

Robot Navigation in Unseen Environments using Coarse Maps

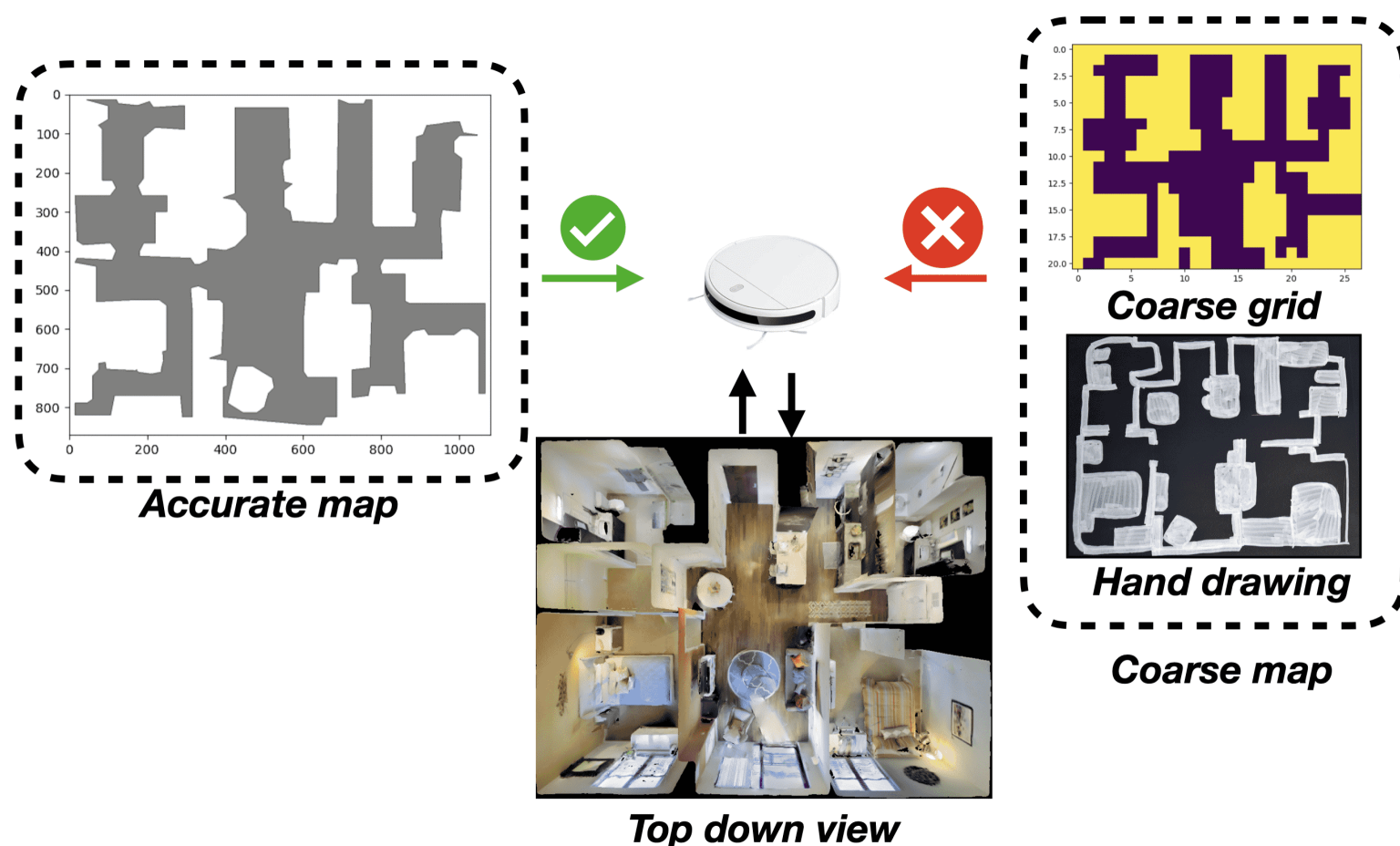
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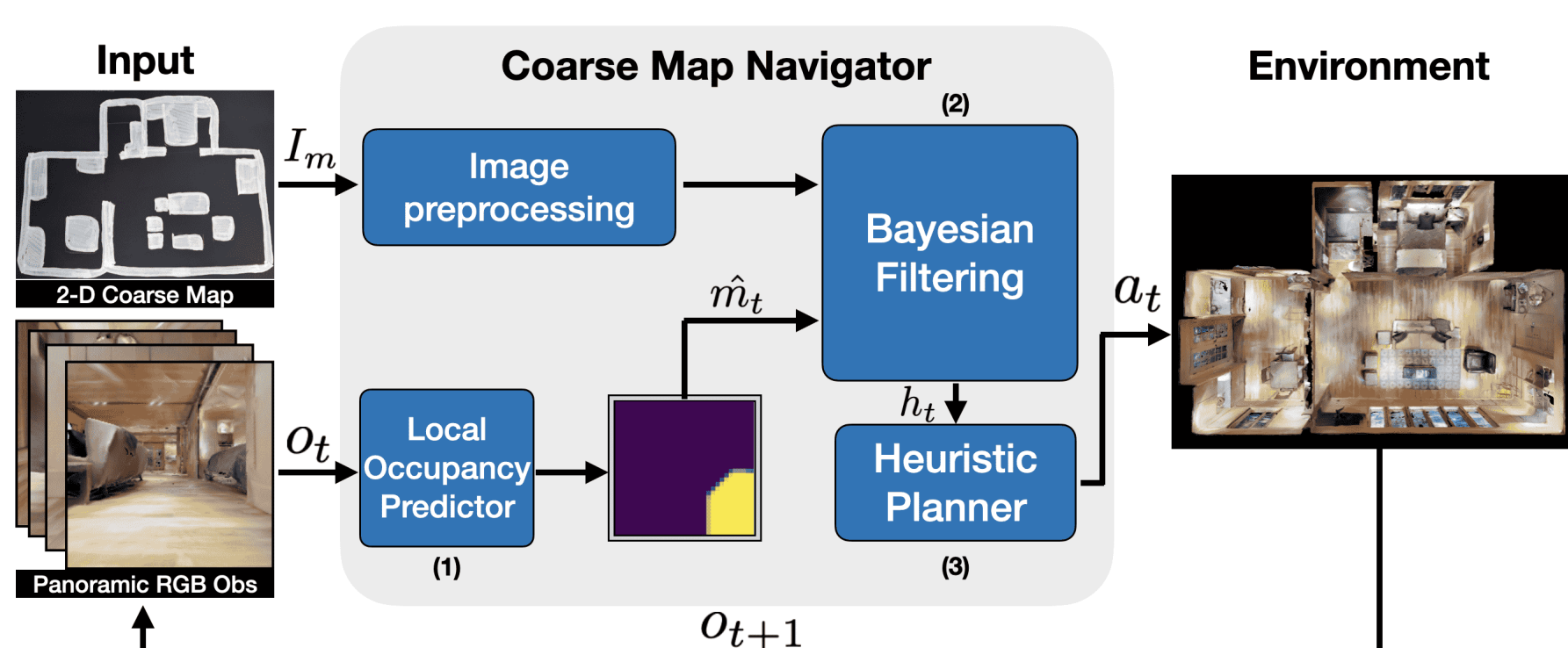


Research Question

Can an autonomous robot directly navigate in previously unseen environments using coarse maps?



Navigation Framework Overview



In this work, we propose the Coarse Map Navigator (CMN), a navigation framework that can perform robot navigation in unseen environments using different coarse maps such as 2-D coarse-grid maps and 2-D hand-drawn maps. See Figure (b) and (c) for instance.

Results in Unseen Photo-realistic Home

TASK CG: COARSE-GRID MAPS WITH GRID OBSERVATIONS

Method	MPP = 0.3		MPP = 0.4		MPP = 0.5	
	SR	SPL	SR	SPL	SR	SPL
RMN	70.4%	33.4%	63.0%	29.1%	57.8%	26.2%
CMN	94.7%	58.0%	95.7%	57.3%	83.8%	51.9%

TASK CI: COARSE-GRID MAPS WITH IMAGE OBSERVATIONS

Method	MPP = 0.3		MPP = 0.4		MPP = 0.5	
	SR	SPL	SR	SPL	SR	SPL
RND	10.7%	9.5%	10.7%	9.5%	10.7%	9.5%
RMN	53.3%	45.8%	54.1%	11.4%	49.3%	11.3%
MCSE	78.9%	28.4%	76.9%	28.8%	70.0%	30.4%
CMN	91.6%	50.7%	87.8%	51.2%	70.0%	37.7%

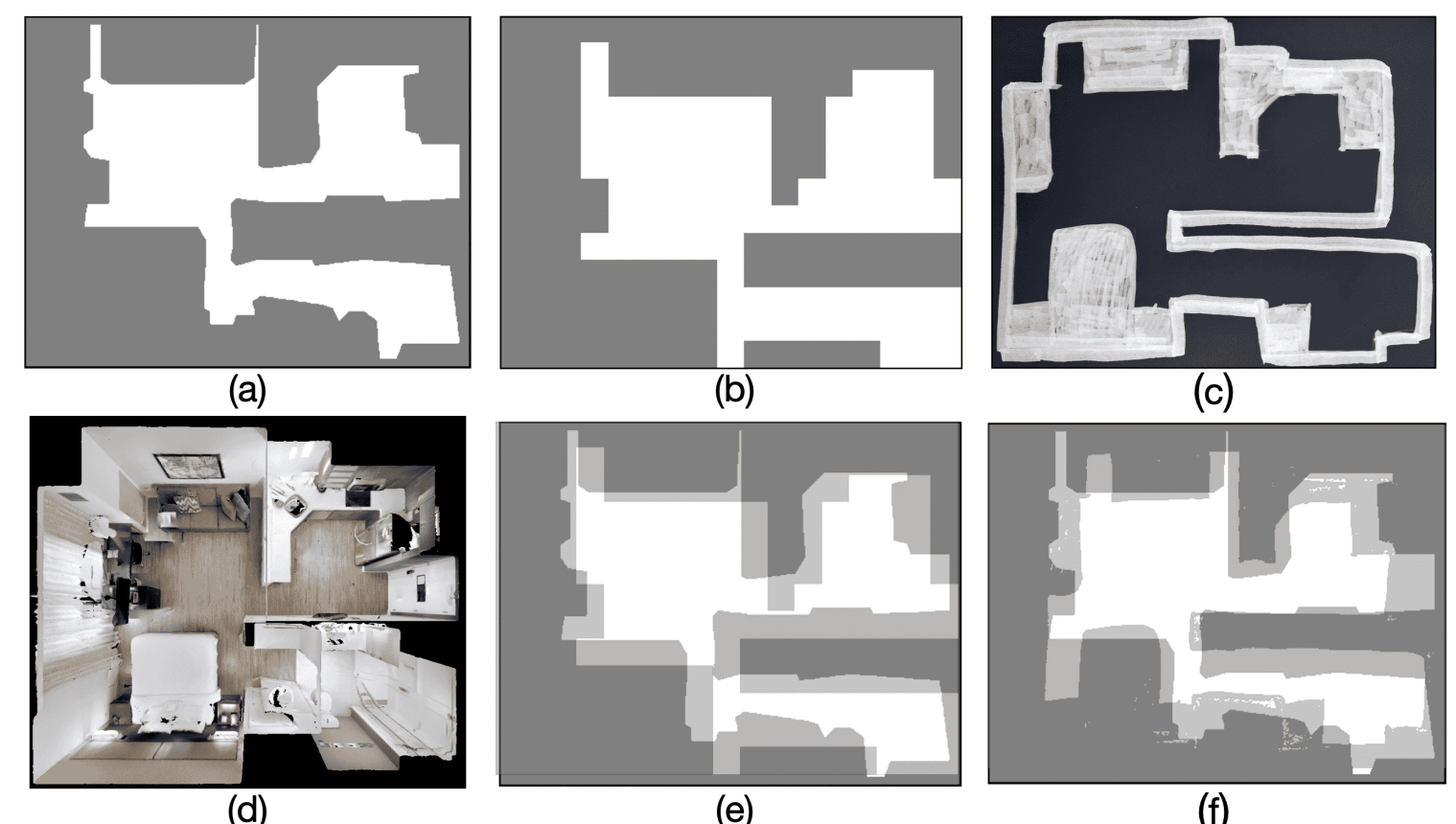
TASK HD: HAND-DRAWN MAPS WITH IMAGE OBSERVATIONS

Method	SR	SPL
RMN	58.5%	23.8%
CMN	75.6%	36.5%

SR: mean Success Rate. SPL: mean Success rate weighted by Path Length. MPP: Meters Per Pixel.

What are the challenges?

1. Unseen high-dimensional observations in photo-realistic home environments, depicted in Figure (d).
2. Error and misalignment in 2-D coarse maps, shown as light gray areas in Figure (e) and (f).



Visual Navigation Task with Coarse Maps

The robot is initialized at a random location in an environment it does not encounter before. We define three tasks with increasing difficulty as follows:

TASK VARIANTS AND CHALLENGES INVOLVED

	Task CG	Task CI	Task HD
Coarse-grid map	✓	✓	
Hand-drawn map			✓
Local grid observations	✓		
Image observations		✓	✓
Location uncertainty	✓	✓	✓
Motion uncertainty	✓	✓	✓
Observation uncertainty		✓	✓
Non-uniform scale (MPP)			✓

Task CG: Coarse-grid map with Grid observations. Task CI: Coarse-grid map with Image observations. Task HD: Hand-Drawn map.

Coarse Map Navigator is Robust to Different Coarse Maps

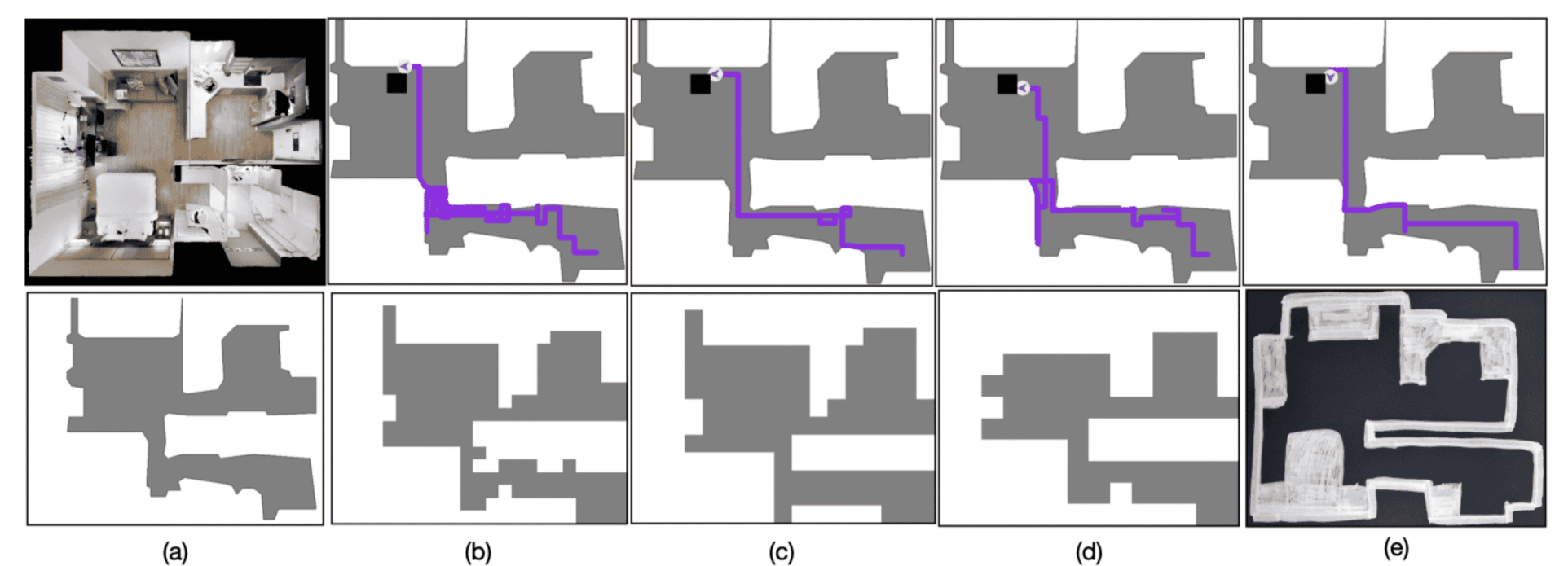


Fig. 5. Visualization of trajectories for CMN (top row) using different coarse maps (bottom row). Column (a) shows the top-down view and the ground-truth *metric* map of one environment. Columns (b) – (d) show the trajectories of the robot using *coarse-grid* maps with MPP = 0.3, 0.4, 0.5 respectively (input coarse maps shown in bottom row). Column (e) shows the trajectory of the robot using a *hand-drawn* map.

Coarse Map Navigator Corrects Localization Error in Hand-Drawn Maps

