizer, Workshop at RSS (2023)

Major Research Experience & Awards

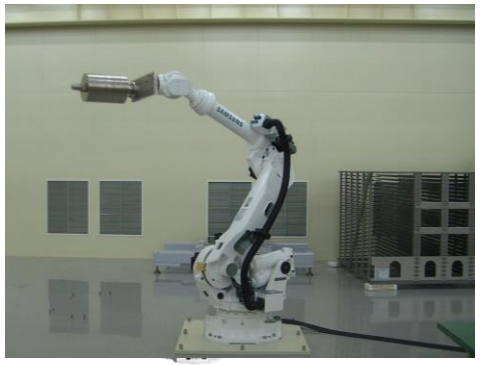
- Postdoctoral Associate, MIT CSAIL (2018-2020)
- Research Engineer, Samsung (2008-2012)
- ICRA Outstanding Planning Paper Award (2023)
- ICRA Outstanding Navigation Paper Award Finalist (2022)
- Google Research Scholar Award (2022)

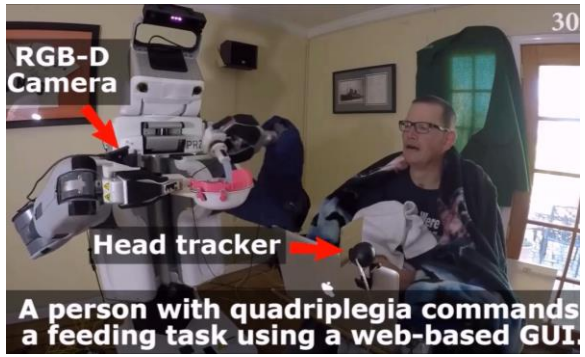
Funding Agencies

SAMSUNG NRF 산업통상자원부 IITP 정보통신기획평가원

Google Research DRB

Representative Work





Korea Advanced Institute of Science and Technology

At a Glance

Opened
in 1971

Located
in Daejeon, S. Korea

Students
12,348

Comprise of 6 Colleges
7 Schools
33 Departments
55 Programs

Faculty and Staff

Faculty	731
Staff	907

International Population

Faculty	137
Students	929

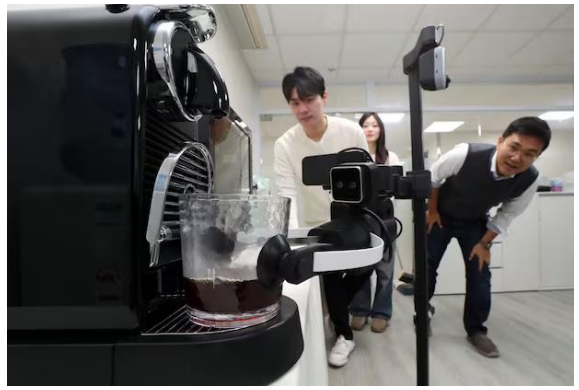
Robust Intelligence & Robotics (RIRO) Lab

Opened
in 2020 Fall

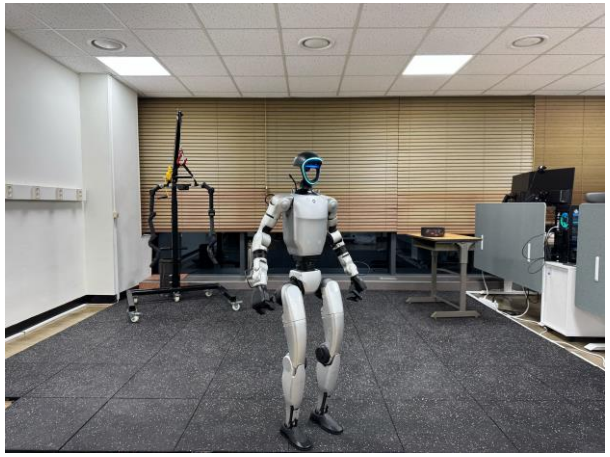
Affiliation
School of Computing

Members
4 Ph.D. (+1 soon)
11 M.S.
1 visiting scholar

Research Area
Manipulation,
Skill Learning,
HRI



KAIST



Robust Intelligence & Robotics Lab

Robust Intelligence & Robotics (RIRO) Lab

Projects

Gov. Proj	7
Industry Proj	3

Facilities

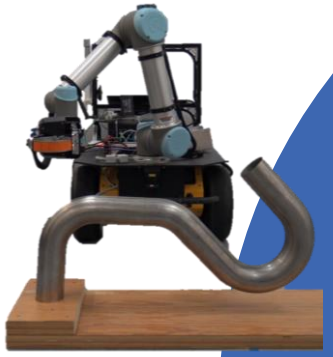
Office room	3
Robot Lab	3
Server	6ea.
Workstation	8ea.
3D Printer	2ea.

Equipments

Humanoid Robot	1ea.
Dual Arm	1ea.
Robot Arm	2ea.
Mobile Arm	2ea.
Robot Hand	1ea.
Quadruped Robot	1ea.

Human-Centered Robotics:

How to bridge the gap between humans and robots?



Skill Learning

Task-and-Motion Planning

Human-Centered Robotic Manipulation

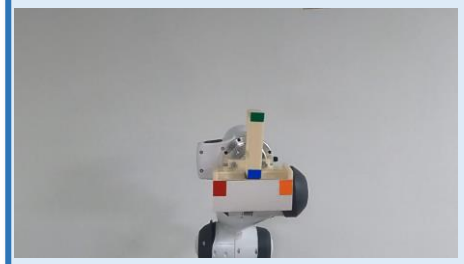
Machine Commonsense

Natural Language Understanding

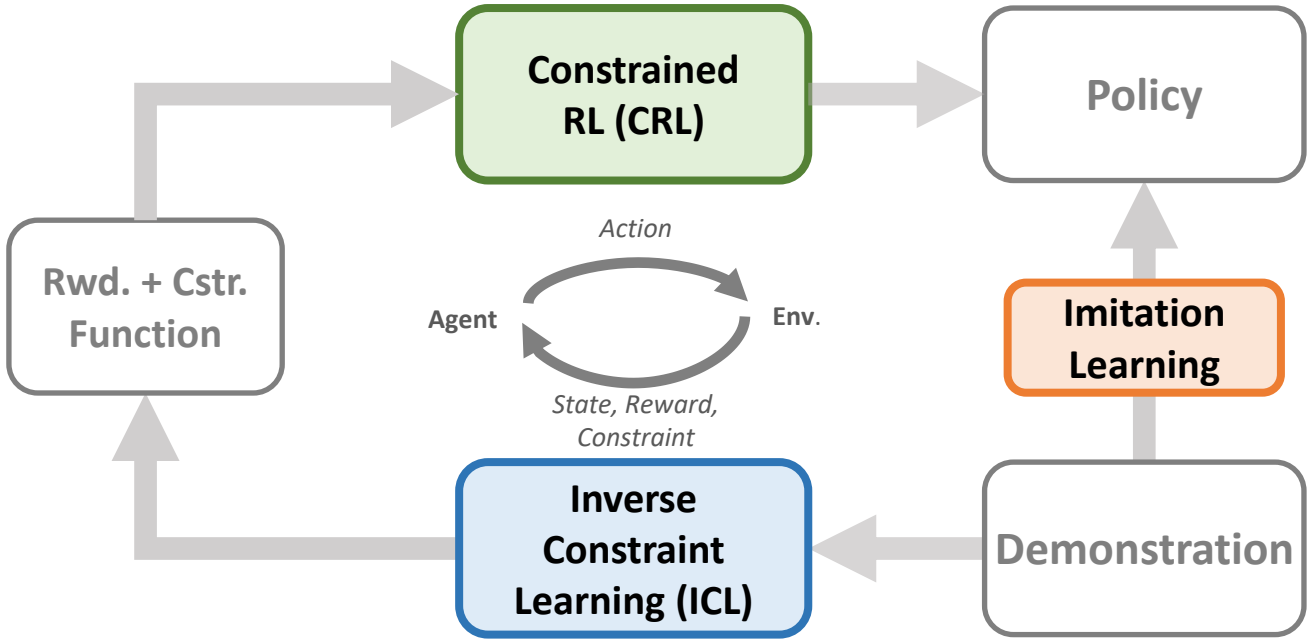
I arrived at the door.
"Push the door"

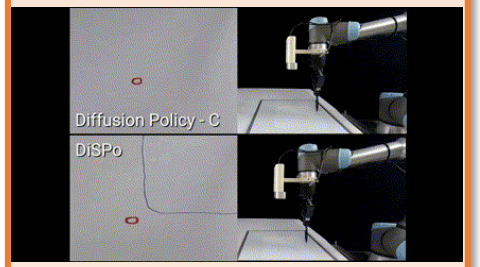
Inverse Skill Learning

Inverse Logic-Constraint Learning (RA-L'25)

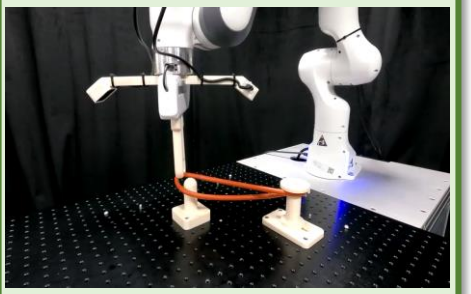


Transferable Constraint Learning (RA-L'24)

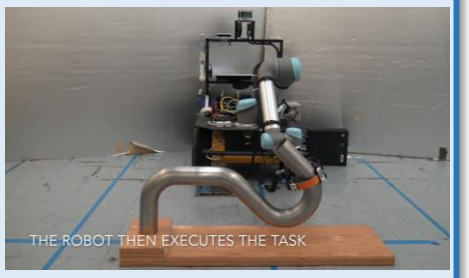




Diffusion-SSM based Policy (ICRA'26)



Deformable Object Manipulation (RSS'25)



Constraint-based BN-IRL (CoRL'19)

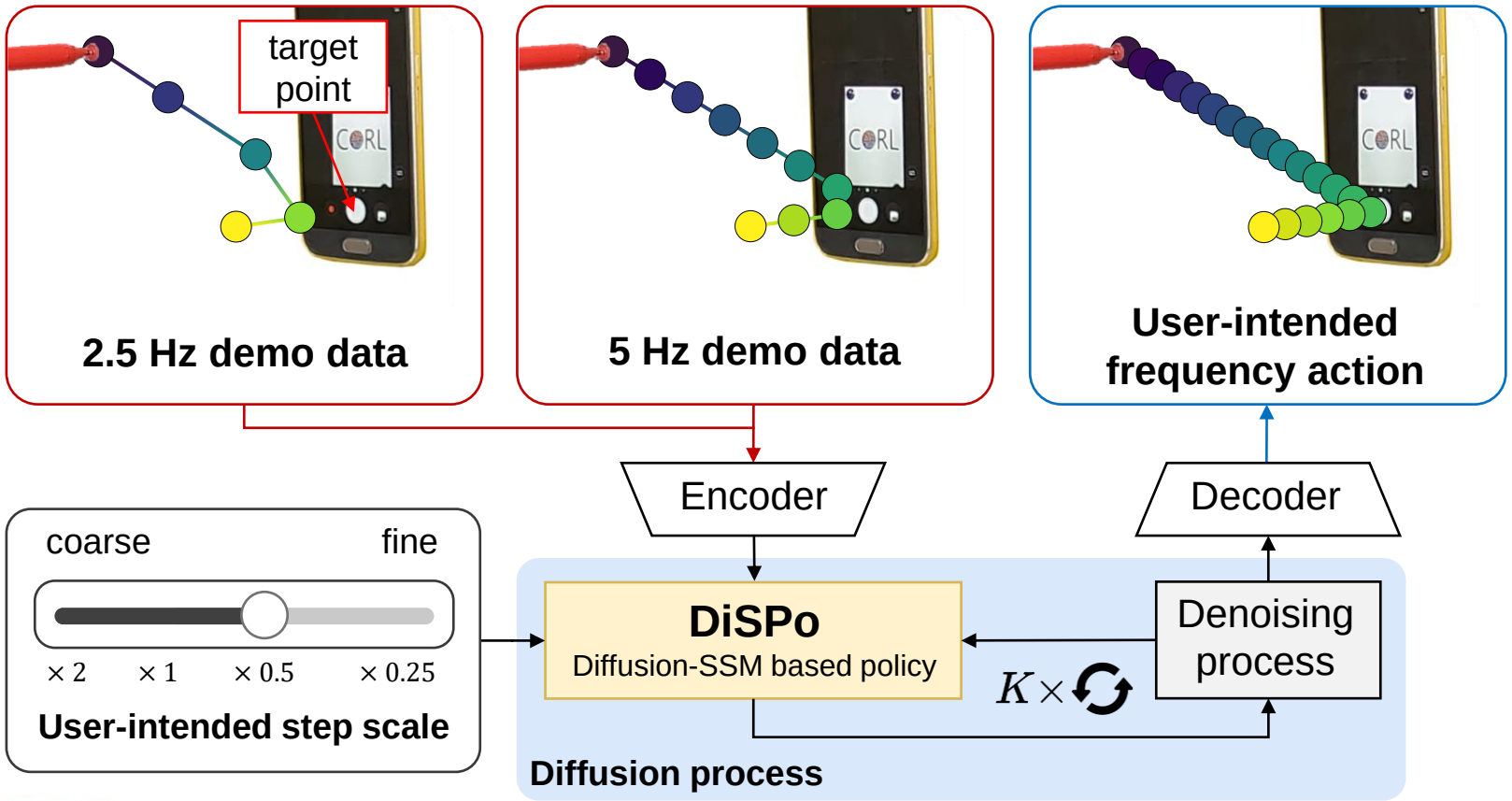
Dynamic Movement Primitives ('07-'08)

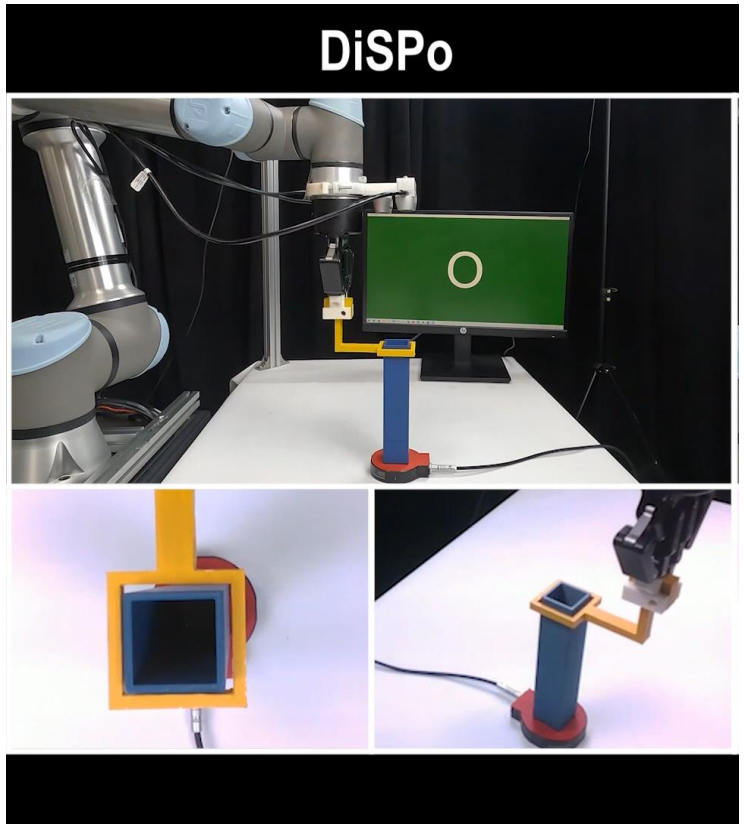
Coarse-to-fine manipulation

DiSPo: Diffusion-SSM based Policy

Jaehyeong

DiSPo that leverages a state-space model, Mamba, to learn from diverse coarse demonstrations and generate multi-scale actions.





Oh, Nayoung, et al. "DiSPo: Diffusion-SSM based Policy Learning for Coarse-to-Fine Action Discretization." ICRA, 2026.

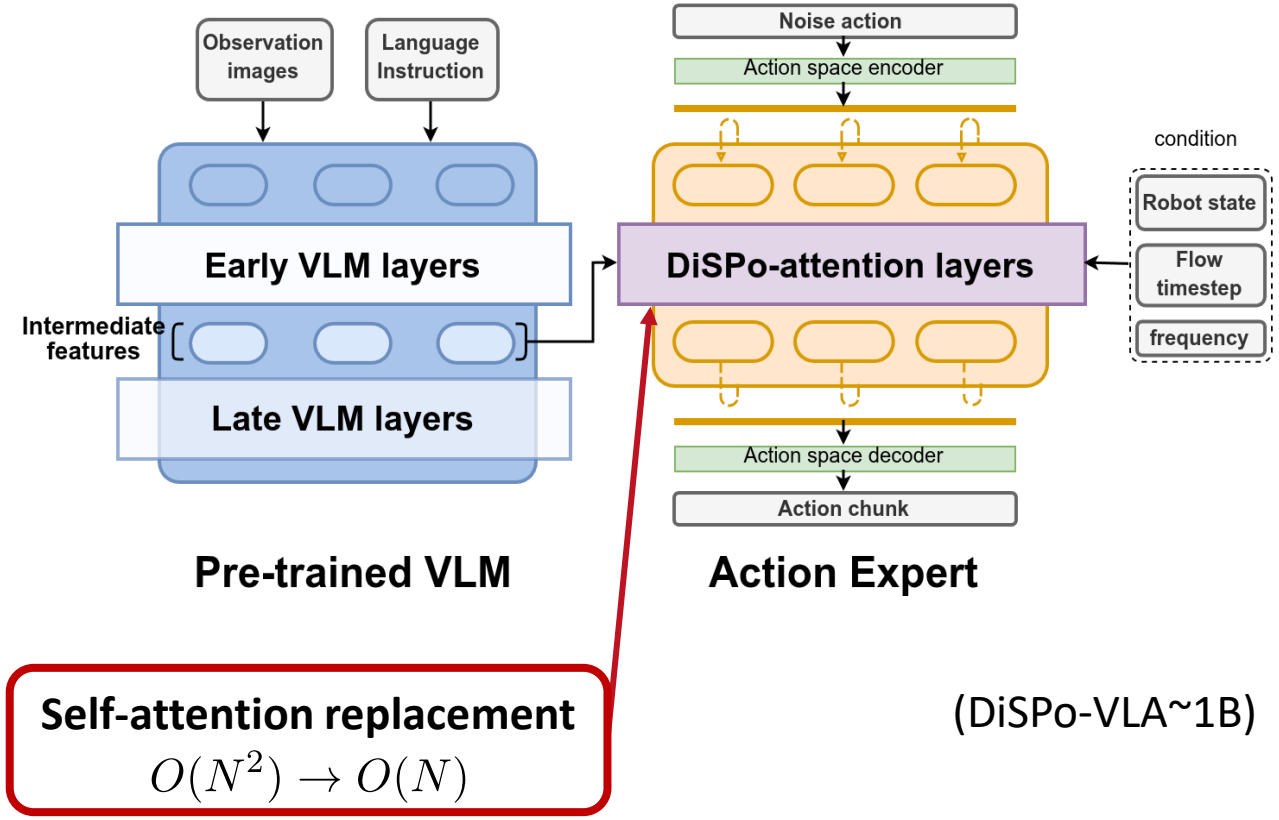
Coarse-to-fine manipulation

DiSPo-VLA (1B)

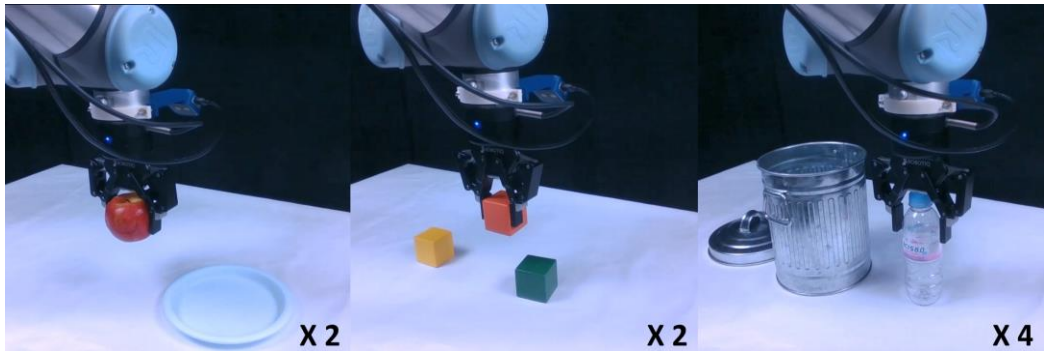
Sangyun

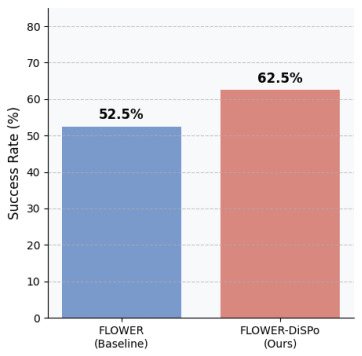
(to be submitted)

DiSPo's multi-granularity learning reduces time & storage complexities in large scale training.

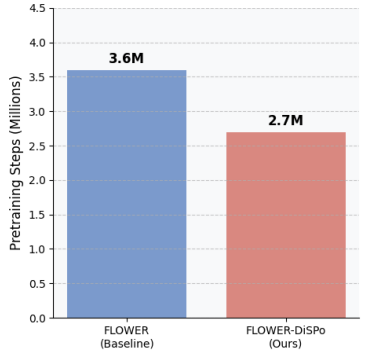


(DiSPo-VLA~1B)

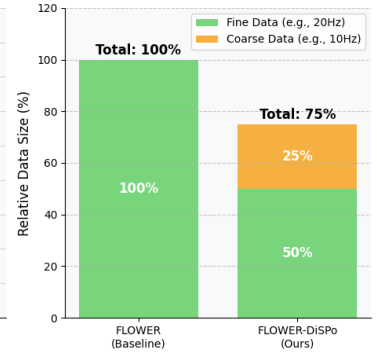




Success Rates



Pretraining steps

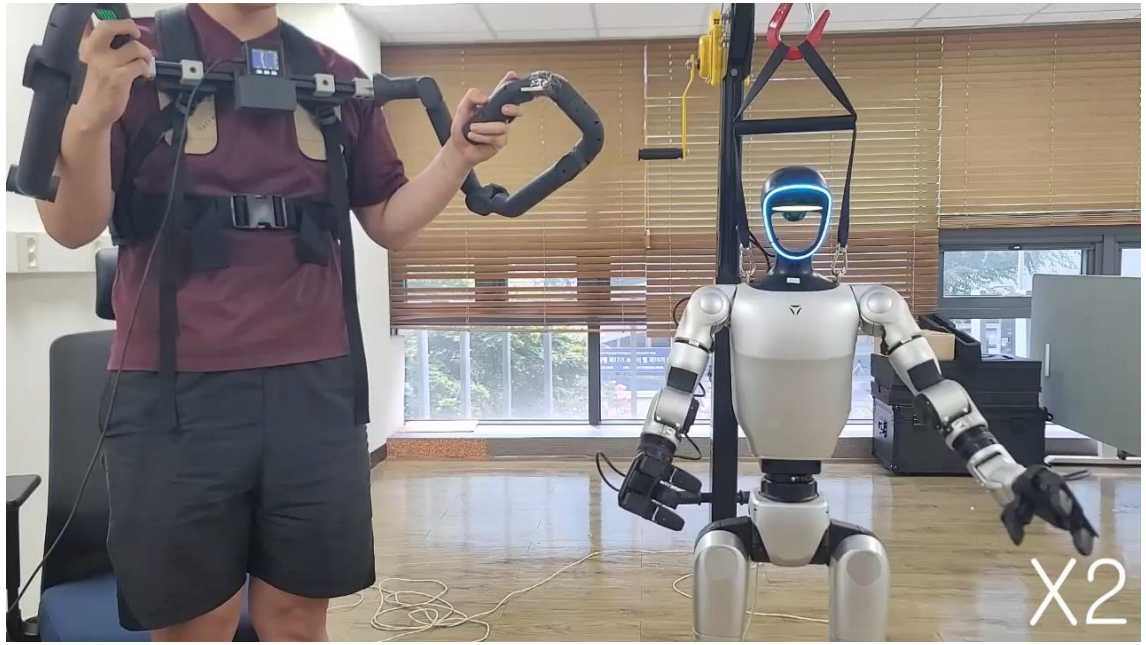


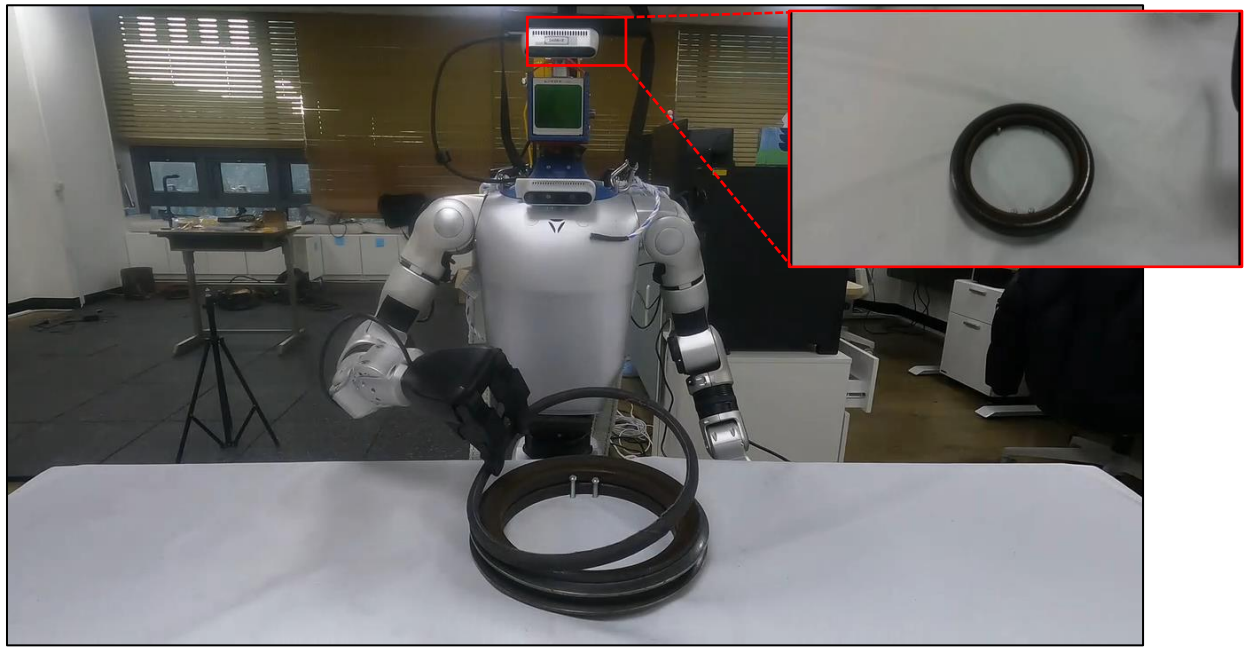
Relative dataset size

Humanoid Bi-manual Manipulation


Seungsup Chankyu

We learn manipulation skills for highly elastic deformable objects using a humanoid's dual arms via reinforcement learning.





Constraints in Everyday Tasks

Credit: Ljupco

A wide variety of constraints

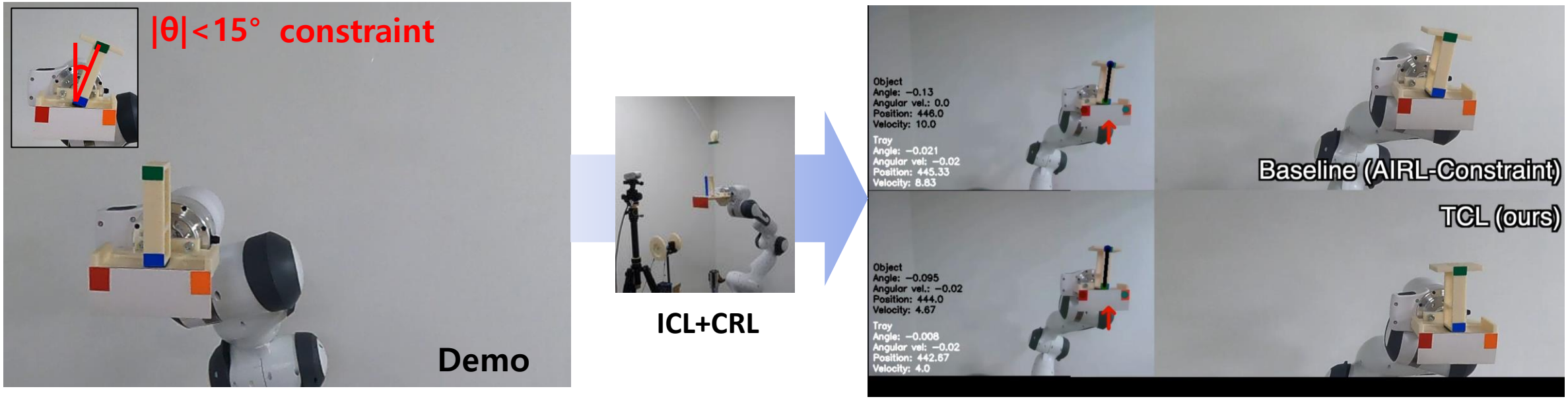
- Safety constraints
- Operational constraints
- Task-specific constraints
- Preference, legal, privacy, etc.

You may fail to complete the carrying without satisfying constraints.

Inverse Constraint Learning

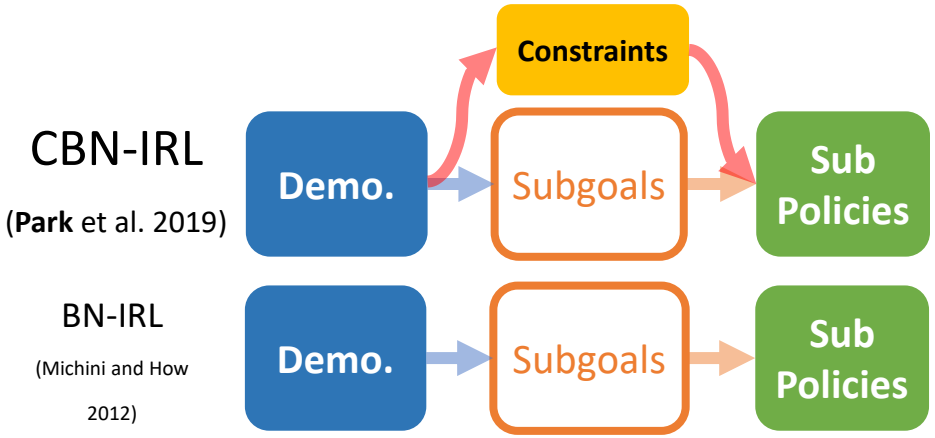
Transferable Constraint Learning (TCL)

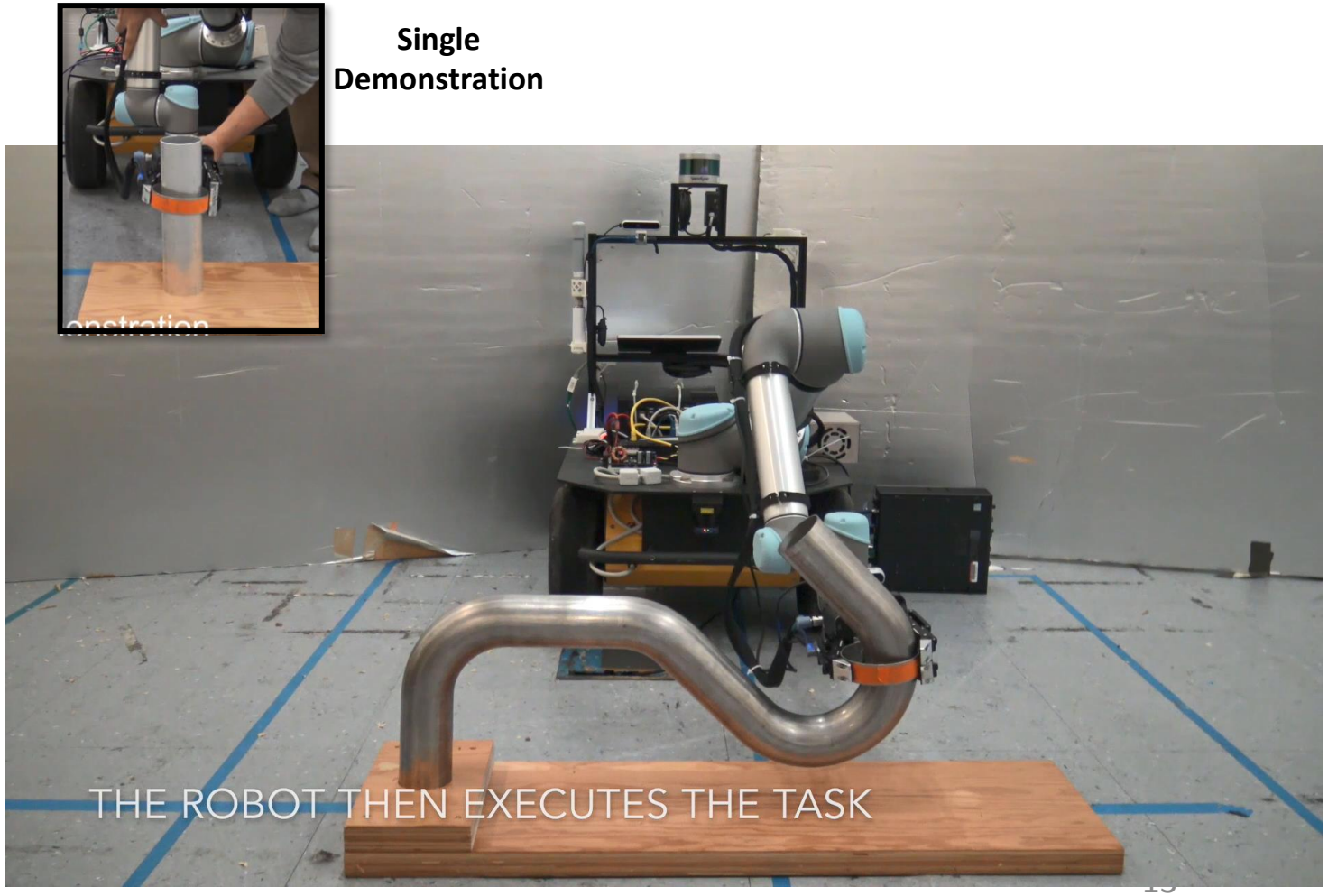
A transferable constraint learning (TCL) algorithm that jointly infers a task-relevant reward and task-agnostic constraint.



J. Jang et al., "Inverse Constraint Learning and Generalization by Transferable Reward Decomposition," RA-L, 2024.

> **Locally active constraints are common in manipulation.**





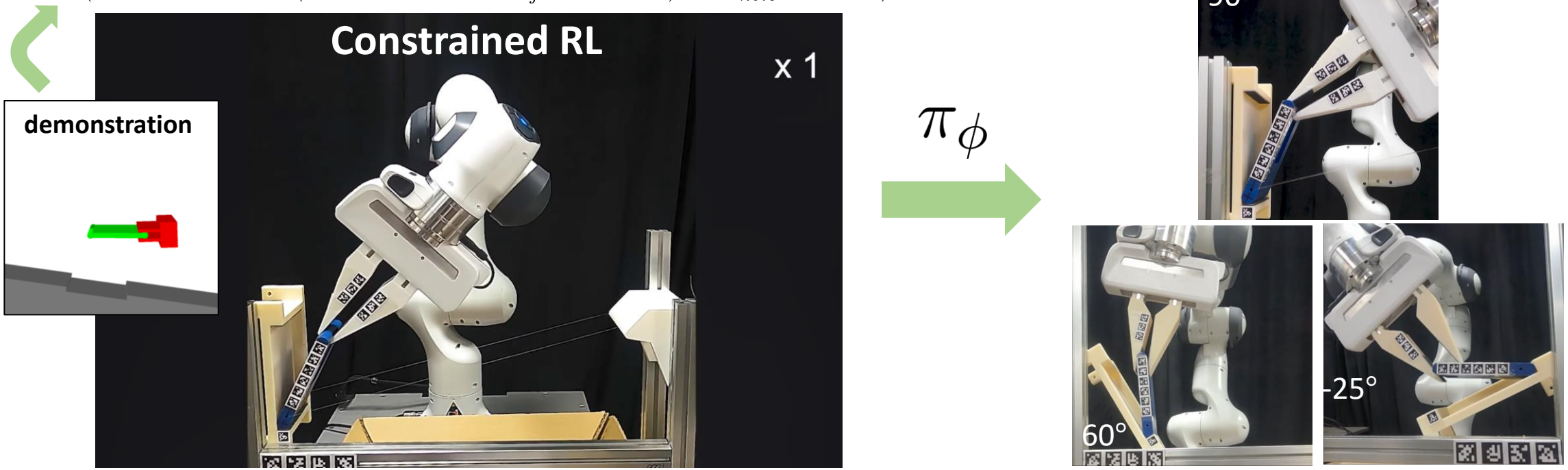
Park, Daehyung, et al. "Inferring task goals and constraints using bayesian nonparametric inverse reinforcement learning." CoRL, 2020.

Inverse Constraint Learning

ILCL : Inverse Logic-Constraint Learning

ILCL learns temporal logic constraints from temporally constrained demonstration leveraging two-player zero-sum game framework.

$$\diamond\left(^{\Sigma_h}\theta^{peg} > 34.88^\circ \wedge \left(^{\Sigma_h}\theta^{peg} < 4.217^\circ \ \mathcal{R}\ d^{peg}_{jaw} < 0.0053\right) \wedge \Box d^{peg}_{hole} < 0.0072\right)$$



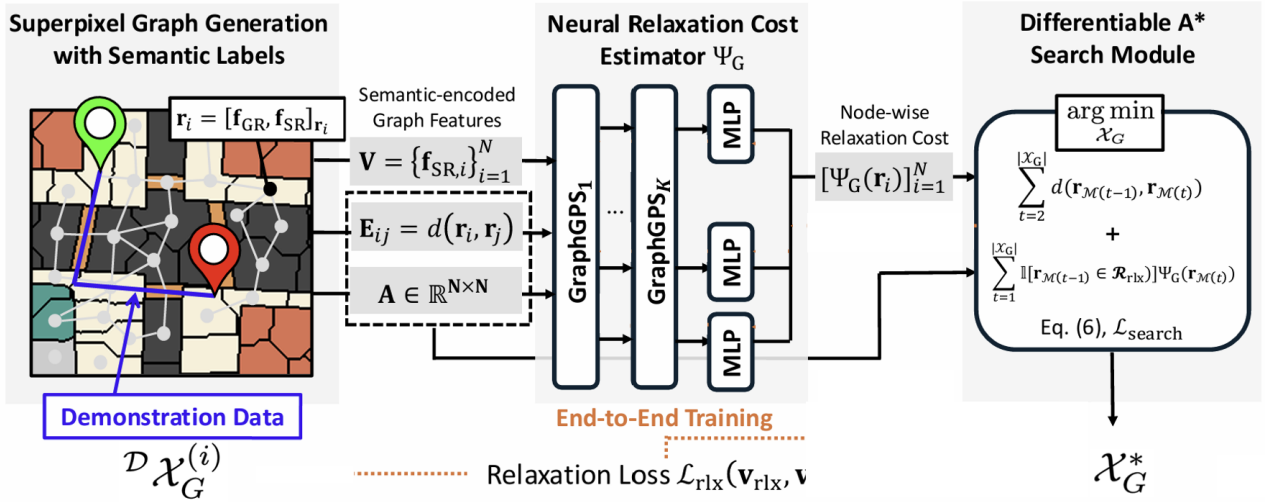
Cho, Minwoo, Jaehwi Jang, and Daehyung Park. "ILCL: Inverse Logic-Constraint Learning From Temporally Constrained Demonstrations." *RA-L,* 2025.

SuReNav: Superpixel Graph-based Constraint Relaxation for Navigation in Over-constrained Environments

Moonkyeong

Can we find a best-effort solution that avoids all hard constraint regions while minimally traversing the least risky areas?

SuReNav learns to automatically relaxes regional constraint while planning a graph path.

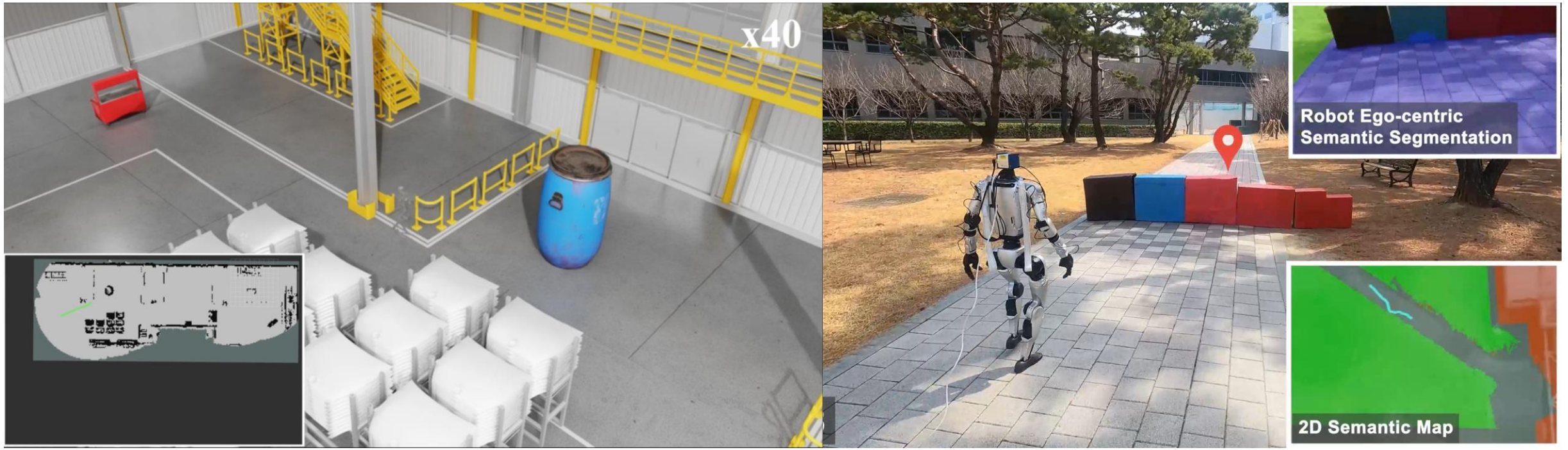


Koh, Keonyoung, et al. "SuReNav: Superpixel Graph-based Constraint Relaxation for Navigation in Over-constrained Environments." ICRA, 2026.

SuReNav+: Human-like Humanoid Nav.


Woosong Hyungjin

We extend SuReNav by integrating human preference-aware constraint relaxation and navigation on a superpixel graph in and outdoor environments.



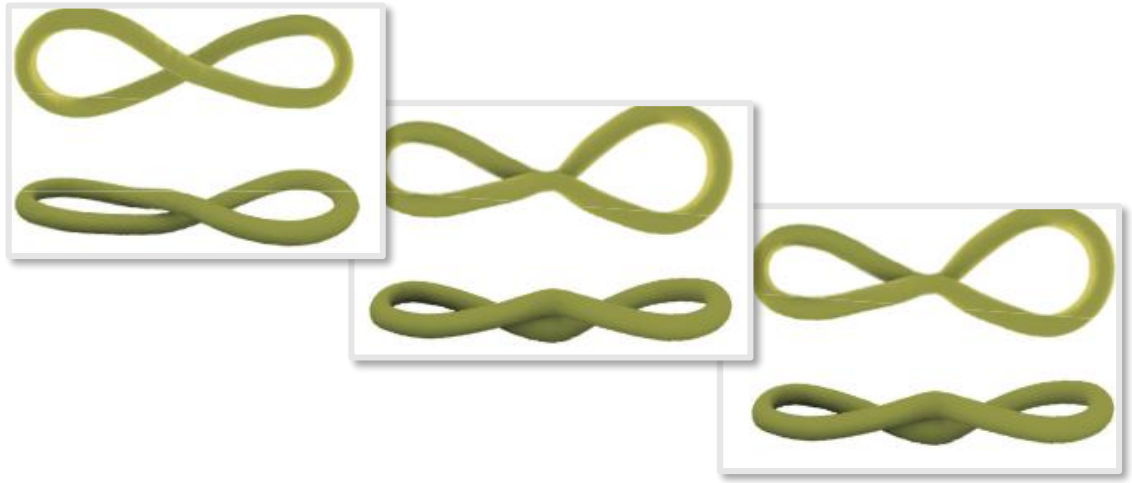
Implicit Neural-Representation Learning for Elastic Deformable-Object Manipulations

Minseok

Problem: Deformable elastic-object manipulation in real world

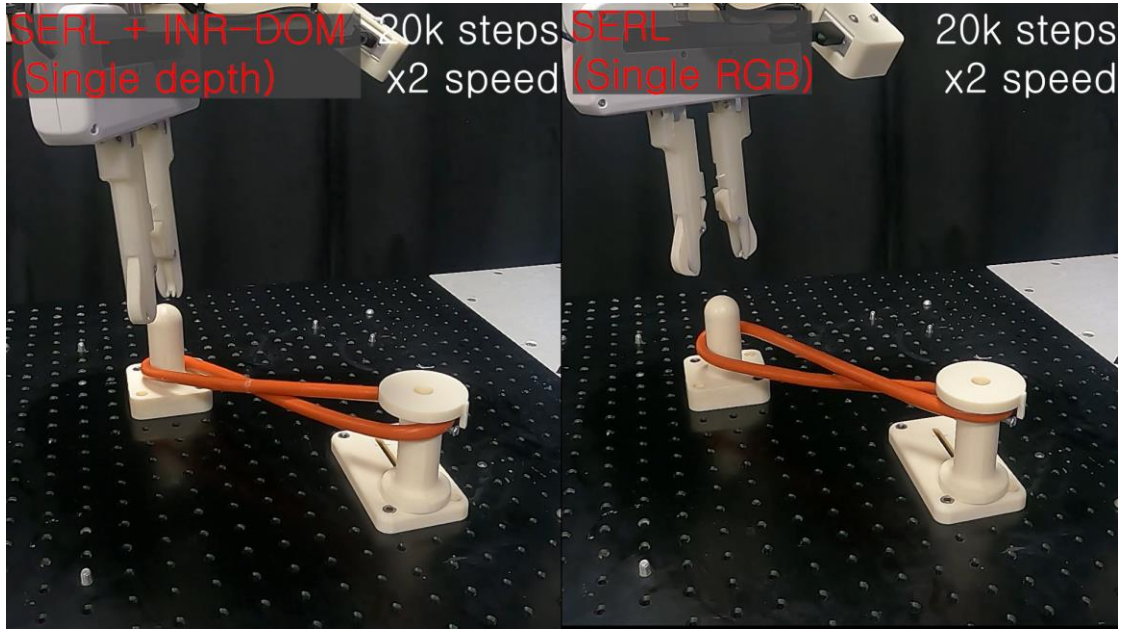
Challenge: Partially-observable unlimited DoF → sampling complexity in RL

Solution: Implicit neural representation learning with contrastive RL



Visually similar, but geometrically largely different DLOs

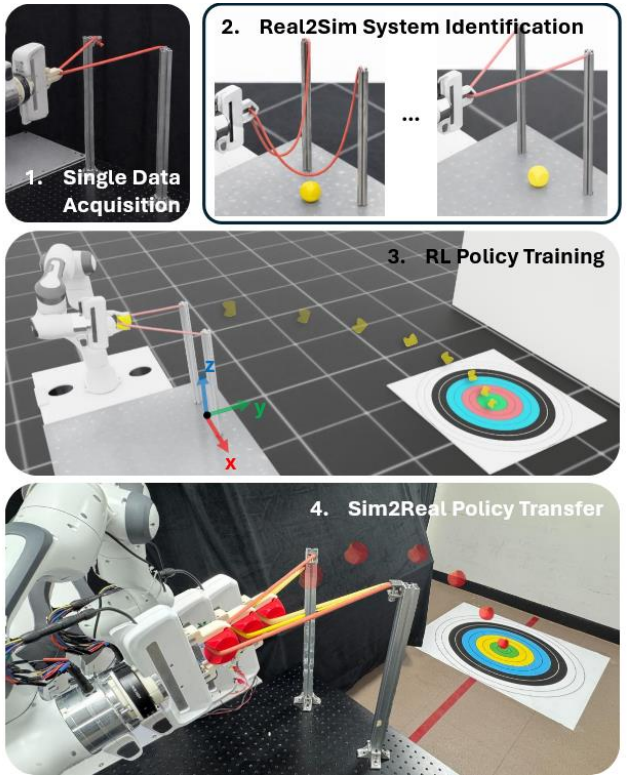
→ precise & consistent representations

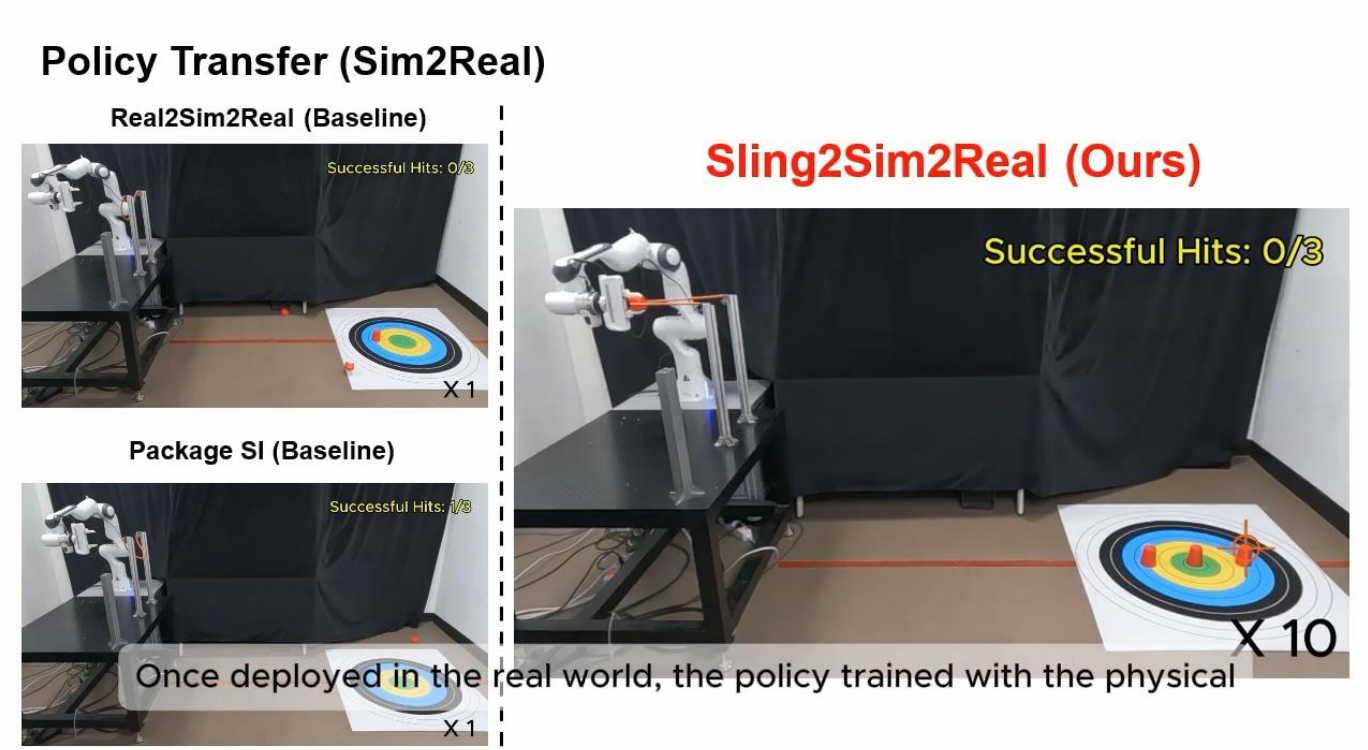


Sling2Sim2Real: One-Shot Elastic System Identification for Non-Destructive Slingshot Policy Learning

(under review)

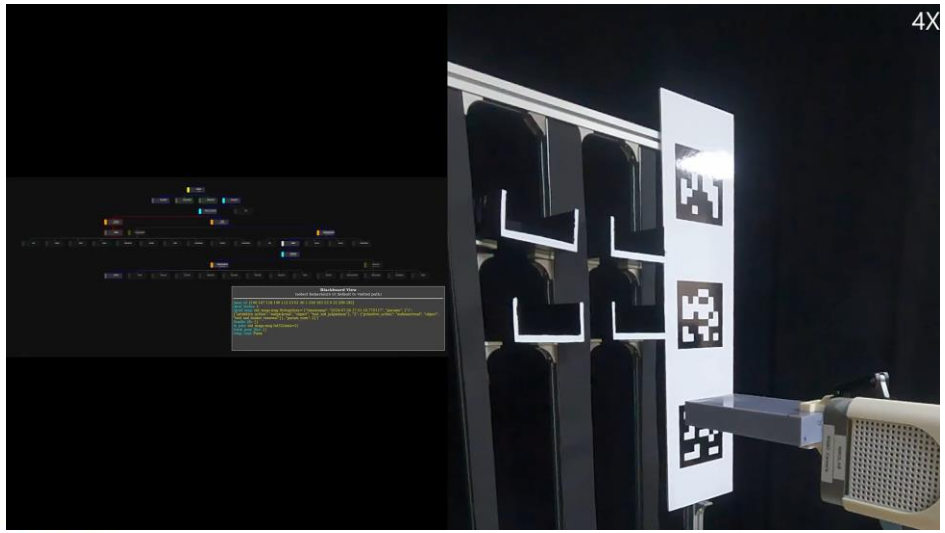
Our one-shot Real2Sim2Real framework that identifies elastic parameters from a single non-destructive interaction and enables policy learning in simulation.





Task and/or Motion Planning

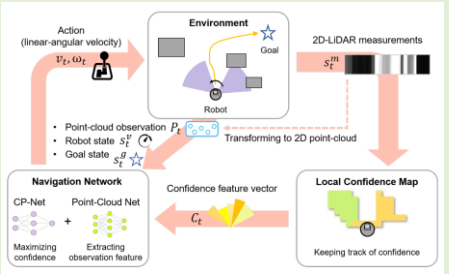
- **Motion planning under environmental changes or occlusions**
- **Task (re)-planning under changes**
- **Online-recovery with behavior tree**
- **Learning-based collision check**



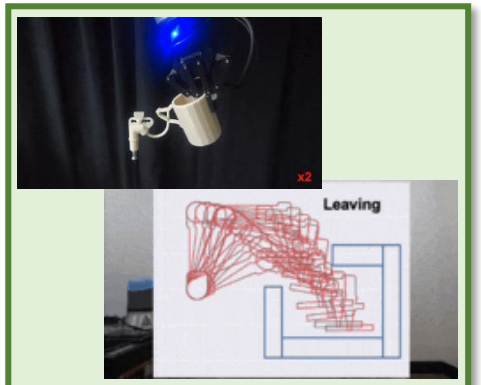
Recovery with behavior tree

Reactive TAMP
(ICRA'21)

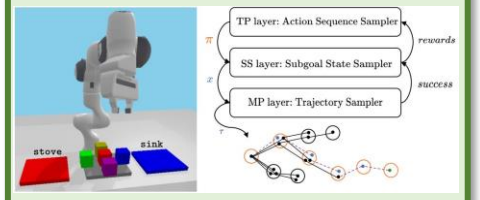
Outstanding Navigation Award Finalist



Confidence-based Nav.
(ICRA'22)



GraphDistNet
(ICRA'24, RA-L'22)

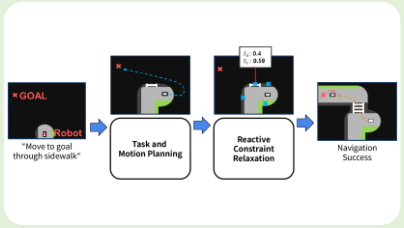


Reachability Tree-based TAMP
(ICRA'23)

Outstanding Planning Paper Award

Traj. Optimization
(ICRA'23)

Student Paper Award



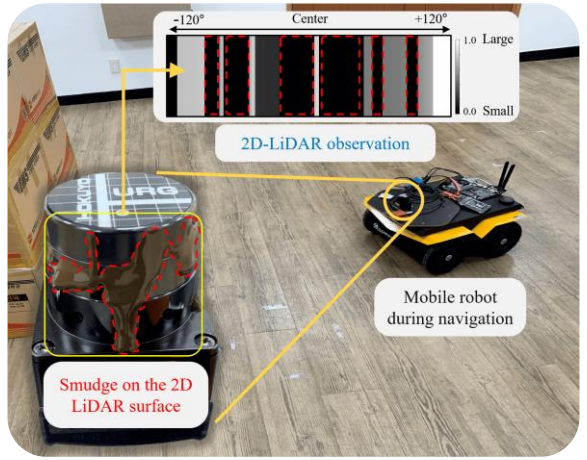
Reactive Constraint Relaxation
(RiTA'22)

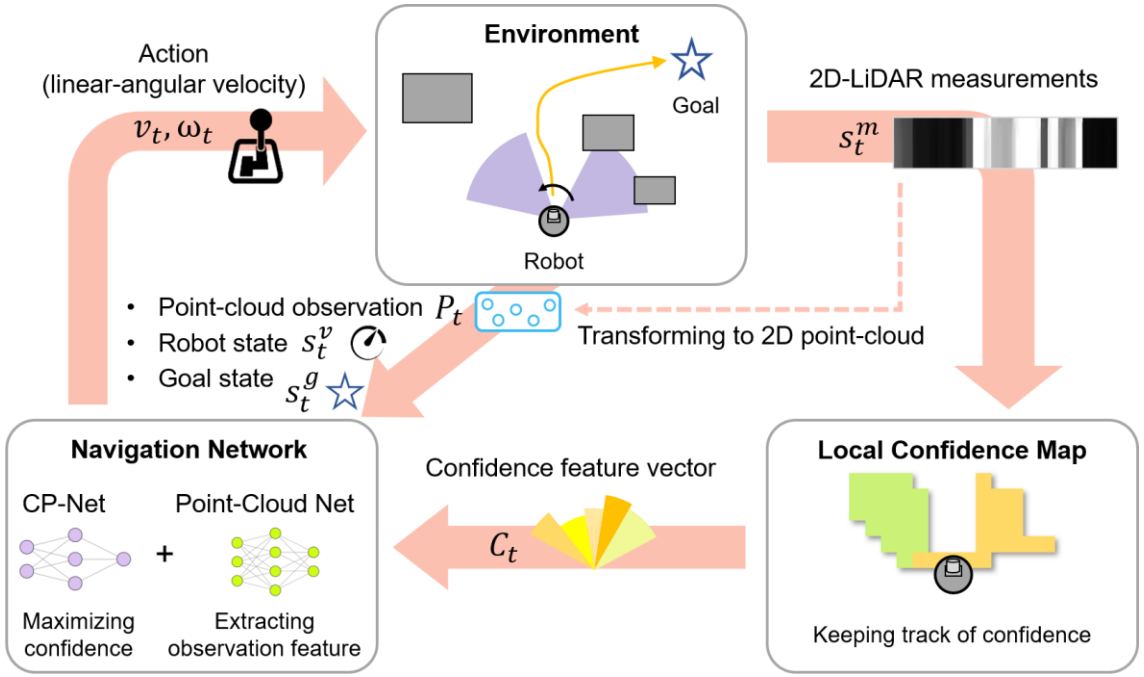
Confidence-Based Robot Navigation Under Sensor Occlusion

ICRA22 – Outstanding Navigation Paper Finalist

Consider unexpected occlusions on navigation sensors.

We propose a **confidence-based navigation method** trained through DRL. (Collaboration with Prof. Sung-eui Yoon)



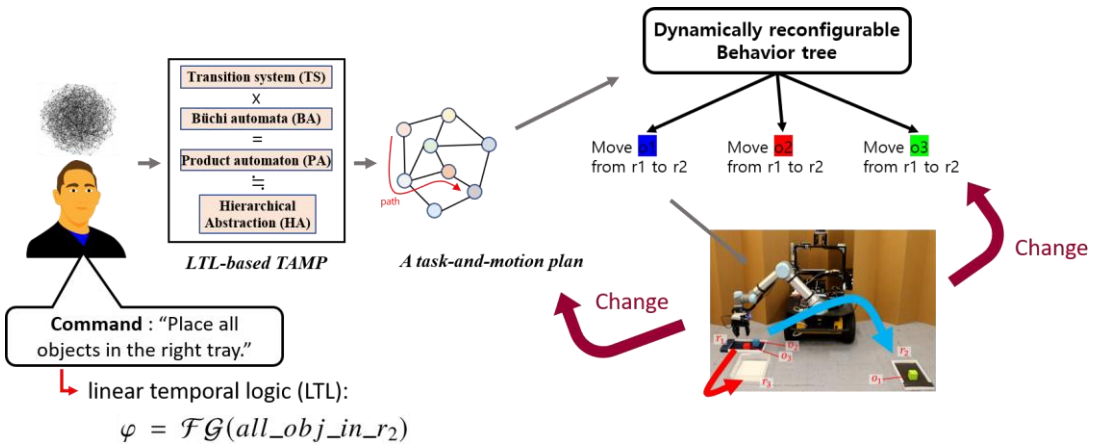


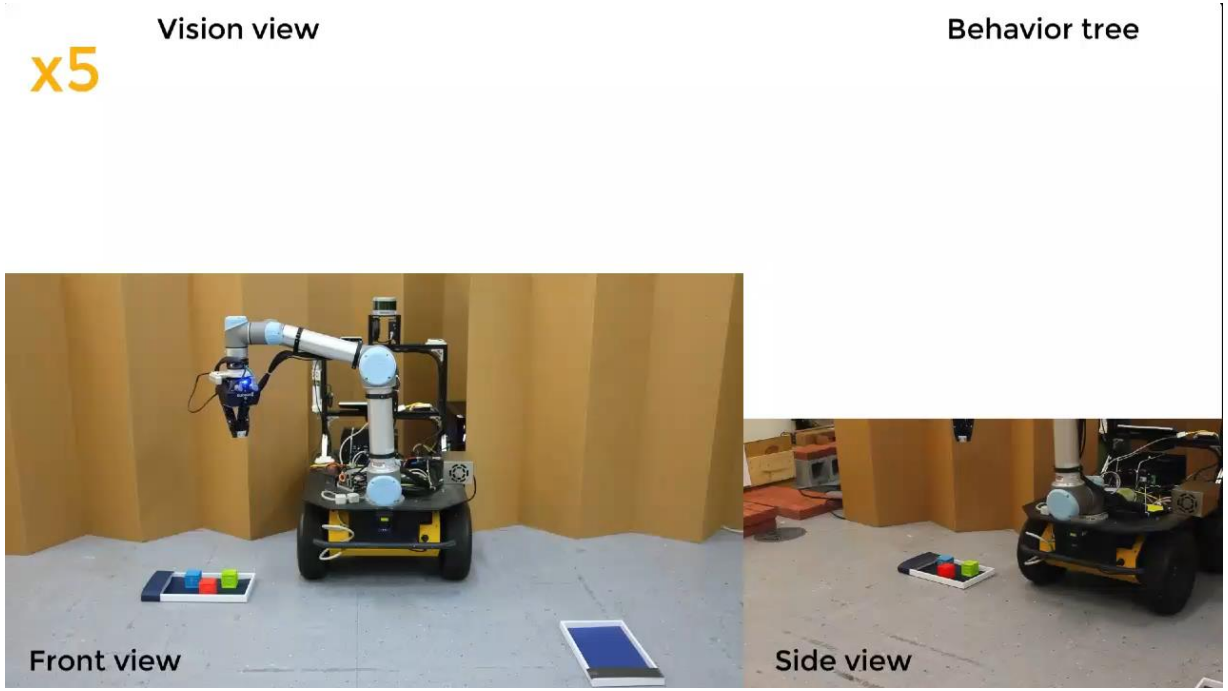
Ryu, Hyeongyeol, et al. "Confidence-based robot navigation under sensor occlusion with deep reinforcement learning." *ICRA*, 2022.

Task and Motion Planning under Changes

We propose **TAMP with Linear Temporal Logic (LTL).** (Collaboration with Dr. Shen Li and Dr. Yoonchang Sung)

The hierarchical architecture for efficient replanning and execution to handle environmental changes





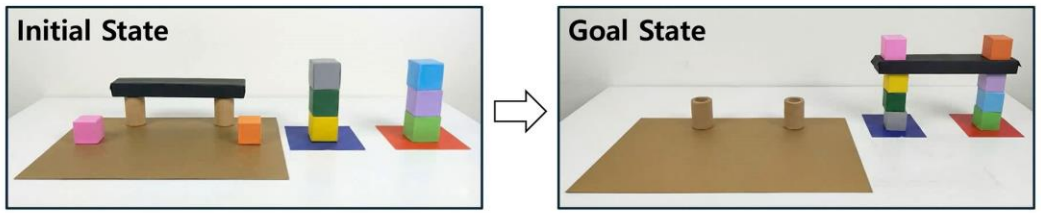
ForeSight: Autoregressive Plan Monitoring for Efficient Long-Horizon Replanning and Execution

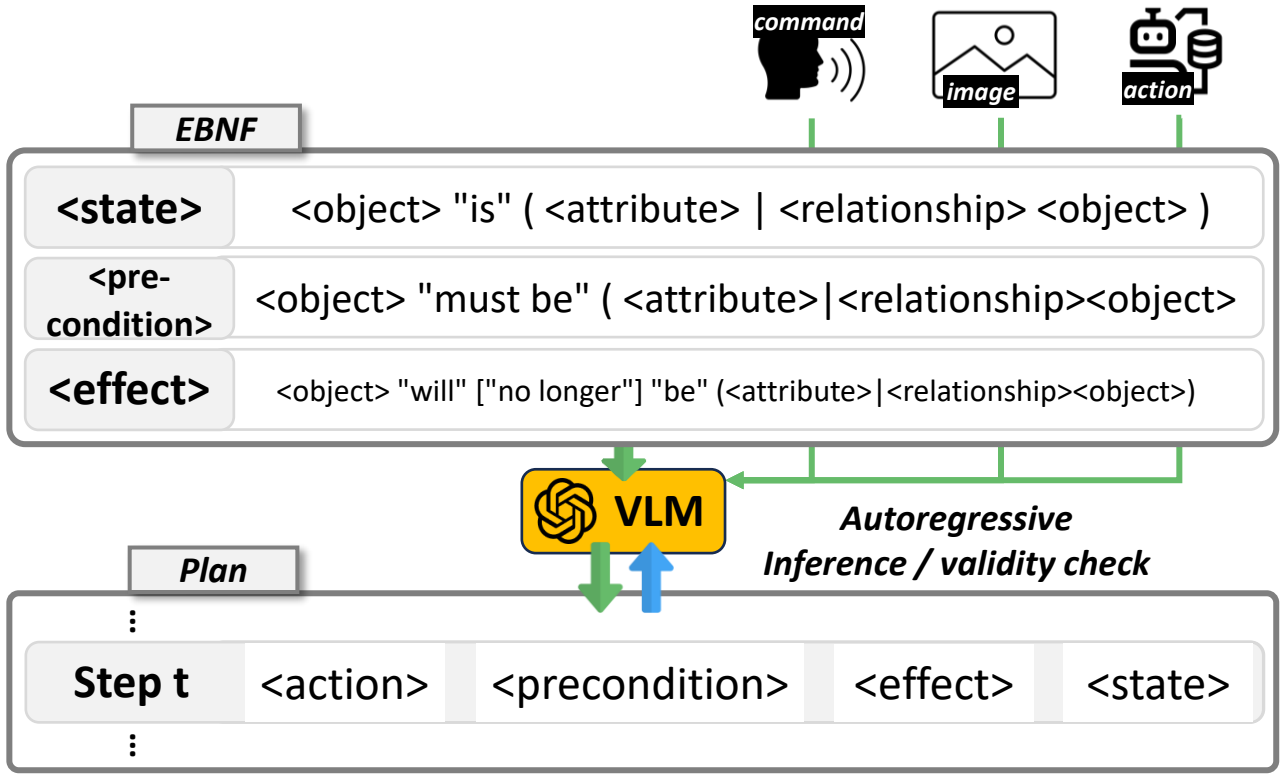

Yeseung Gyungjin

(under review)

- **Extended Backus–Naur Form (EBNF)-based Chain-of-State prompt**
  - ⟶ *Consistent representation* for *long-horizon task planning*
- **Autoregressive plan validity checking**
  - ⟶ *Early detection + Reactive planning*

Task: Build a tower using cubes and one bar.



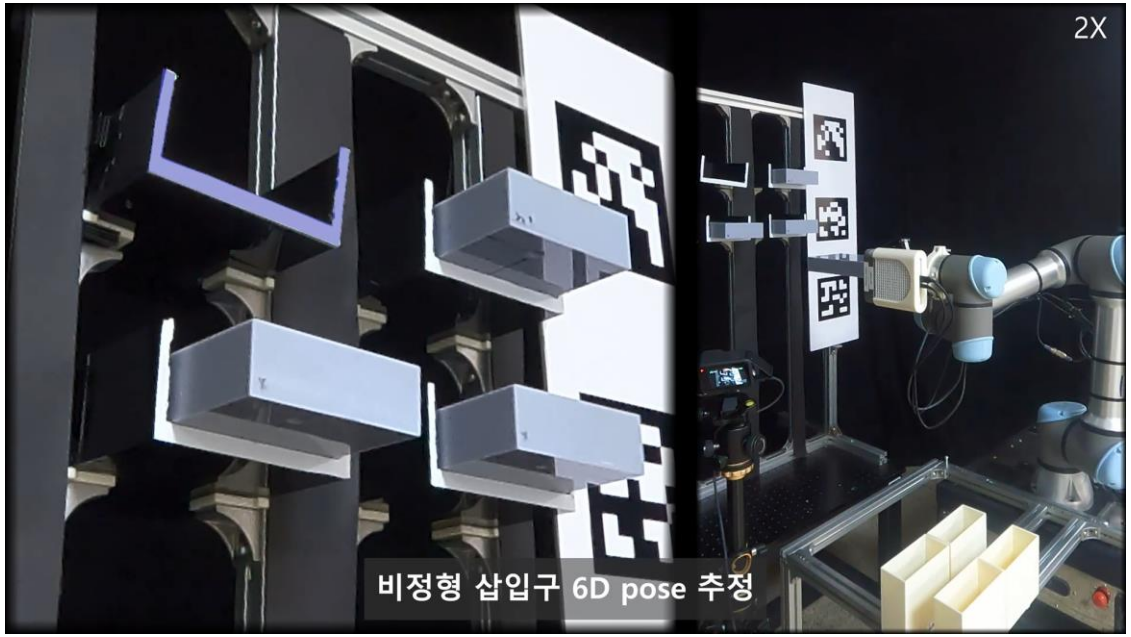


Multimodal Task-and-Motion Planning for multi-pack insertation task

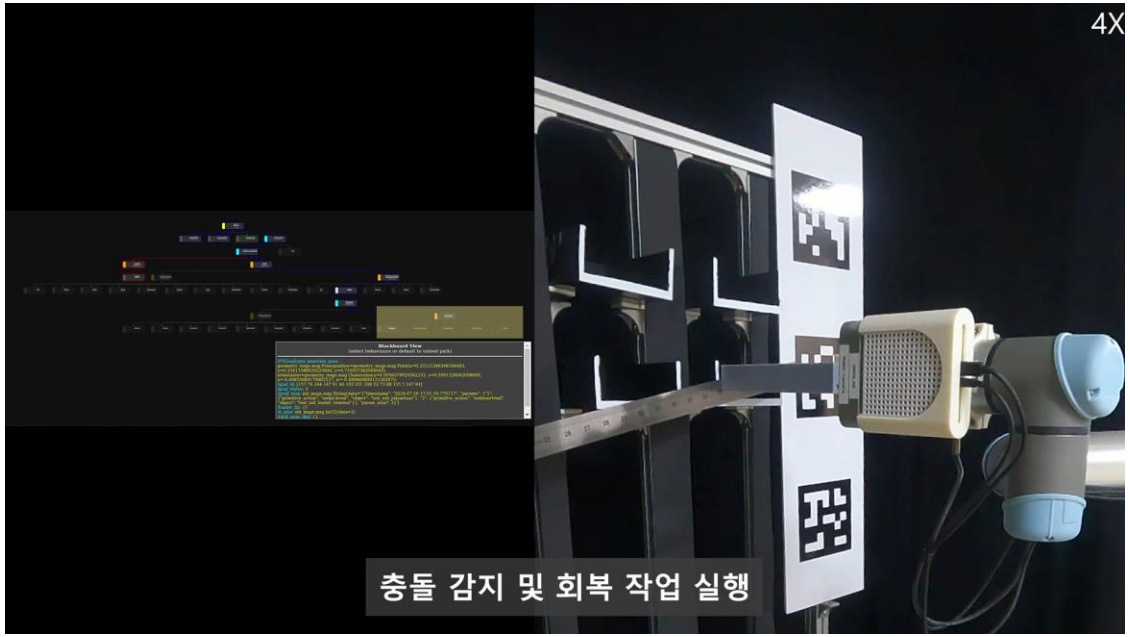
SEMES

Task planning and multi-modal recovery using behavior tree

- 6D pose estimation for multi holes in real-world
- Safe motion planning and simulation



Automatic HDD/SDD quality check system



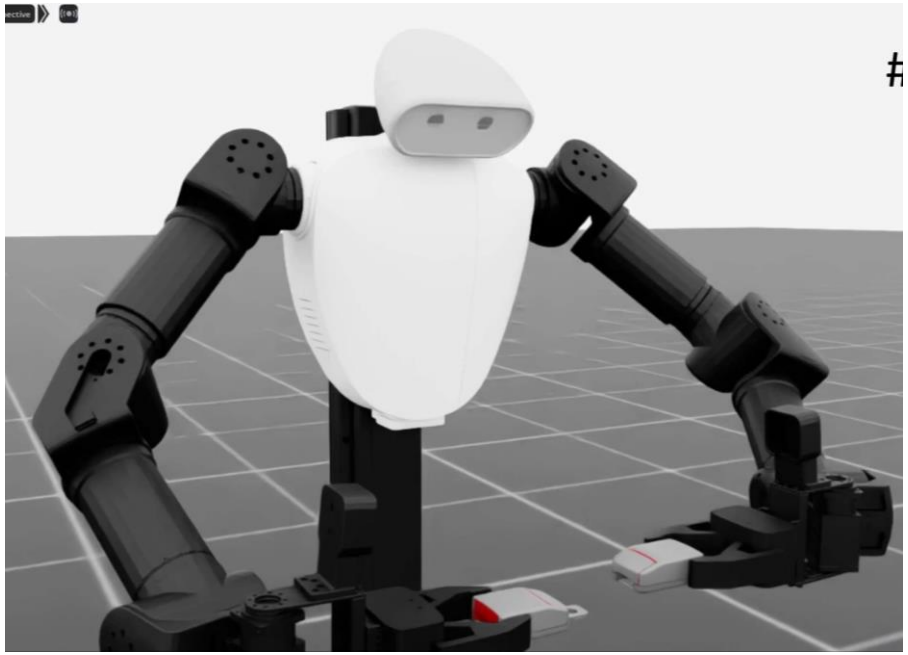
Recovery with behavior tree

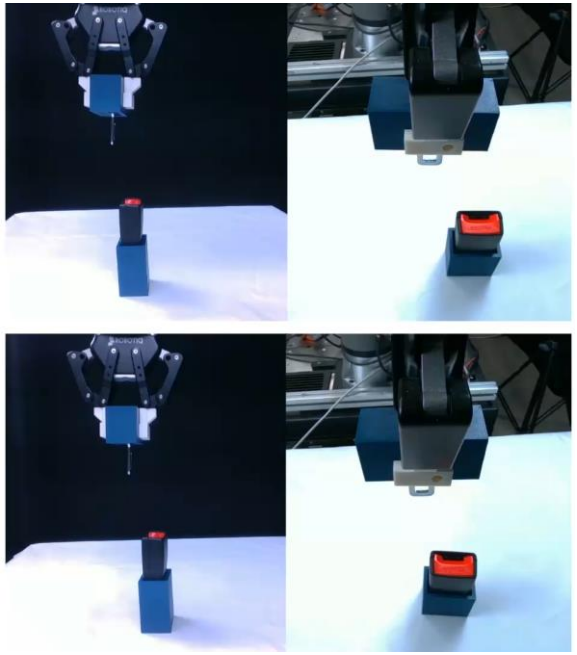
Humanoid Precision Task Execution

Jun

Jaehyeong

We develop a behavior tree–based system for executing precision tasks on humanoid robots.



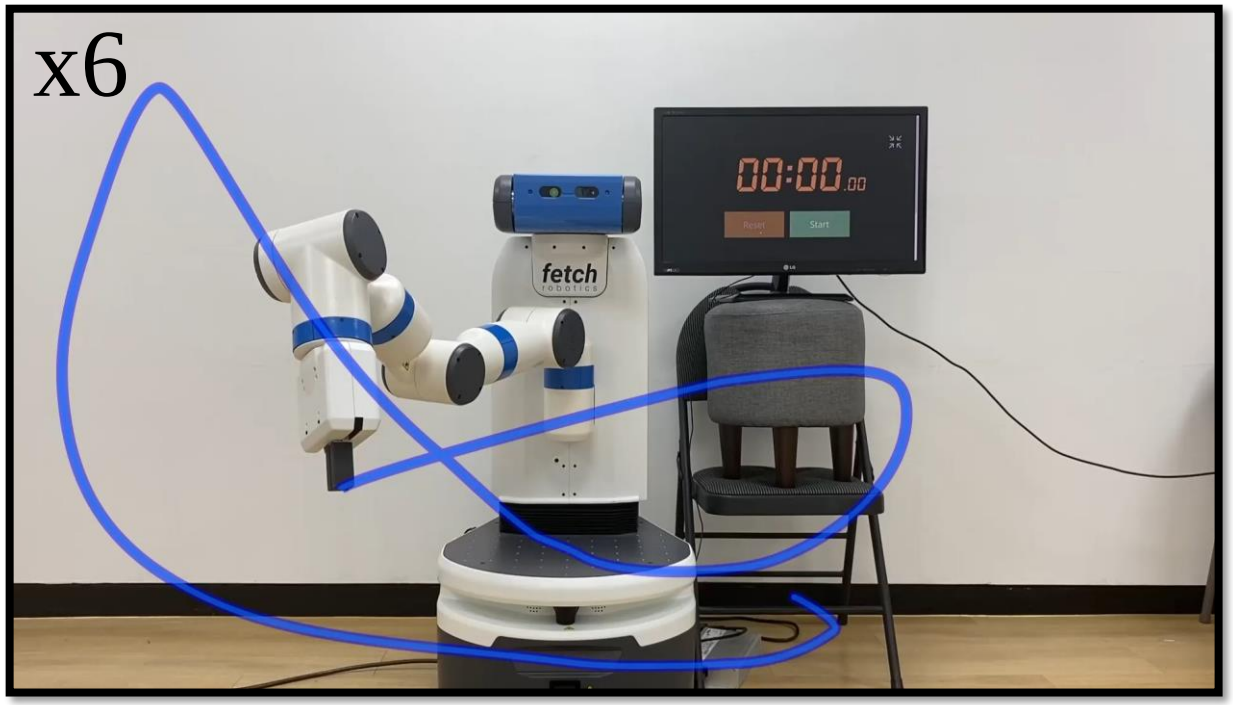


Learning-based Initialization of Trajectory Optimization

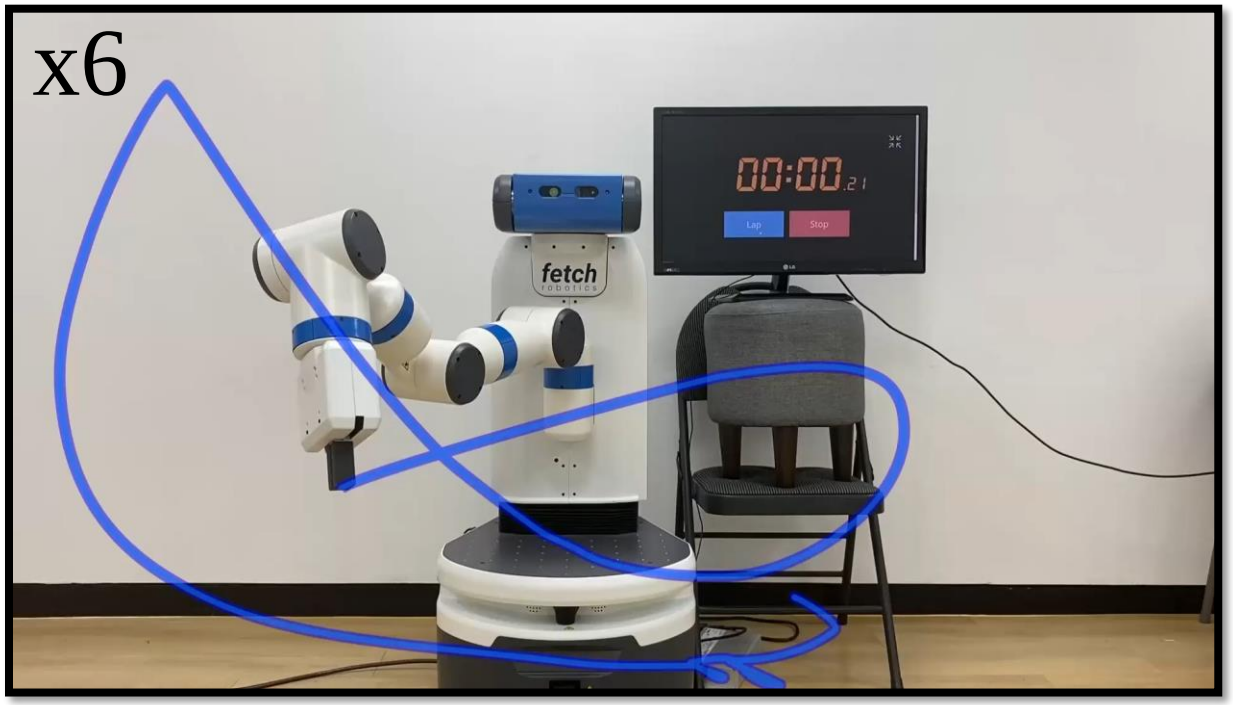
ICRA23 – Outstanding Planning Paper Award

- Benchmark name: '*Random #64*' | Trajectory optimizer: TORM [Kang et al. 2020]

*with **RL-ITG** (ours)*



*with **Greedy** (baseline)*



- Total execution time: **00:46.76** 01:43.16

about **220%** faster than *Greedy*

min : sec

Yoon, Minsung, et al. "Learning-based initialization of trajectory optimization for path-following problems of redundant manipulators." *ICRA*, 2023.

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Natural-Language Grounding

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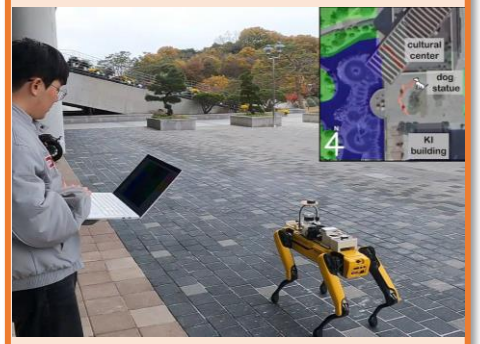
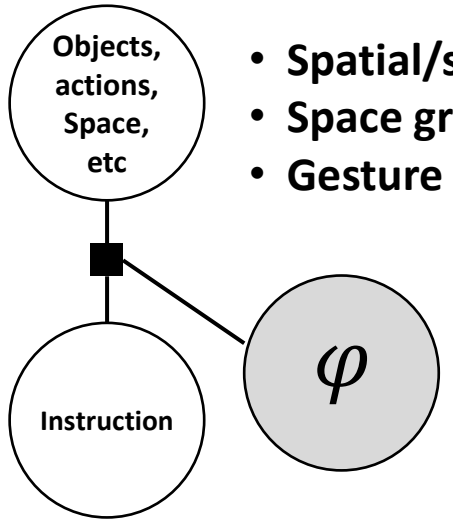
Multi-modal Estimation & Communication (IJRR'20)

LINGO-Space for Language Grounding (AAAI'24)

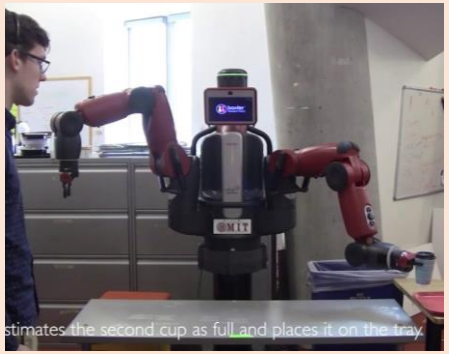


Language-guided Navigation (Proj. 23-24)

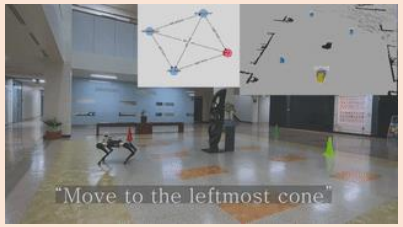


- **Spatial/space grounding**
- **Space grounding-based VLA**
- **Gesture grounding**

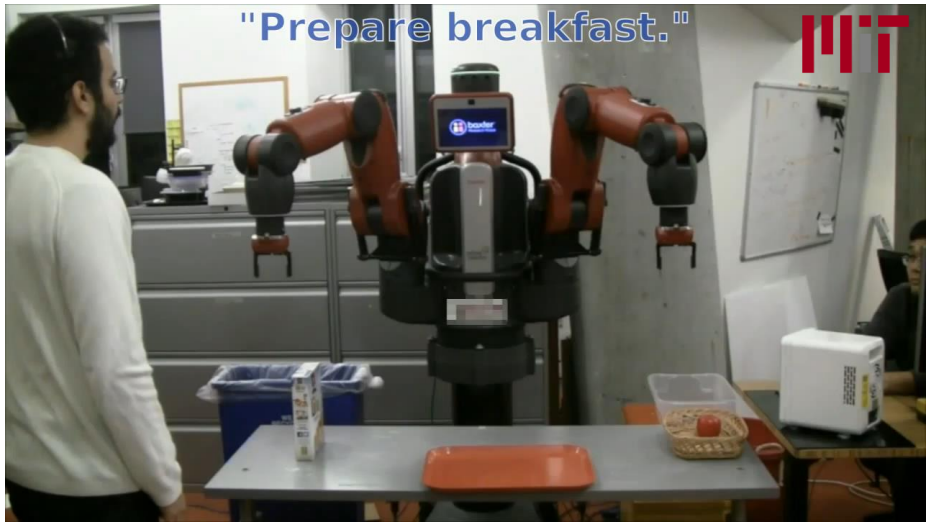
SGGNet2: Speech-guided Navigation (RO-MAN'23)



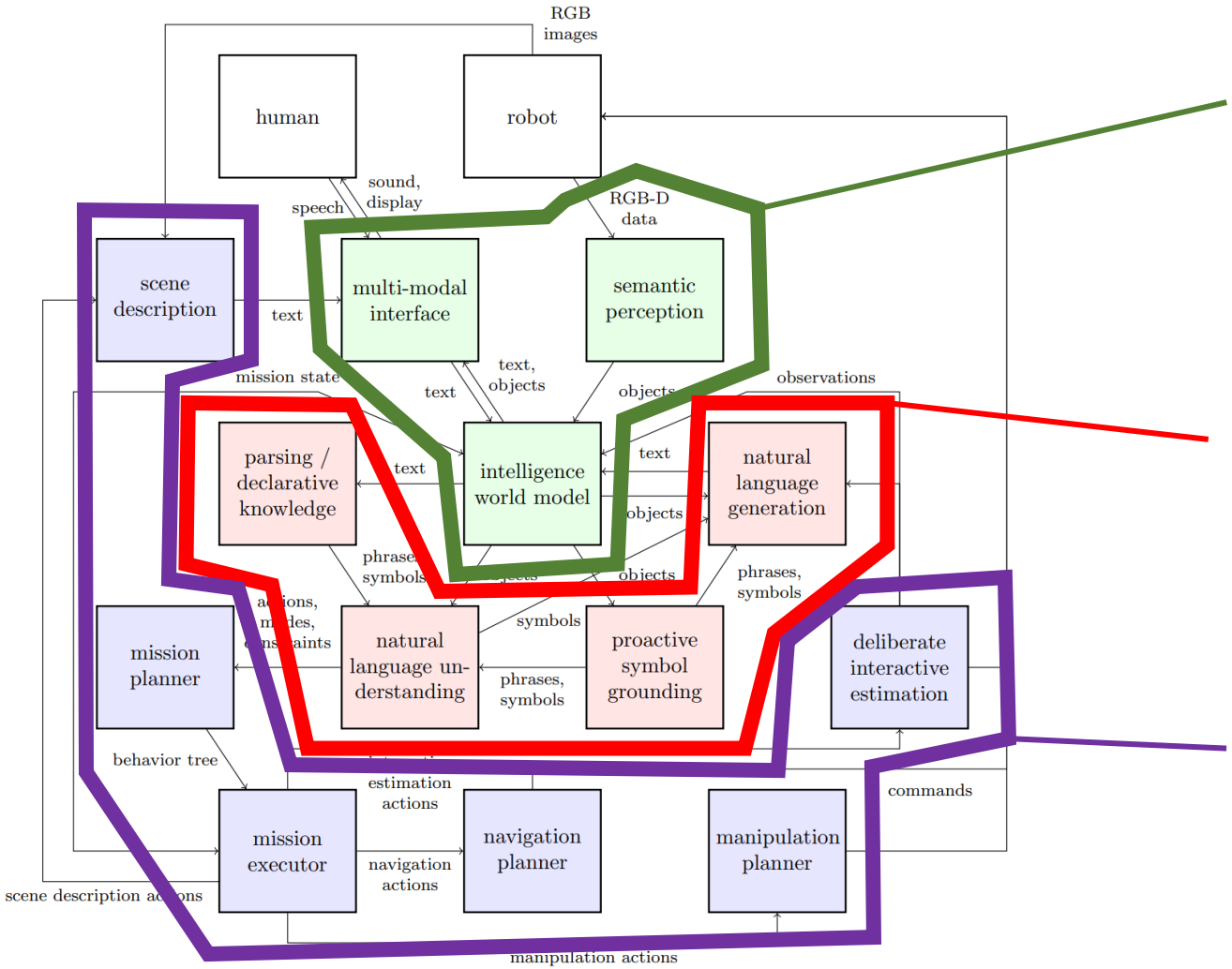
Grounding Robot Plans (CoRL'18)

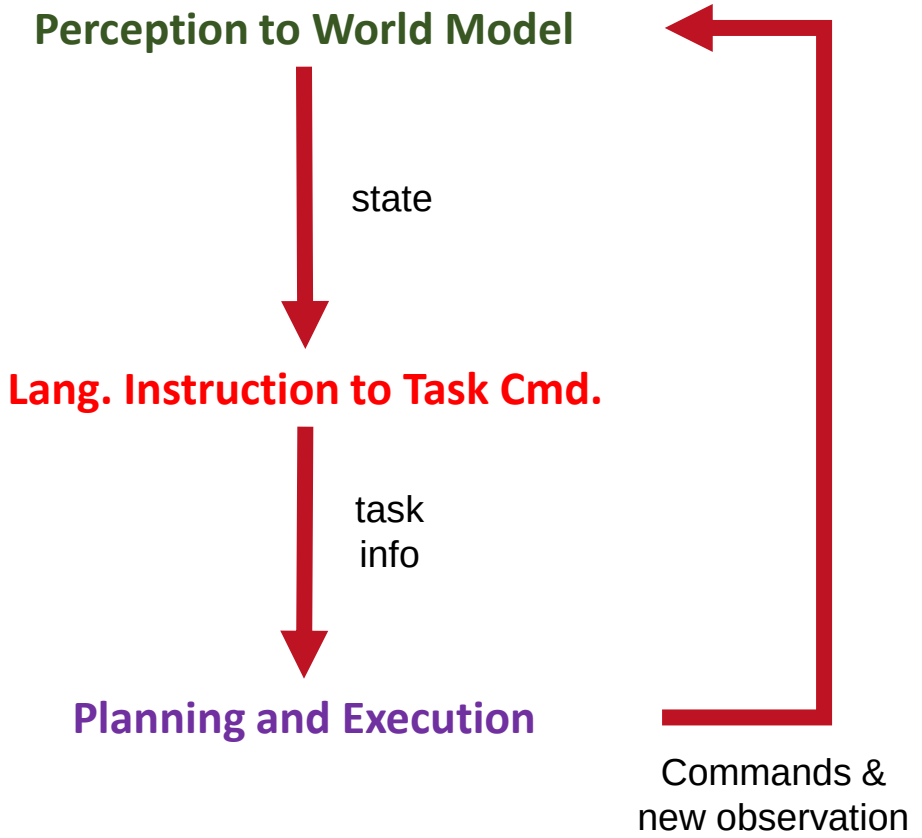


Language-guided Navigation (Ro-MAN'23)



Intelligence Architecture for Grounded Language



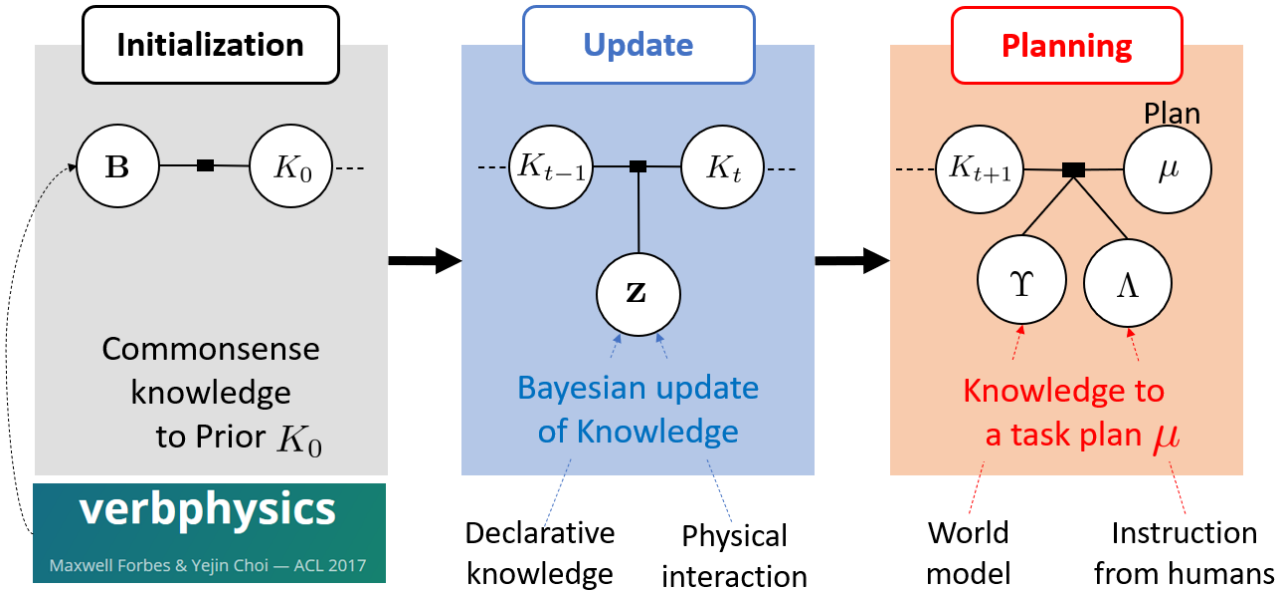


T. M. Howard, E. Stump, J. Fink, J. Arkin, R. Paul, **D. Park**, et al. "An Intelligence Architecture for Grounded Language Communication with Field Robots," *Field Robotics22*.

Multimodal Estimation and Communication

Natural language-driven mobile manipulation

- Infer semantic knowledge of the world using a Bayesian framework
- Correct invalid knowledge and generate a safe plan



*Arkin, J., *Park, D., et a. “Multimodal estimation and communication of latent semantic knowledge for robust execution of robot instructions.” IJRR, 2020.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[FR22, IJRR20]


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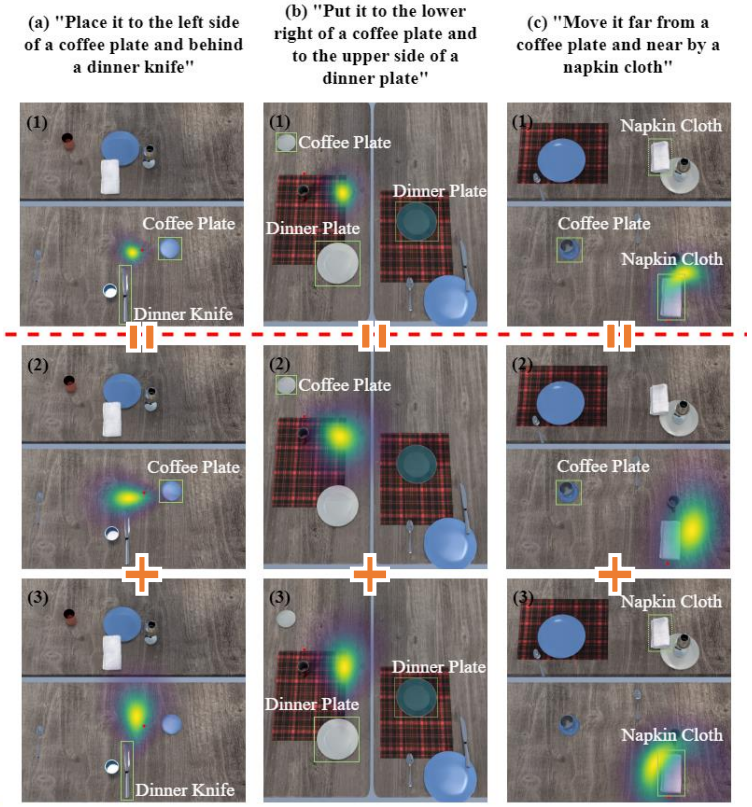
1X

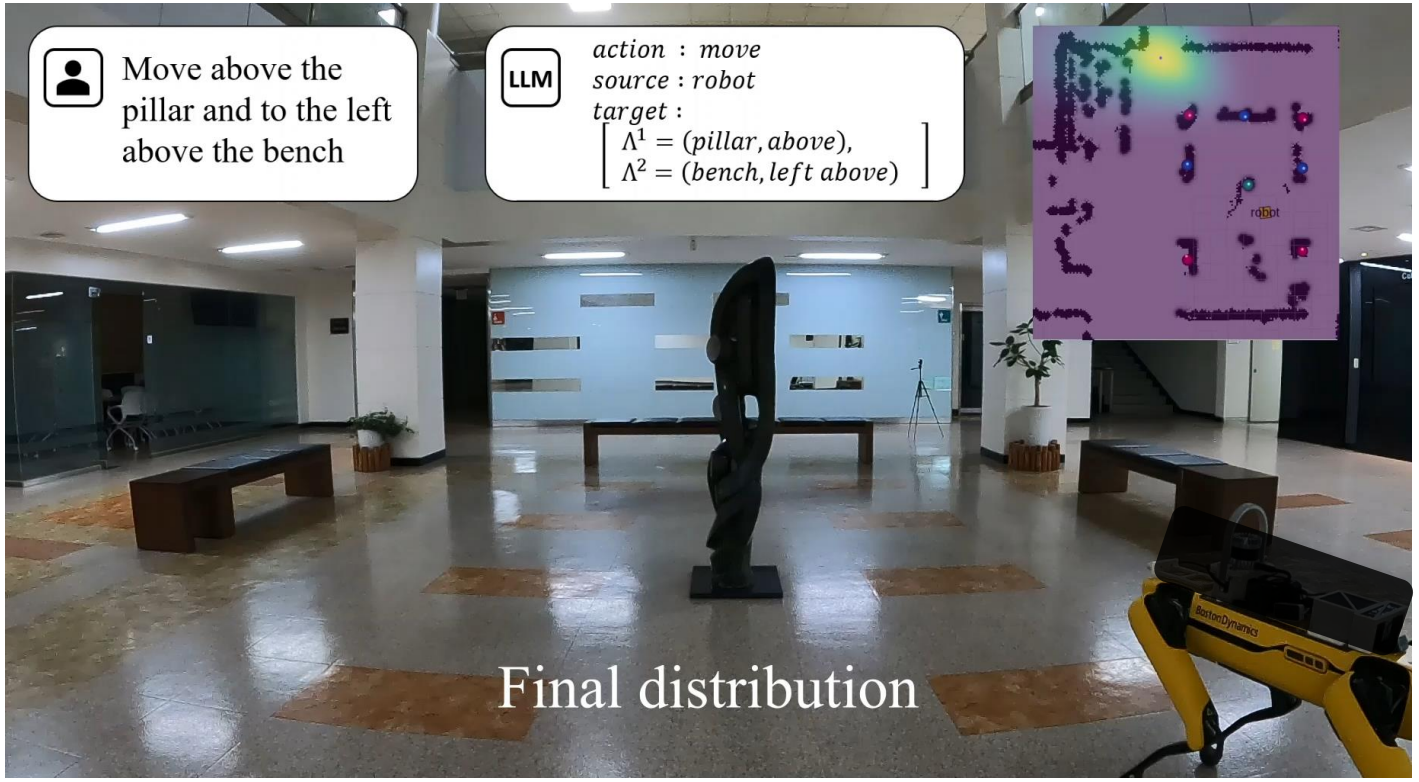
Model-based Space Grounding

Dohyun

LINGO-Space: Language-Conditioned Incremental Grounding

- Our mixture of polar distributions represents positions from combined instructions.
- The probabilistic grounding model infers multiple placement candidates !!





Kim, Dohyun, et al. "Lingo-space: Language-conditioned incremental grounding for space.“ AAAI, 2024.

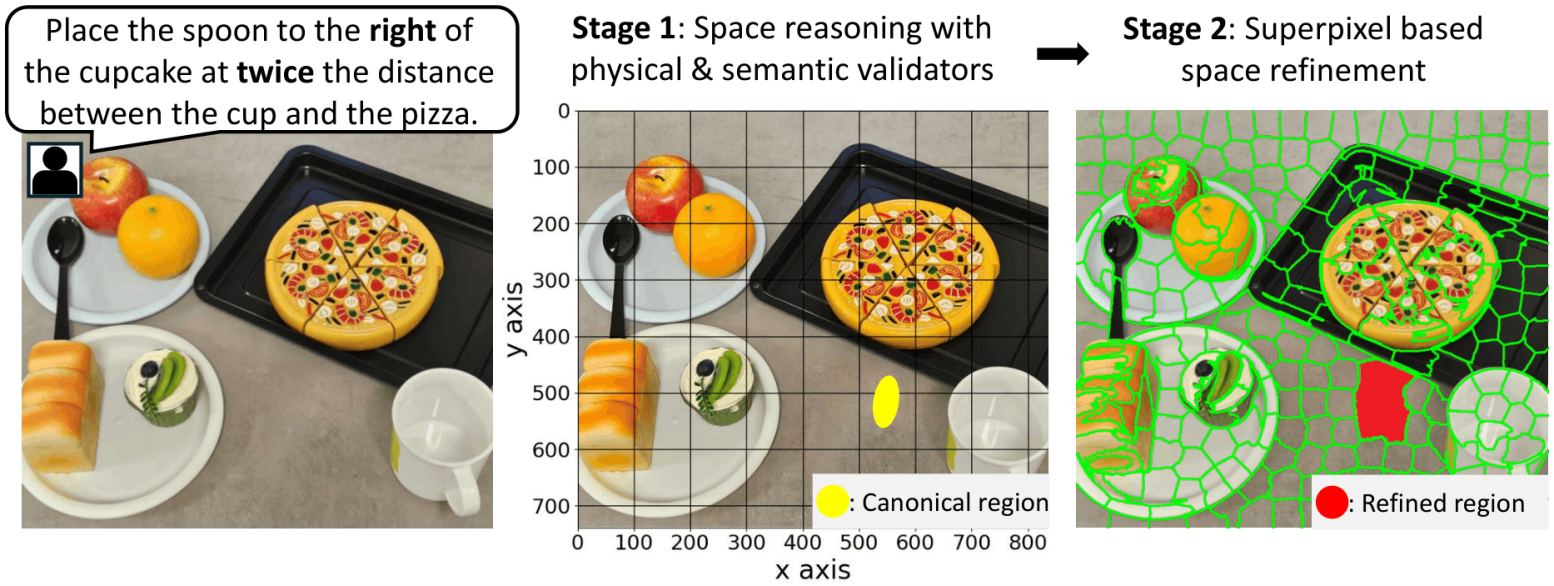
Model-free Space Grounding


Dohyun Junhyeong

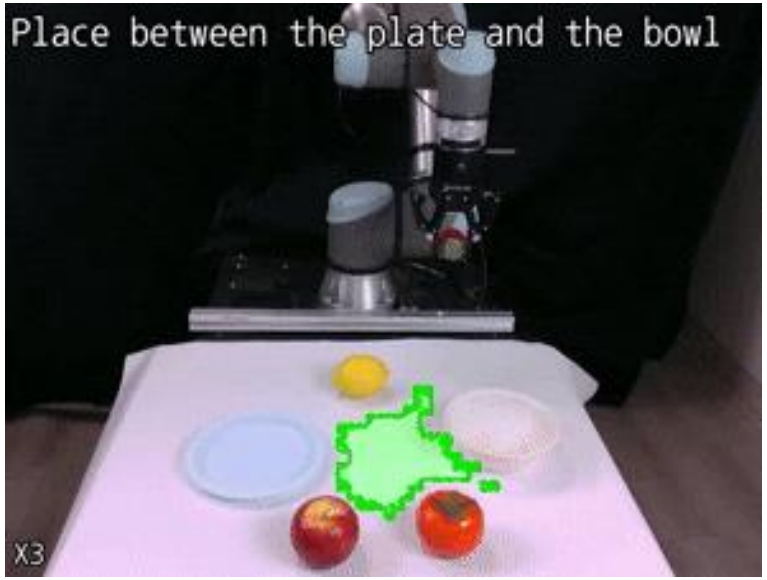
(under review)

C2F-SPACE: Coarse-to-Fine Space Grounding for Spatial Instructions using Vision-Language Models (Collaboration with Dr. Rohan Paul, IIT Delhi)

- Estimates an approximated yet spatially consistent region using a VLM.
- Refines the region to align with the local environment through superpixelization



Two stage grounding



Pixel-grounding with robot manipulation

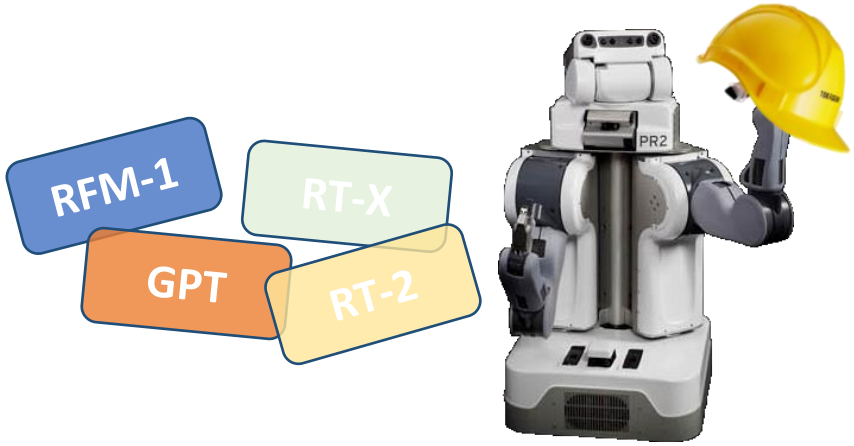
Robots may not work as we want

Take home message

Next-token prediction is now a core part of robot intelligence, but it does not truly model human intelligence yet! (from Prof. Yann LeCun)

- Lack of understanding physical world
- Limited persistent memory
- Poor reasoning
- Absence of planning ability

Put specialized intelligence!



Thank you.
Any questions?

Acknowledgement

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