PredRecon: A Prediction-boosted Planning Framework for Fast and High-quality Autonomous Aerial Reconstruction

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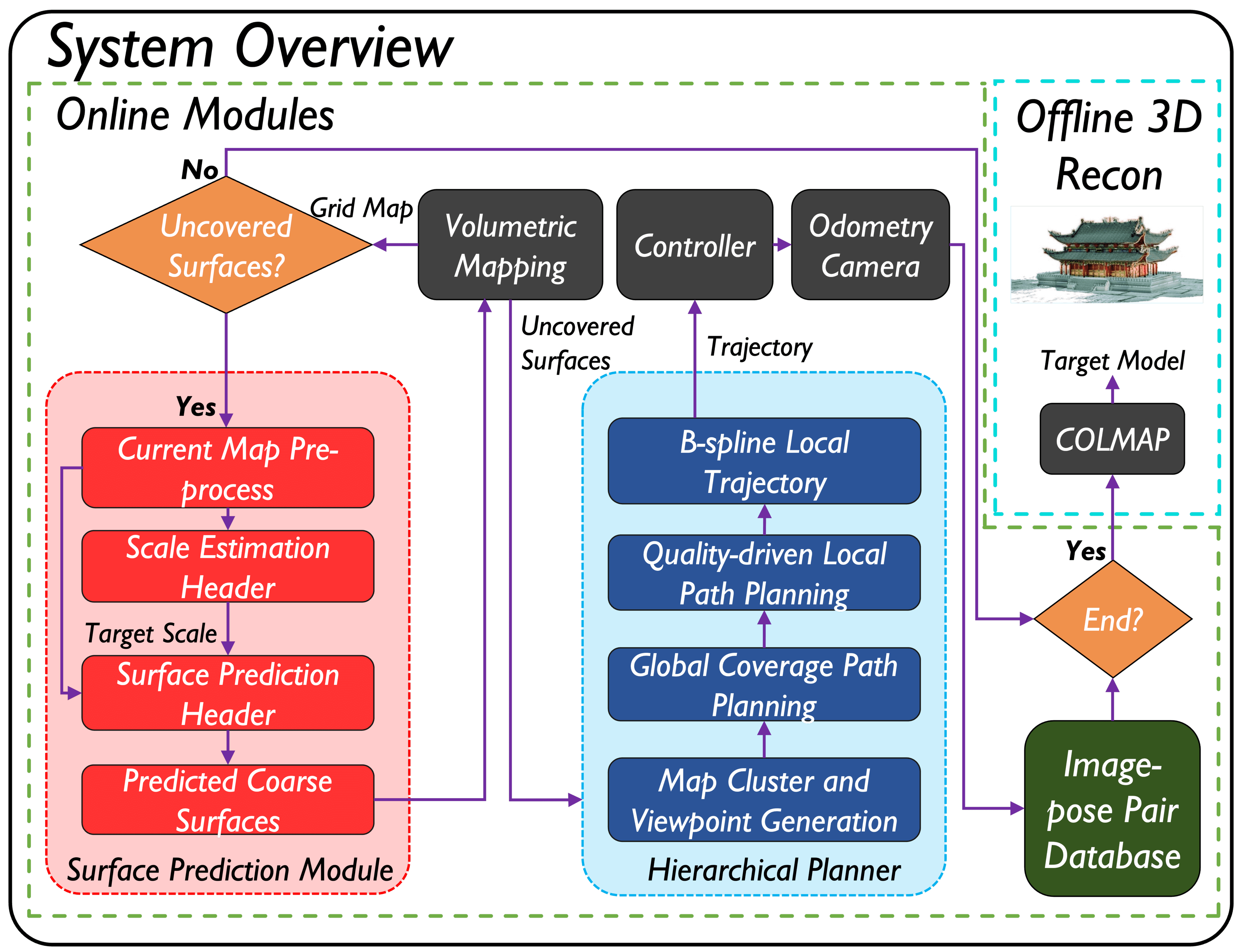
Existing Aerial Reconstruction Approaches

- ***Explore-then-exploit*** **method: Need two scanning trails → Task completion inefficiency**
- **Prior-based method: Planning entirely based on prior information → Task cannot be fully automated**
- **Exploration-based method: Distribute significant time to explore unknown regions → Unsatisfactory efficiency due to exploration**

Our Prediction-boosted Planning Framework

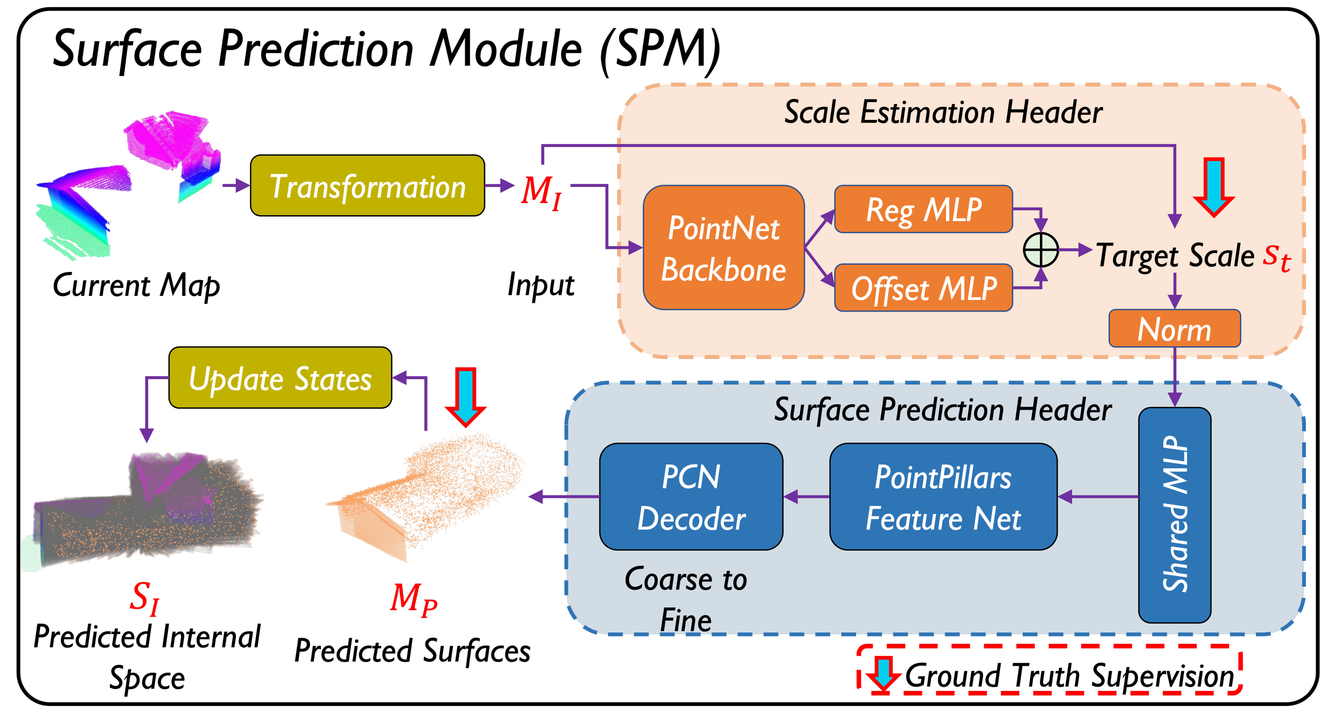


1) A surface prediction module (SPM), which directly infers the complete target surfaces from partial reconstruction information and facilitates efficient global coverage of the target without wasting significant time on extra exploration.

2) A hierarchical planner based on SPM, which sufficiently considers MVS-related factors on the fly and global coverage, achieving higher reconstruction quality and efficiency.

Surface Prediction Module (SPM)

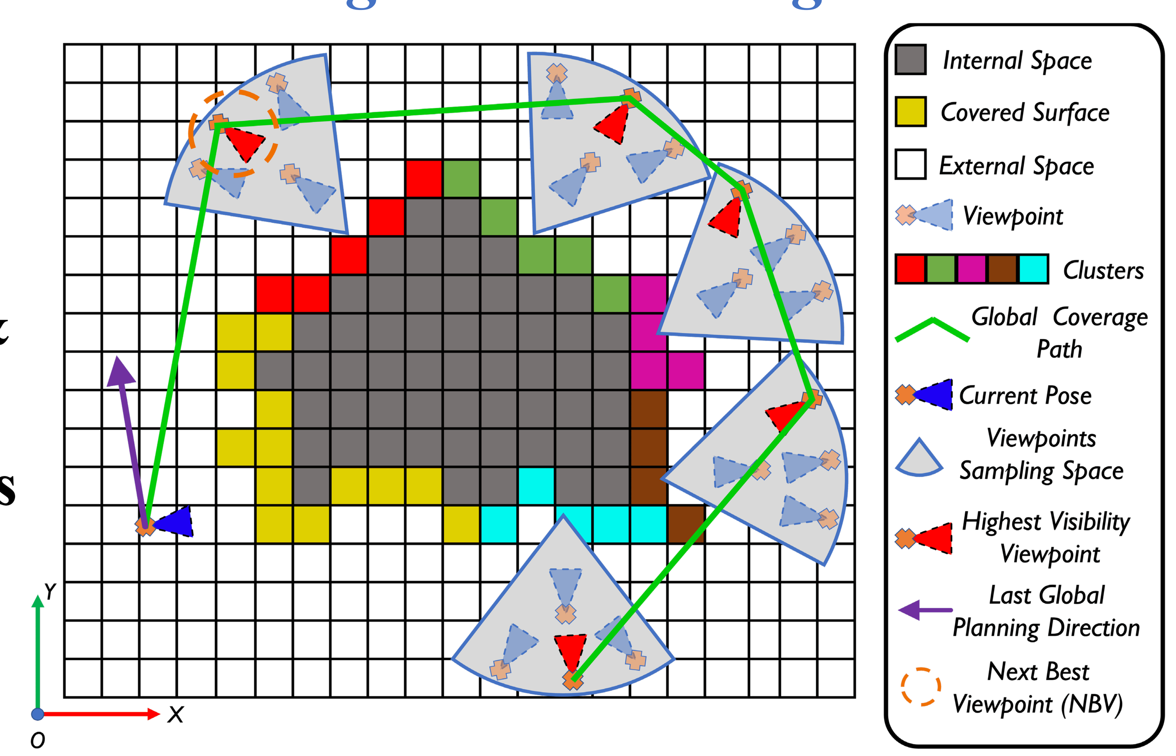
Predict the whole surfaces of the target from partial map to decrease redundant flight.



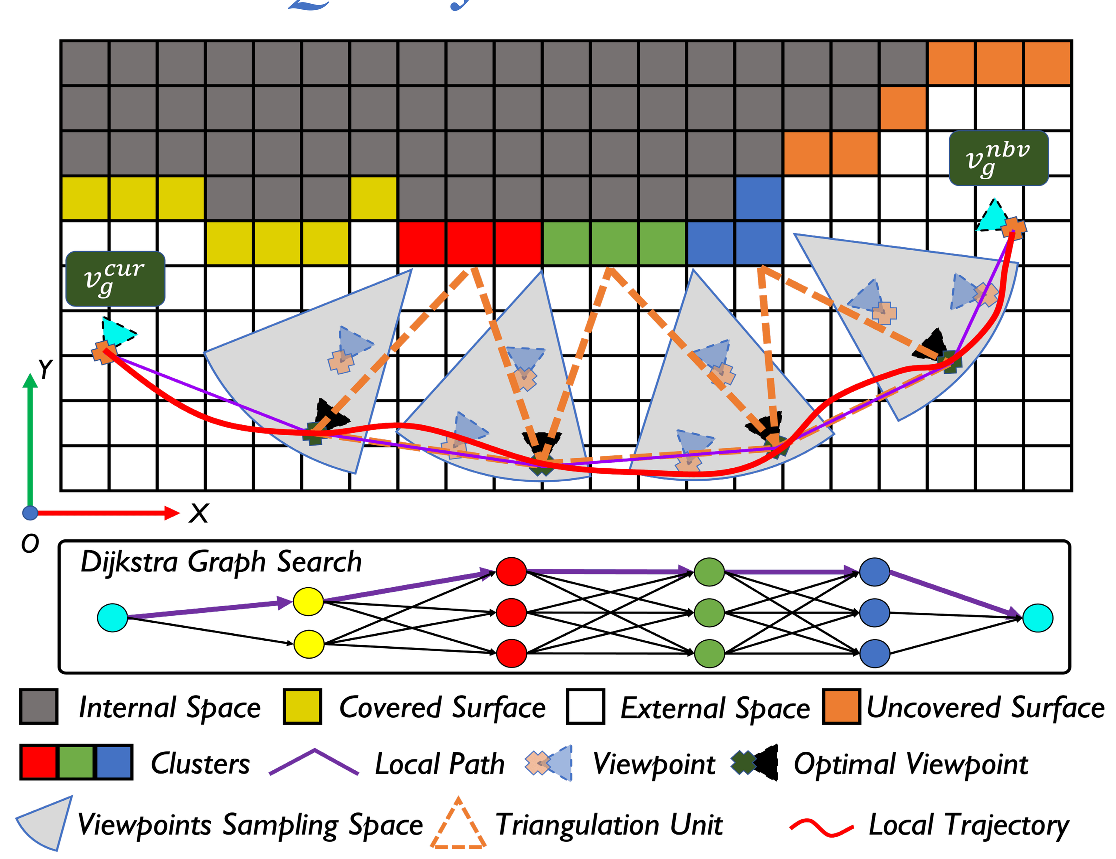
Hierarchical Planner

Global Coverage Path Planning

Efficiently & Completely & Fast cover surfaces



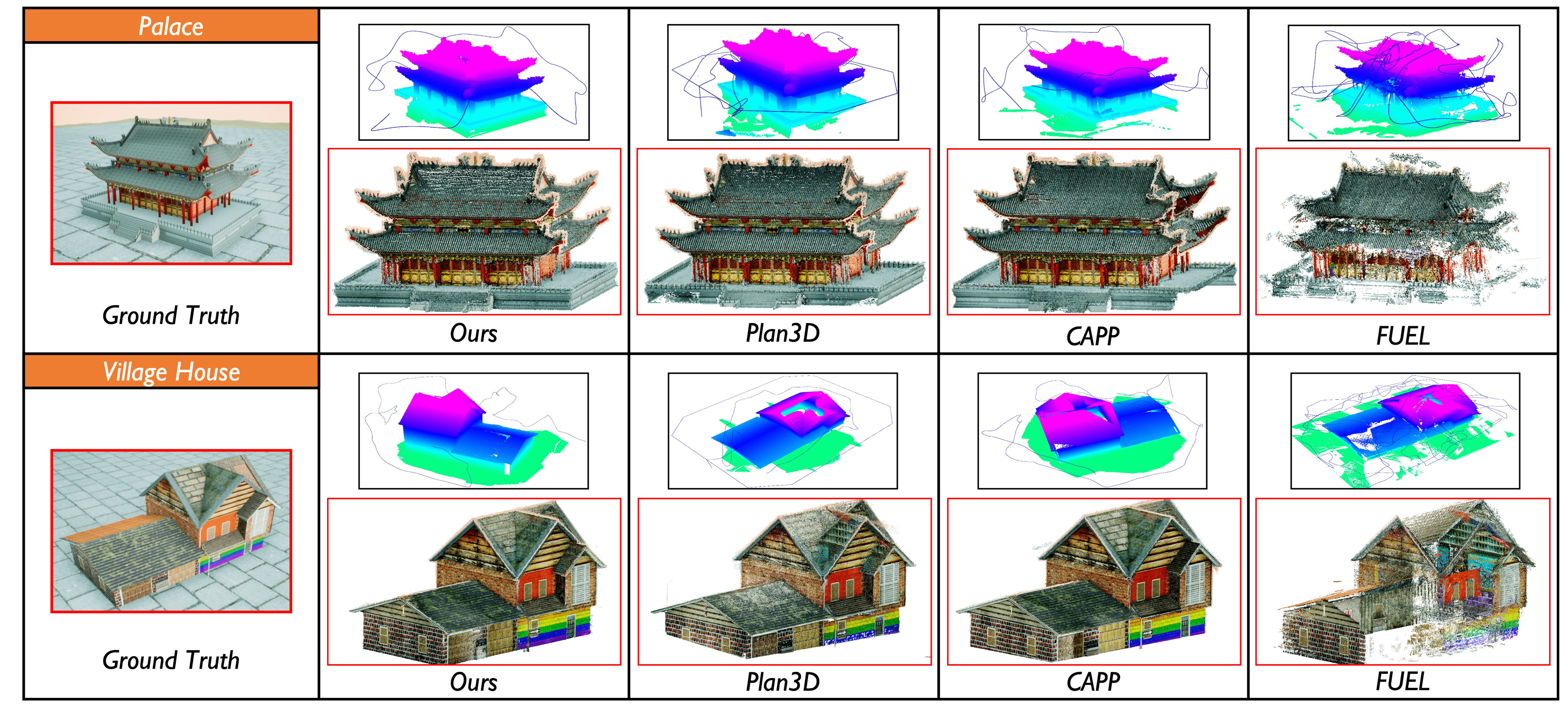
Quality-driven Local Path Planning



Generate path with higher reconstruction quality

Experiments

1. Path planning and 3D reconstruction results in challenging scenarios.



Best efficiency (path length and time) & reconstruction quality (F-score)

$$F-score = \frac{2(Precision \times Recall)}{Precision + Recall}$$

Scene	Method	Prior Model	Path Length (m)	Time (s)	Recall (%)	Precision (%)	F-score (%)
Palace	Plan3D [2]	✗	375.5	507.7	74.48	82.57	78.32
	CAPP [1]	✓	243.6	322.6	69.21	85.86	76.64
	FUEL [6]	✗	371.1	469.8	40.31	38.38	39.32
	Ours	✗	**213.1**	**252.7**	**74.67**	**86.45**	**80.13**
Village House	Plan3D [2]	✗	239.3	310.6	64.28	72.86	68.30
	CAPP [1]	✓	193.4	242.3	80.30	**84.60**	82.40
	FUEL [6]	✗	405.1	506.8	44.35	36.46	40.02
	Ours	✗	**153.2**	**184.6**	**84.54**	83.13	**83.83**

2. Real-time capability

	SPM	Global Planning	Local Planning	Traj. Opt.	Total Comp.
Time (ms)	~26.8	~93.5	~0.5	~3.7	~124.7

3. Point cloud completion performance

Method	#Param(M)	L1_CD (1e-3m)	L2_CD (1e-4m)	F-score (%)
our SPM	**28.20**	**13.6404 / 9.4461**	**14.7100 / 3.9368**	**52.6050 / 68.6693**
PCN [15]	28.91	15.5221 / 10.4897	18.3987 / 4.7741	50.1210 / 65.7207

Paper, code, and video are available:
https://github.com/HKUST-Aerial-Robotics/PredRecon