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Multi-view object pose distribution tracking for pre-grasp planning on mobile robots

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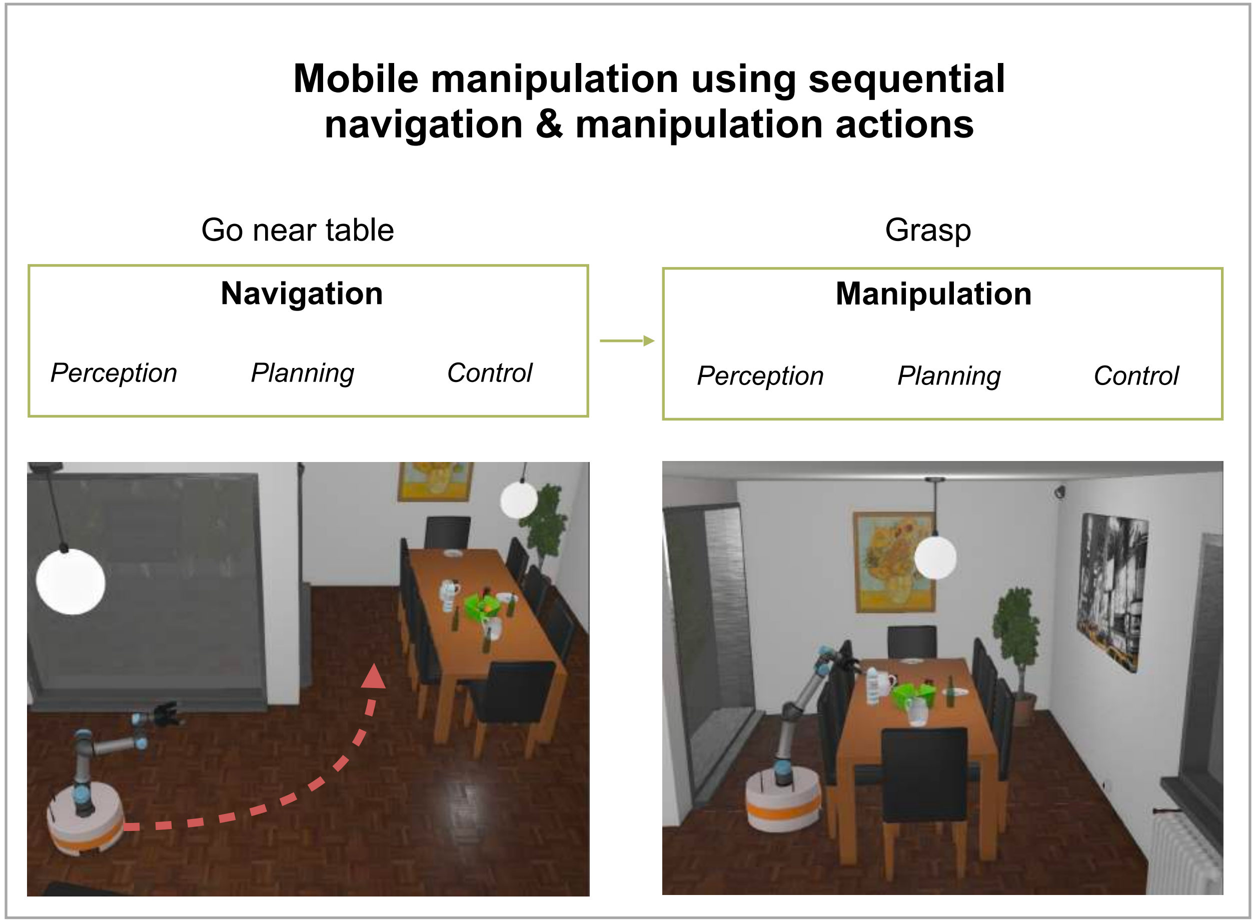
Motivation

Enabling robust and efficient manipulation on mobile robots

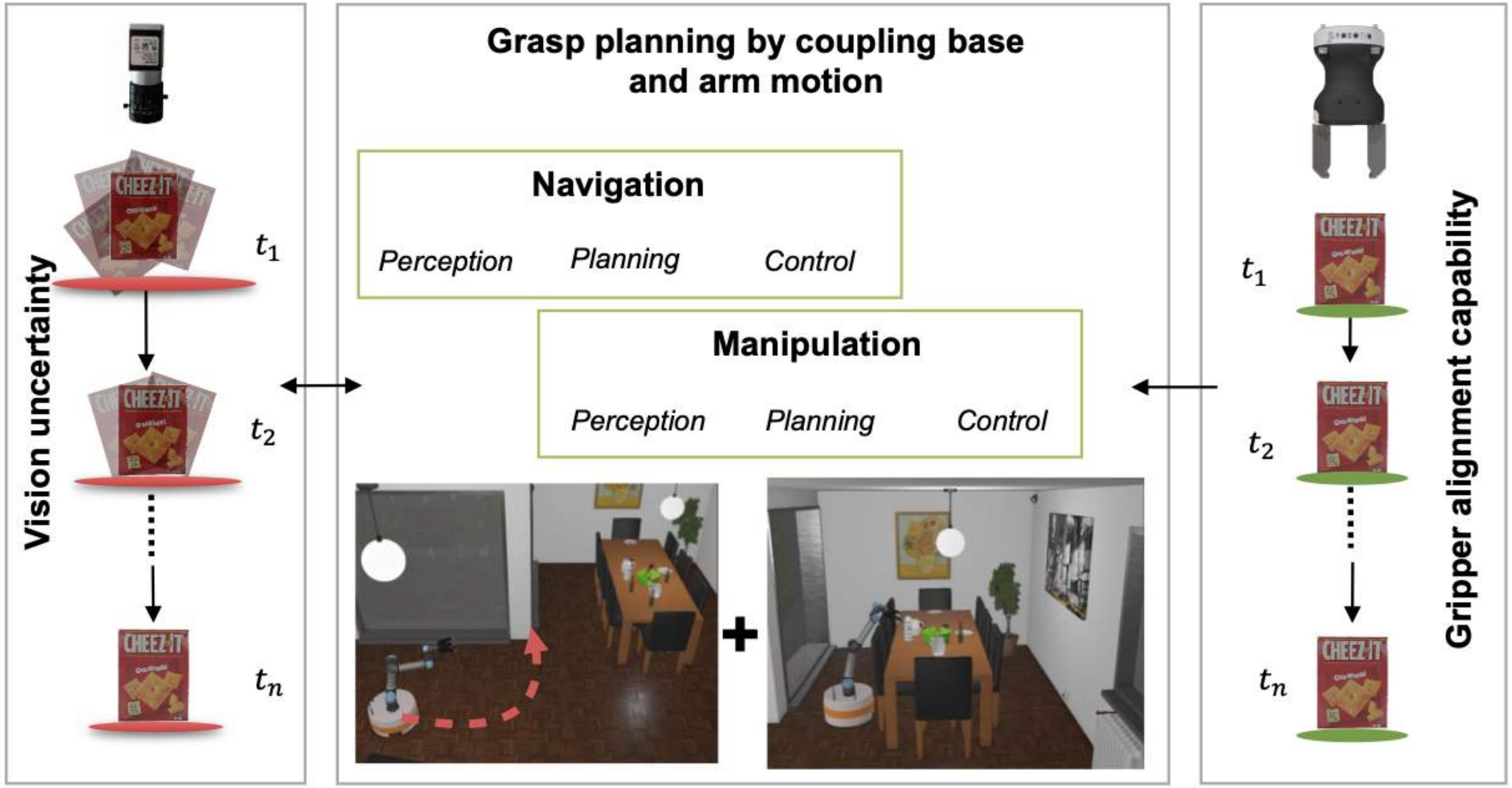
Mobile Manipulation - sequential approach

- Goto near the object table
- Observe the object and estimate its 6D pose
- Plan grasp
- Execute grasp



Problem formulation

- Estimating object pose distribution (uncertainty) to ensure success of grasping task
- Estimating full object pose distribution while robot is still navigating towards the object to enable pre-grasp planning



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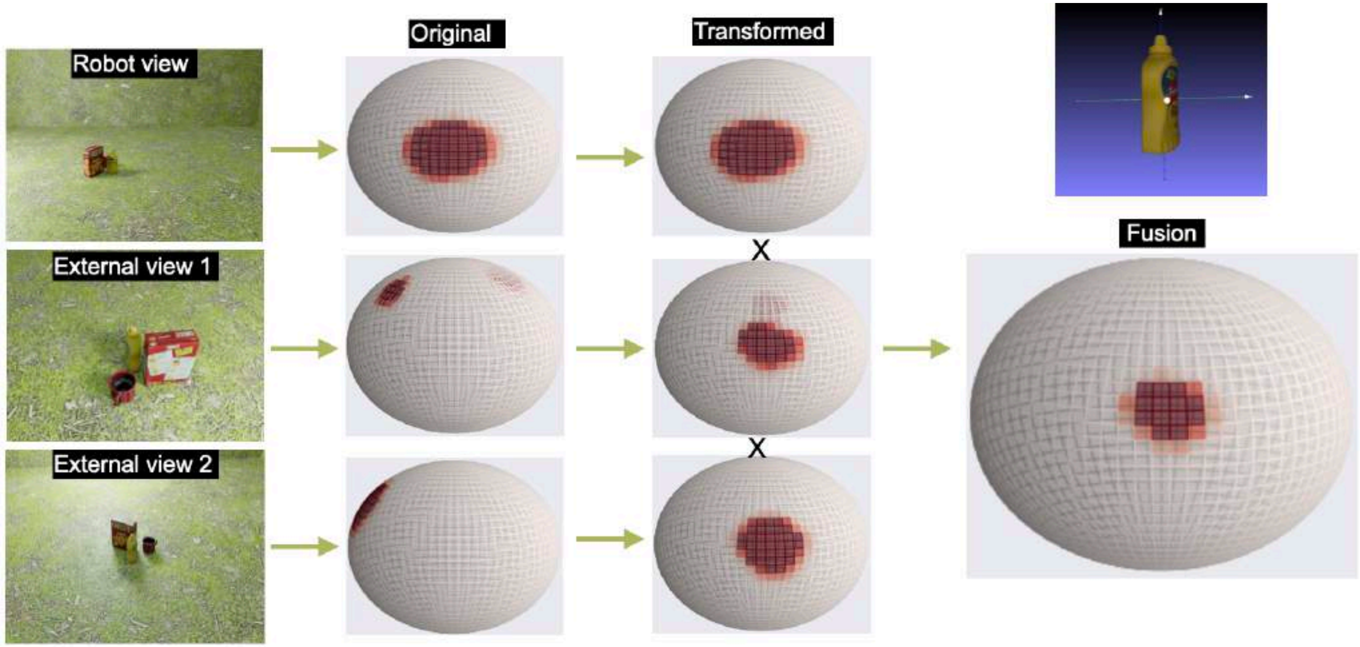
Proposed approach

Multi-view object pose distribution tracking

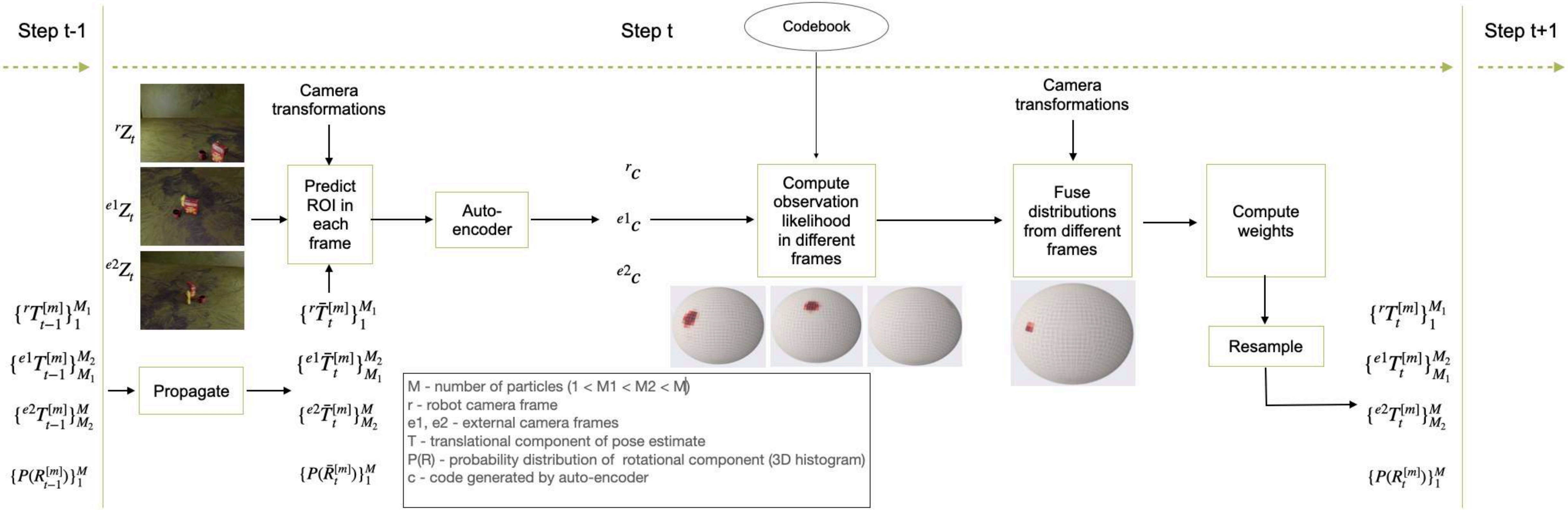
Proposed approach

- Rao-Blackwellized particle filter with de-noising auto-encoder for verifying observations [1]
- Extended to fuse information from external cameras
- Both translation and orientation distributions are modeled as a multi-modal distributions



[1] Deng, Xinke, et al. "Poserbpf: A rao–blackwellized particle filter for 6-d object pose tracking." *IEEE Transactions on Robotics* 37.5 (2021): 1328-1342.

Proposed architecture



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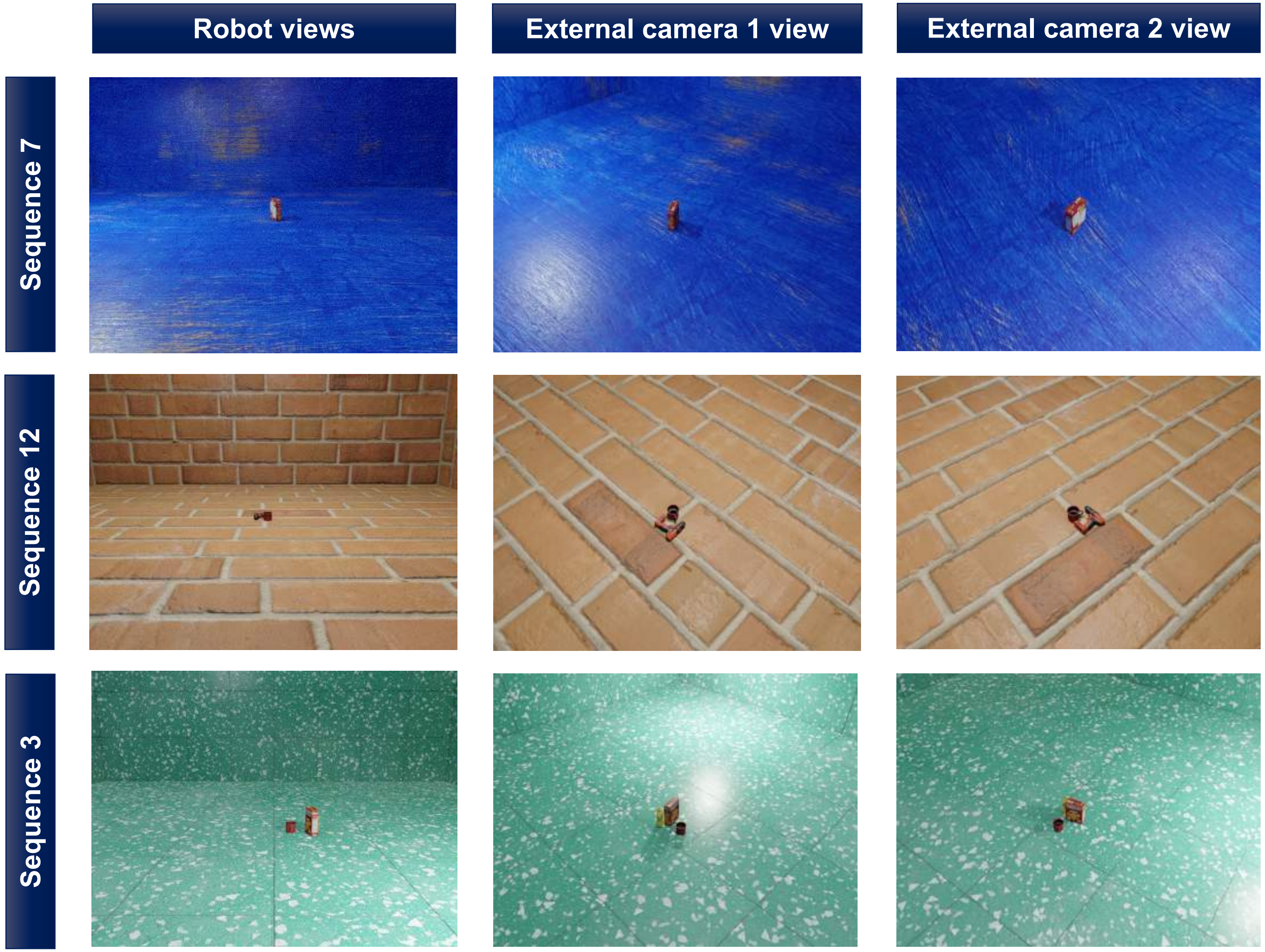
Experimental evaluation

Evaluation dataset

- Simulated dataset [1] containing 8 different YCB objects created using photo-realistic renderer
- Each sequence contains view from robot and external cameras with robot camera simulating robots base and arm motion



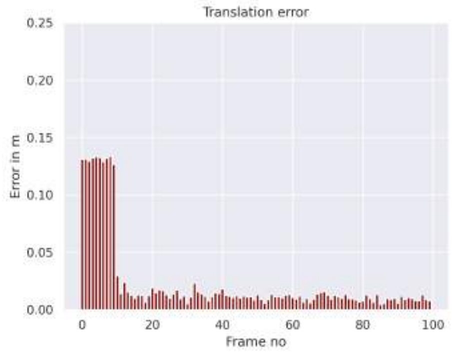
[1] L. Naik, “Multi-view rendered YCB dataset for mobile manipulation,” Feb. 2022. [Online]. Available: https://doi.org/10.5281/zenodo.

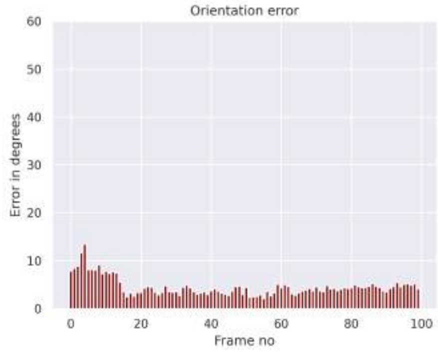
Results - simple scenario

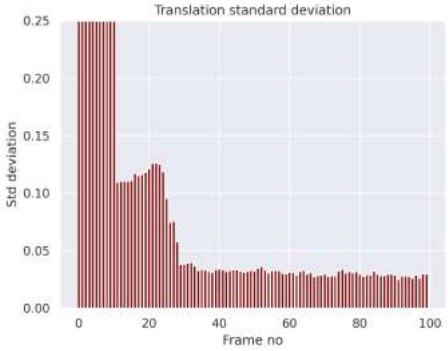
Robot moving closer to object - asymmetric object, no occlusions

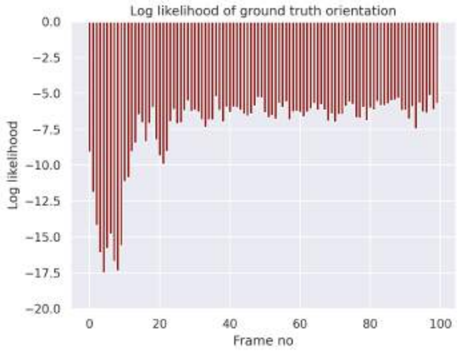
Translational error | **Orientation error** | **Translation uncertainty** | **Orientation uncertainty**

Multi-view

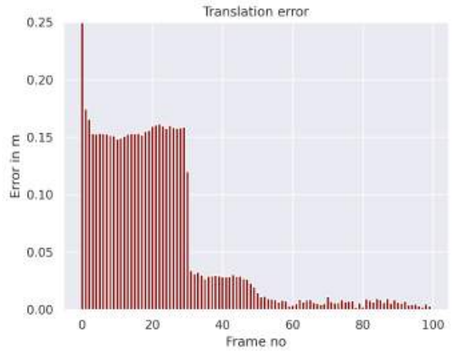


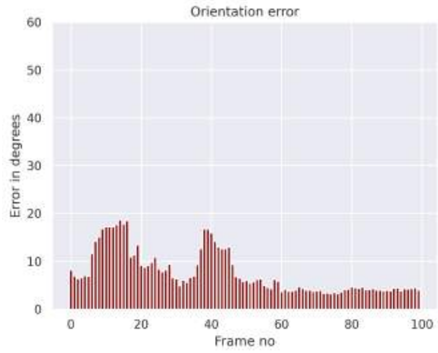


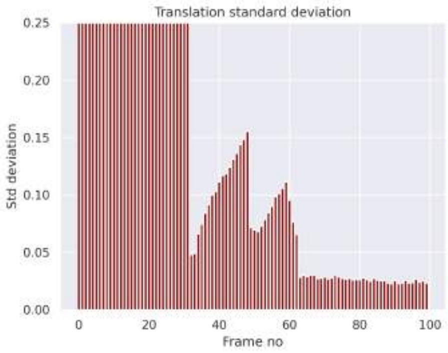


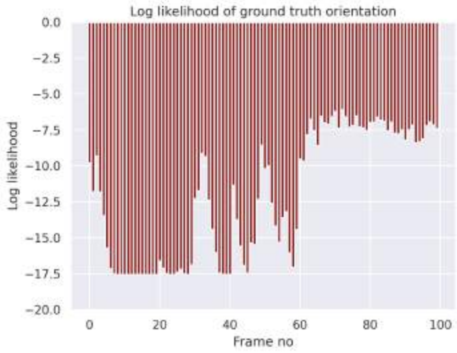


Single-view









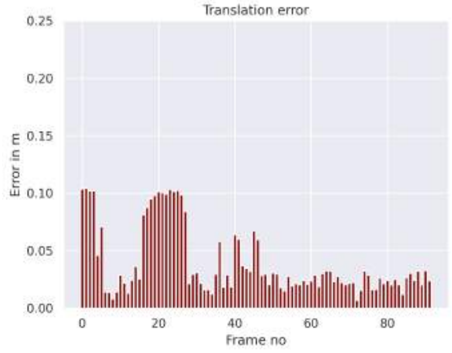
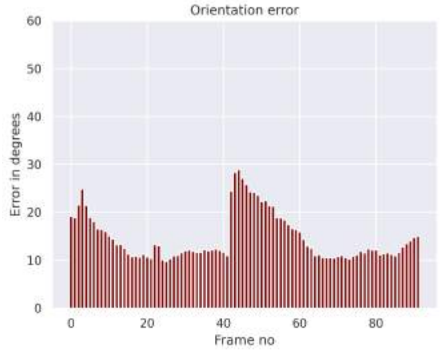
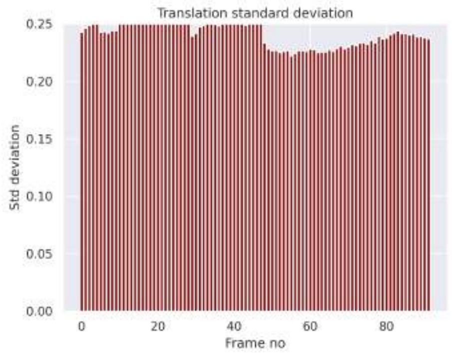
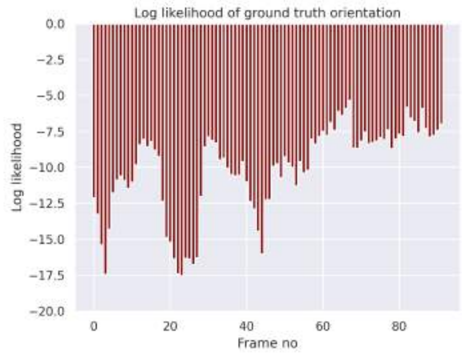
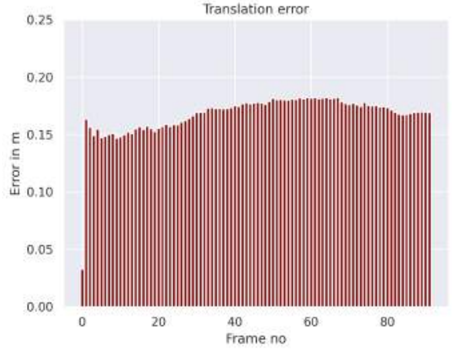
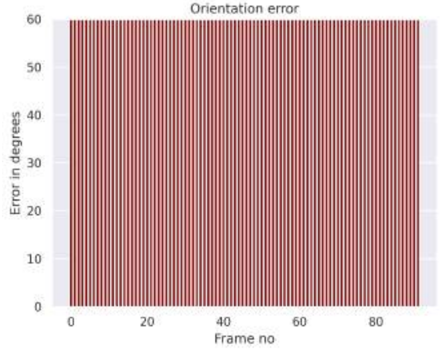
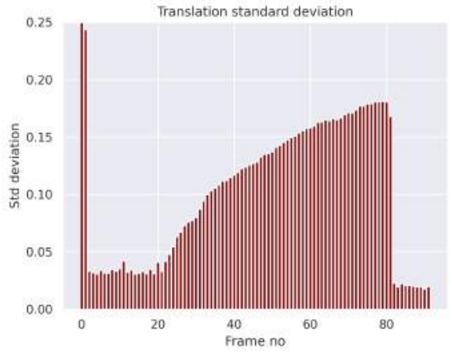
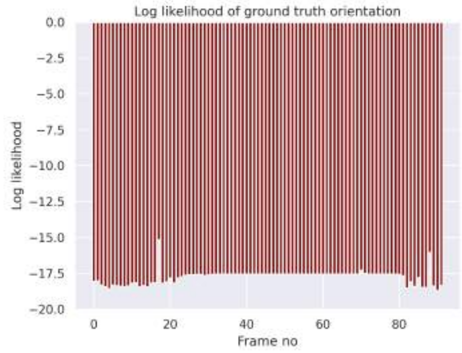
Original robot view

Multi-view result

Single-view result

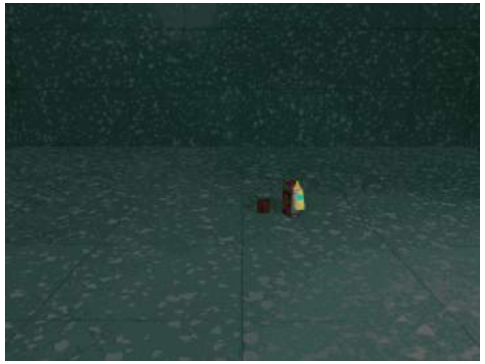
Results - complex scenario

Robot moving closer and around the occluded object with 1 axis of symmetry

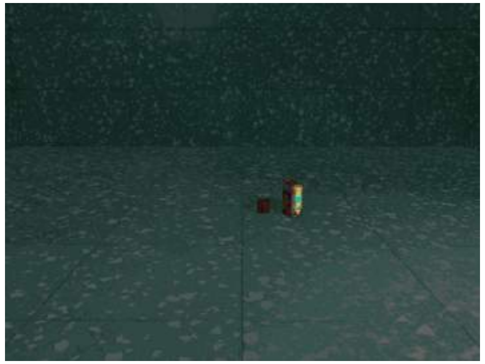
	Translational error	Orientation error	Translation uncertainty	Orientation uncertainty
Multi-view				
Single-view				

Original robot view

Multi-view result



Single-view result



Quantitative results

	Translation error (in m)		Orientation error (in deg)		Translation std. dev (in m)		Log likelihood	
	Multi	Single	Multi	Single	Multi	Single	Multi	Single
Cracker box	0.0121	0.0172	6.33	18.60	0.0781	0.0583	-6.91	-11.09
Mustard bottle	0.0251	0.0621	10.68	93.48	0.1191	0.0601	-7.15	-10.97
Mug	0.0495	0.0778	15.69	130.28	0.1370	0.1151	-13.70	-17.22
Sugar box	0.0411	0.0954	9.50	32.47	0.2065	0.0785	-11.25	-13.53
Banana	0.0800	0.1937	15.85	97.95	0.1640	0.1495	-14.92	-17.63
Master chef can	0.0066	0.0065	6.23	87.06	0.0737	0.0318	-8.35	-11.35
Bleach cleanser	0.0955	0.2774	57.44	152.70	0.2375	0.2991	-13.65	-16.89
Power drill	0.0561	0.3125	17.36	23.97	0.0837	0.0444	-11.19	-12.74
Mean	**0.0457**	**0.1303**	**17.38**	**75.56**	**0.1374**	**0.1046**	**-10.89**	**-13.92**

Conclusions and future work

- The proposed approach can be an enabler for pre-grasp planning tasks such as
  - Selecting the order in which robot should grasp the objects
  - Optimal base position to grasp all the objects

- Pre-grasp planning to grasp planning
  - Using uncertainties to predict grasp failures
  - Planning actions to reduce uncertainties

Thank you

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ReThiCare

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