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

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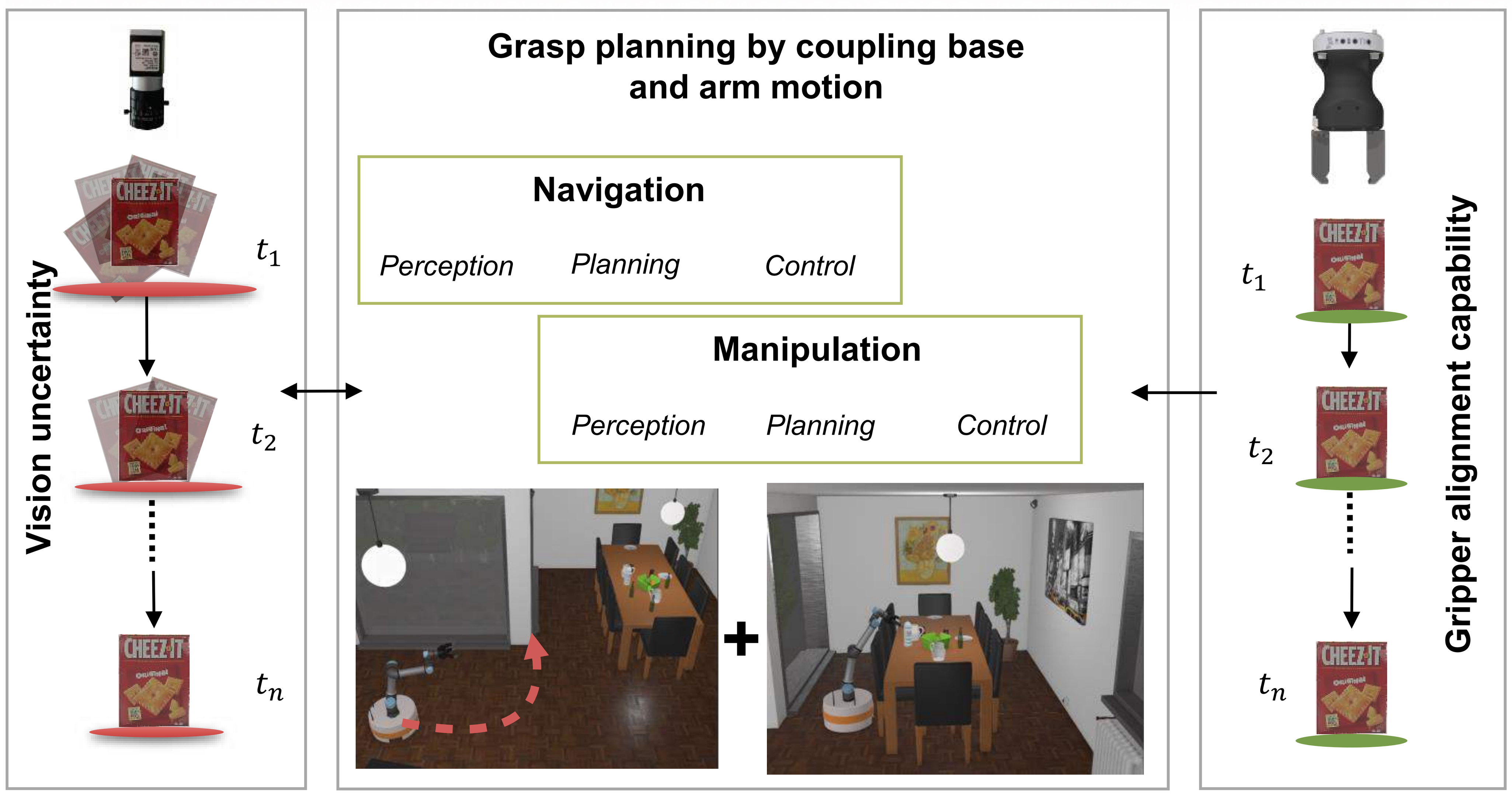
The ability to track the 6D pose distribution of an object when a mobile manipulator robot is still approaching the object can enable the robot to pre-plan grasps that combine base and arm motion. However, tracking a 6D object pose distribution from a distance can be challenging due to the limited view of the robot camera. We present a framework that fuses observations from external stationary cameras with a moving robot camera and sequentially tracks it in time to enable 6D object pose distribution tracking from a distance.



Right: gripper alignment capability (this can be optimised offline and stays constant over time), **Left:** uncertainty in object pose estimate robot wants to grasp (this can be reduced by getting better object views), **Center:** grasp planning by coupling base and arm motion (based on uncertainty in pose estimate can be compensated by gripper, robot plans action either to get better observation or executes the grasp)

Why object pose distribution?

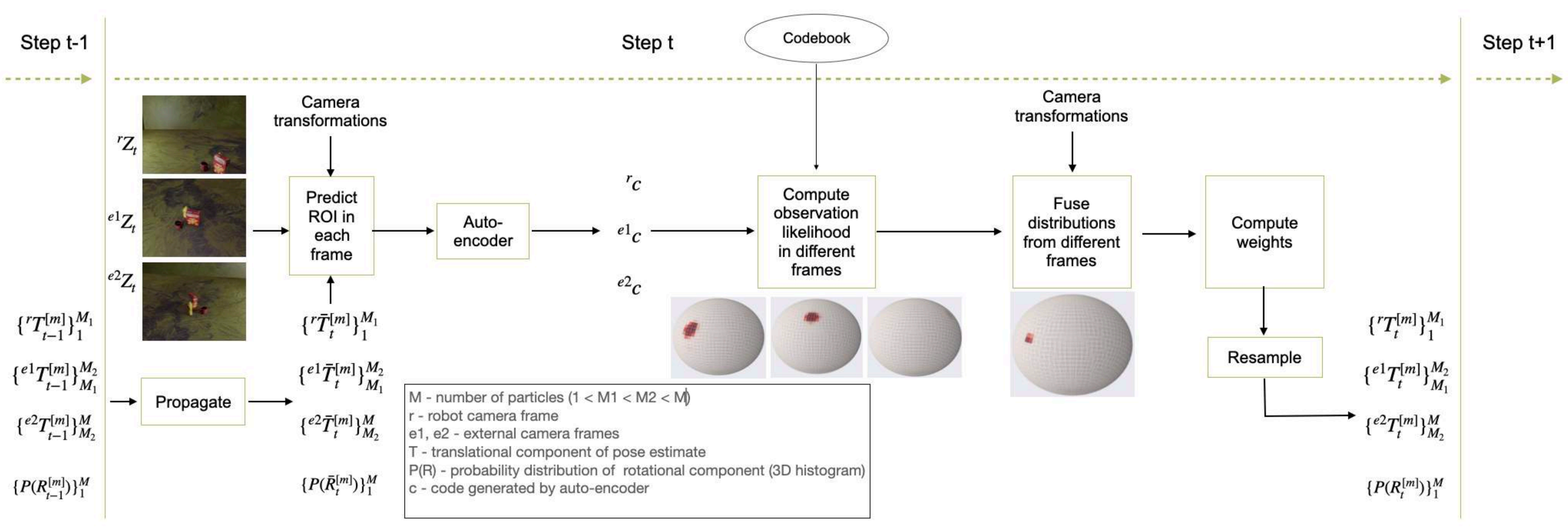
- The robot can determine if the uncertainty in pose estimate can be compensated by its gripper alignment capability
- It can accordingly plan a new action either to reduce pose uncertainty or execute the grasp

Why combine navigation & manipulation?

- The robot can pre-plan the grasps when it is still navigating towards the objects
- When robots is close to the object it can directly execute the grasps without spending time on object pose distribution estimation & grasp planning thus resulting in efficient execution

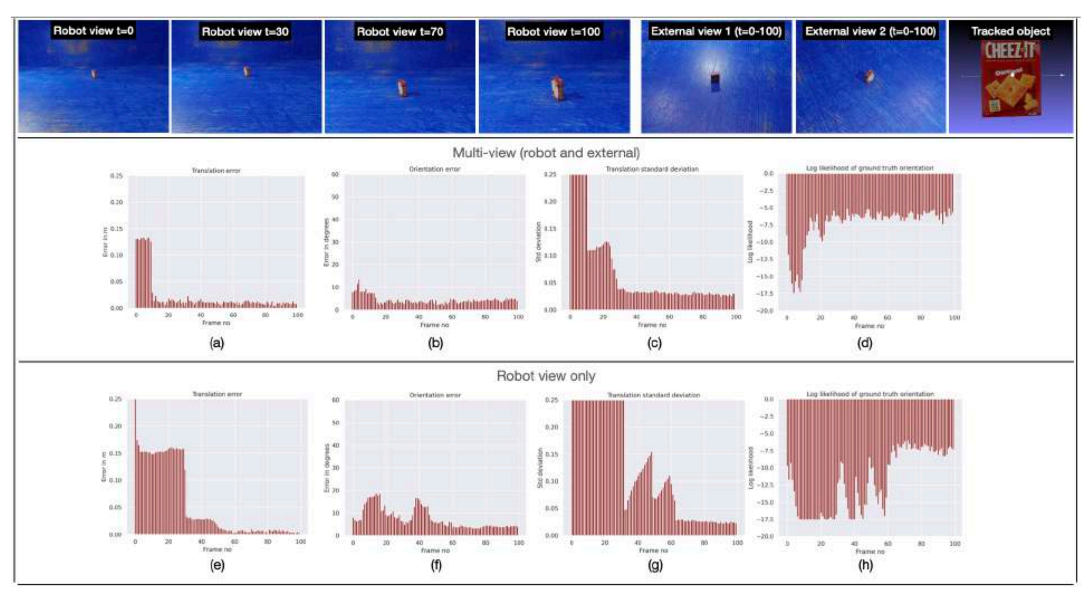
Proposed approach

- We hypothesize that robot can fuse the information from external cameras in the environment to compensate for the limited view of the robot camera and enable 6D object pose distribution tracking from distance.
- We extend PoseRBPF [1] into multi-view full 6D pose distribution tracking framework that simultaneously fuses information from multiple cameras and then sequentially tracks it over time.



[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.

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

- The proposed approach generally results in faster convergence of translation and orientation errors and uncertainties compared to the single view baseline
- In the instances where the single view approach performs better than the multi-view, it happens because the robot camera has a much better view of the object compared to external camera views.

Future work

- Determining when to use robot and external cameras
- Planning robot camera views to improve estimates

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