DIPP: A Diffusion-based Potential Planner for Synergistic Navigation and Mapping

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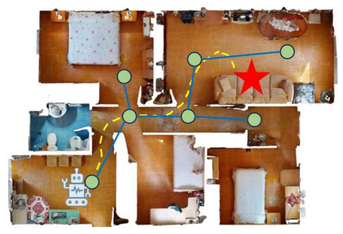
Abstract

Motivations:

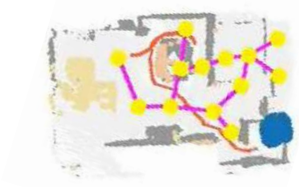
- **Persistent Memory: agents must build reusable maps across long-horizon tasks**
- **Map-Plan Synergy: navigation and topological mapping should reinforce each other**
- **Generative Prior: diffusion models jointly capture goal-directed and structural potentials**

Contributions:

- **Propose a diffusion-based potential planner, DIPP**
- **Unify navigation and topological mapping in one model**
- **Validate DIPP on Habitat-Gibson, surpassing SOTA**



(a) Dual Potentials

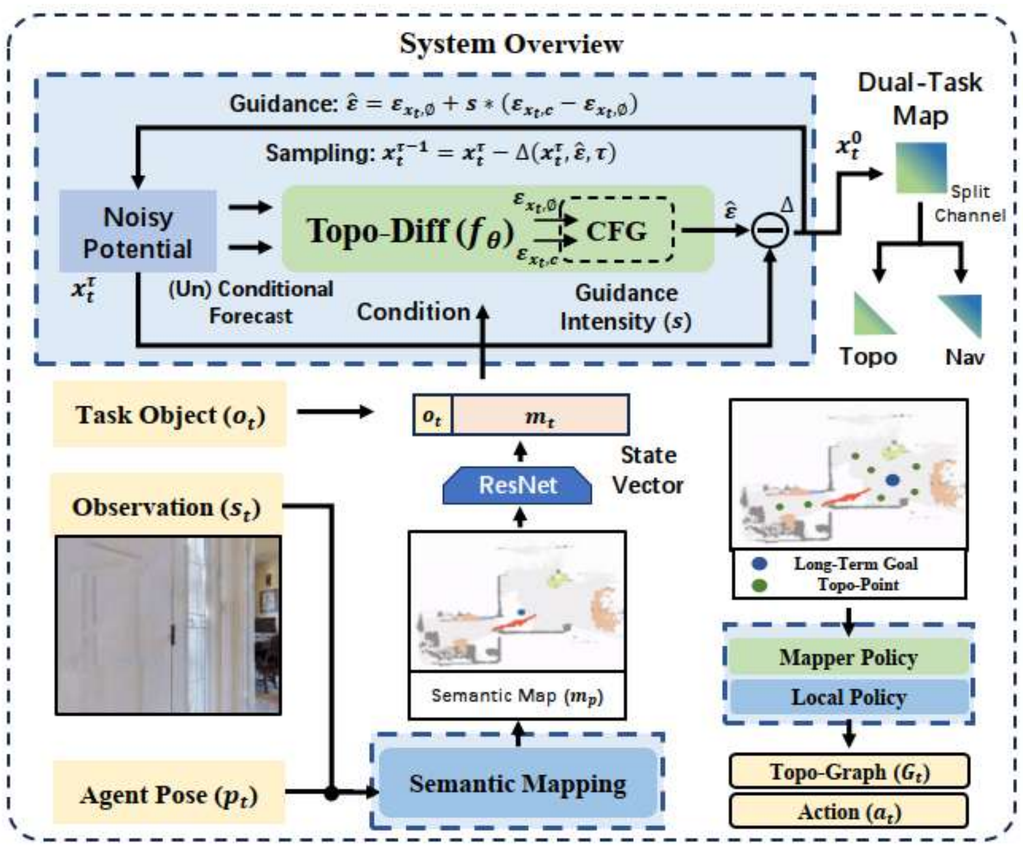


(b) Persistent Graph

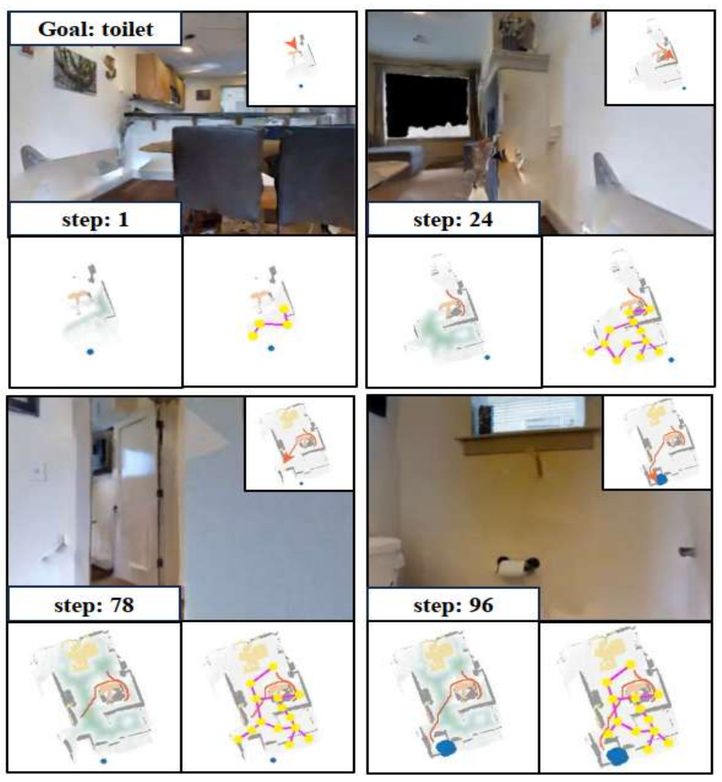
(c) habitat-sim

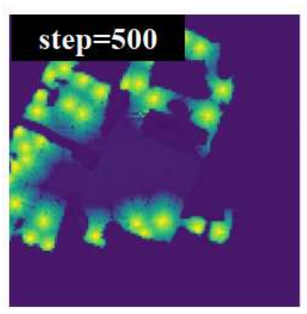
Methodology

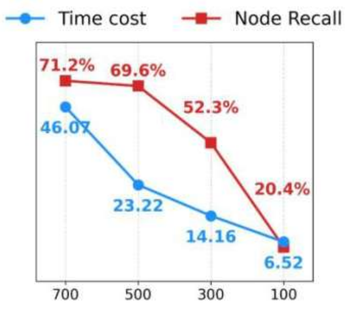
- **Build a top-down semantic map**
- **Generate dual potential fields**
- **Refine topological graph from learned potentials**
- **Plan long-horizon waypoints**
- **Execute low-level control**



Visualization Results







We present qualitative experiments deploying DIPP in the Habitat simulator, where the agent incrementally builds a topological graph while navigating to target objects.

Interested?
Scan the QR code, watch the video, and learn more.

Quantitative Experiment

Experimental results comparing DIPP against state-of-the-art baselines and ablations on key designs.

SR: Success Rate SPL: Success weighted by Path Length DTS: Distance to Target NR: Node Recall

Method	SR ↑	SPL ↑	DTS ↓
Modular Methods			
Frontier Exploration[25]	0.643	0.283	1.78
SemExp [6]	0.717	0.396	1.39
PONI [1]	0.736	0.410	1.25
L3MVN [26]	0.769	0.388	1.01
T-Diff [2]	0.796	0.449	**1.00**
Imagine-Before-Go [27]	0.780	0.440	1.11
End-to-End Method			
DD-PPO [7]	0.150	0.107	3.24
SSIF [28]	0.600	0.312	1.89
Our Method			
DIPP (Potential Fusion)	0.748	0.454	1.18
DIPP (Hierarchical System)	**0.807**	**0.476**	1.08

α	SR ↑	SPL ↑	DTS ↓
0.0	0.641	0.347	1.98
0.3	0.701	0.412	1.49
0.5	**0.748**	**0.454**	**1.18**
0.7	0.724	0.435	1.24

Training Strategy	SR ↑	SPL ↑	DTS ↓
Ours (Stage 1 + Stage 2)	**0.748**	**0.454**	**1.18**
Ours (Only Stage 2)	0.542	0.291	2.53

The hierarchical system achieves 80.7% SR and 0.476 SPL, surpassing all baselines, while ablations confirm the topological potential as an essential prior and the two-stage curriculum as critical to performance.