Multimodal Ranking for Target Objects and Receptacles Based on Open-Vocabulary Instructions

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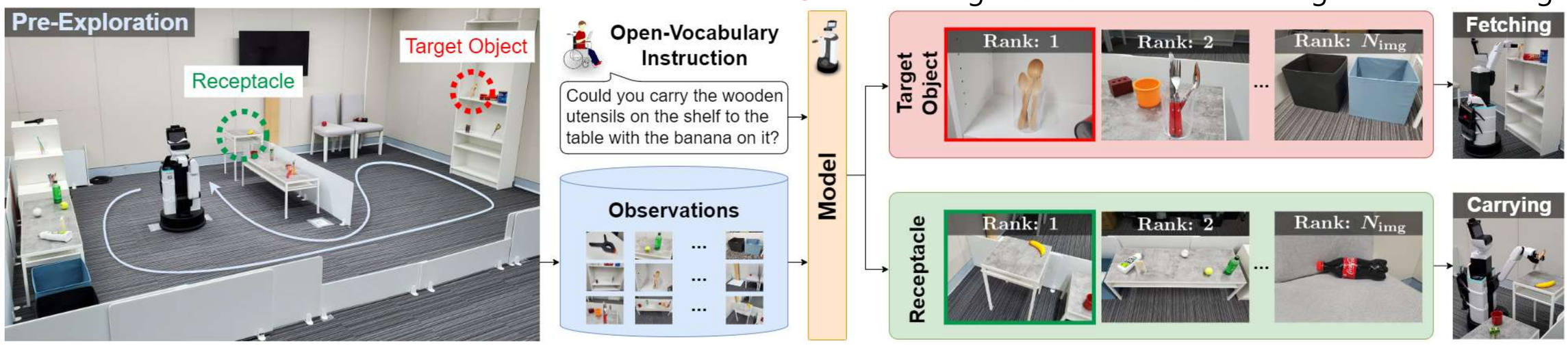
Abstract: Domestic service robots (DSRs)

Task	Image retrieval-based open-vocabulary fetch-and-carry
Novelty	1. LLM-based Task Paraphraser 2. Segment Anything Region Encoder
Results	1. Outperformed the baseline methods on the novel dataset 2. Achieved a success rate of 82% in the physical experiments



Related work: Open-vocabulary manipulation

RREx-BoT [Sigurdsson+, IROS23]	Vision-and-language navigation based on the images collected through pre-exploration
MultiRankIt [Kaneda+, RA-L24]	Object fetching tasks based on the human-in-the-loop setting
OVMM [Yenamandra+, CoRL23]	Open-vocabulary mobile manipulation tasks SOTA method achieved SR of only 10%

☹ Few existing methods handle the image retrieval setting

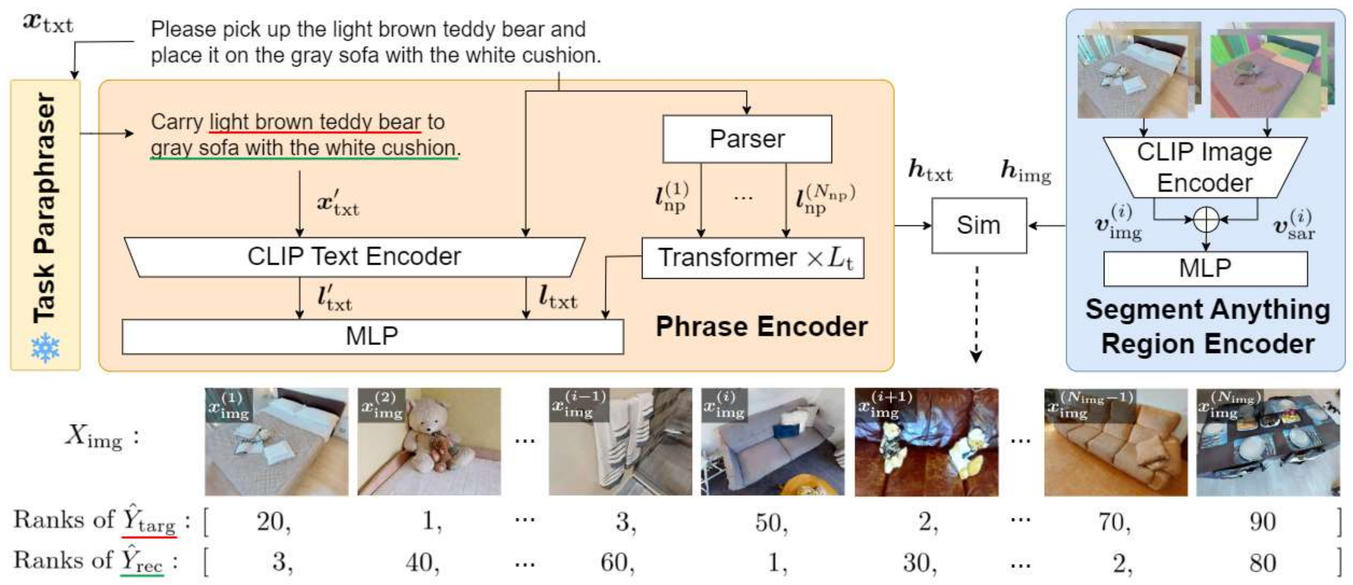
Method

■ Retrieves images of both target objects and receptacles using multimodal foundation models

1. Task Paraphraser:
   Paraphrases instructions including redundancy into standardized format using LLM

2. Phrase Encoder:
   Obtains fine-grained text features from instructions using CLIP [Radford+, ICML21]

3. Segment Anything Region Encoder:
   Enhances visual features regarding shape and contour of objects by utilizing SAM [Kirillov+, ICCV23]

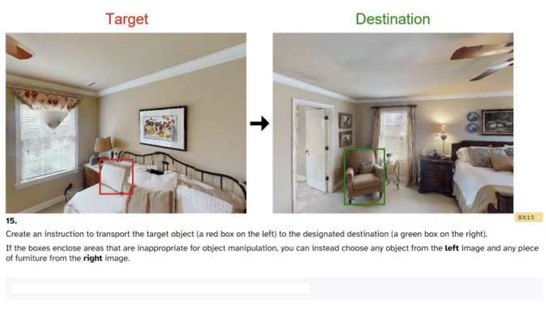


Settings: 1. Newly-built dataset, 2. Physical experiments in the standard environment [Okada+, AR19]

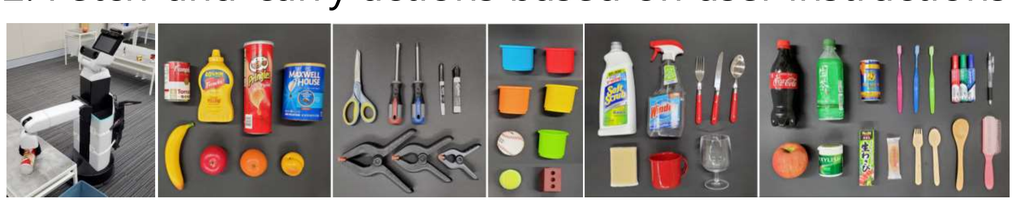
1. LTRRIE-FC dataset based on HM3D [Ramakrishnan+, NeurIPS21]

Instructions were collected by 226 annotators using a crowdsourcing service

#envs	#images	#instrs	Sentence length
774	7,148	6,581	15.69 (average)



2. Fetch-and-carry actions based on user instructions



DSR: HSR [Yamamoto+, ROBOMECH J.19]

Objects: YCB [Calli+, RAM15]

Results: 1. Outperformed the baseline methods, 2. Achieved a success rate of 82% in zero-shot setting

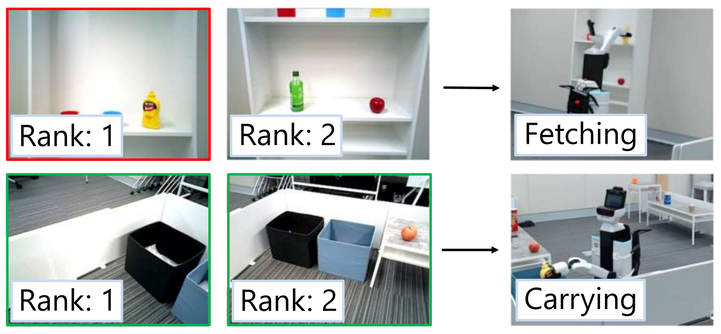
1. Quantitative results: Standard metrics for image retrieval

[%]	MRR↑	Recall@5↑	Recall@10↑
CLIP [Radford+, ICML21]	10.8	13.7	24.9
MultiRankIt [Kaneda+, RA-L24]	20.5 ± 2.3	30.1 ± 3.4	48.2 ± 1.4
	+2.0	+3.1	+4.8
Ours	**22.5** ± 1.4	**33.2** ± 1.8	**53.0** ± 2.5

2. Qualitative result: Successful sample

■ Target Object

■ Receptacle



"Can you take the mustard container on the shelf to the black box?"

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