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HelixSurf: A Robust and Efficient Neural Implicit Surface Learning of Indoor Scenes with Iterative Intertwined Regularization

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Code Link: https://github.com/Gorilla-Lab-SCUT/HelixSurf

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ID 970

Definition & Challenge

Definition:

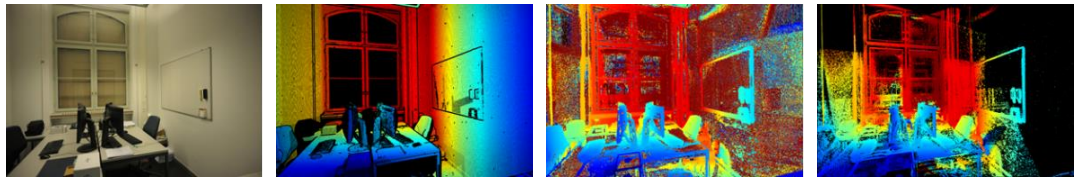
Given a set of calibrated RGB images of an indoor scene captured from multiple views, the task is to reconstruction the scene geometry with fine details.

Capture

Challenge:

- **Exposure / highlight / textureless areas**

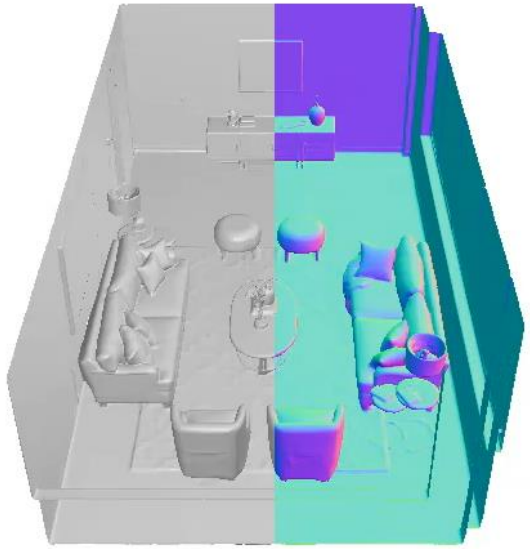
Reference View | Ground Truth | Baseline1 | Baseline2



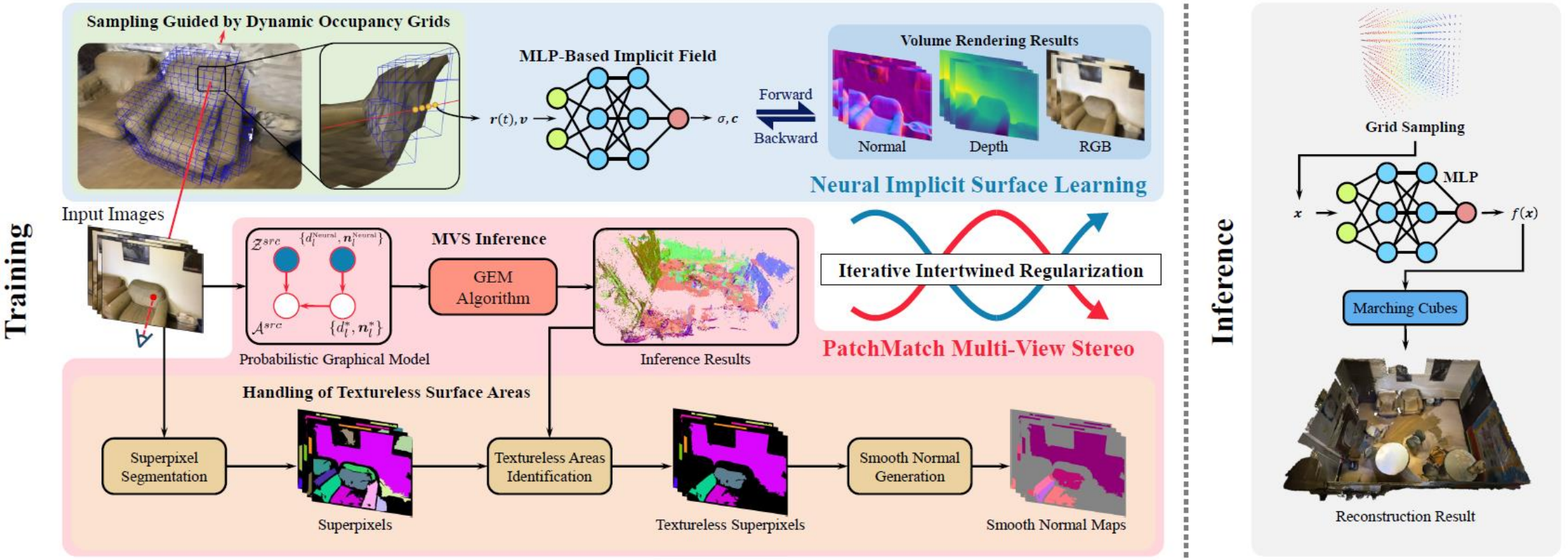
- **Long time for optimization**

≈10 hours

Reconstruct



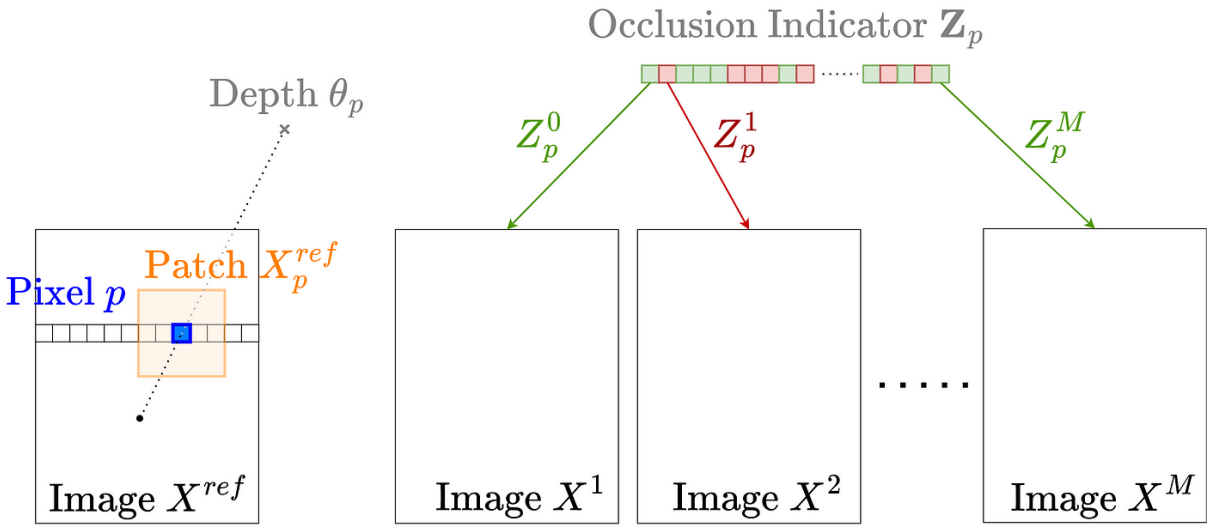
HelixSurf: Method Overview

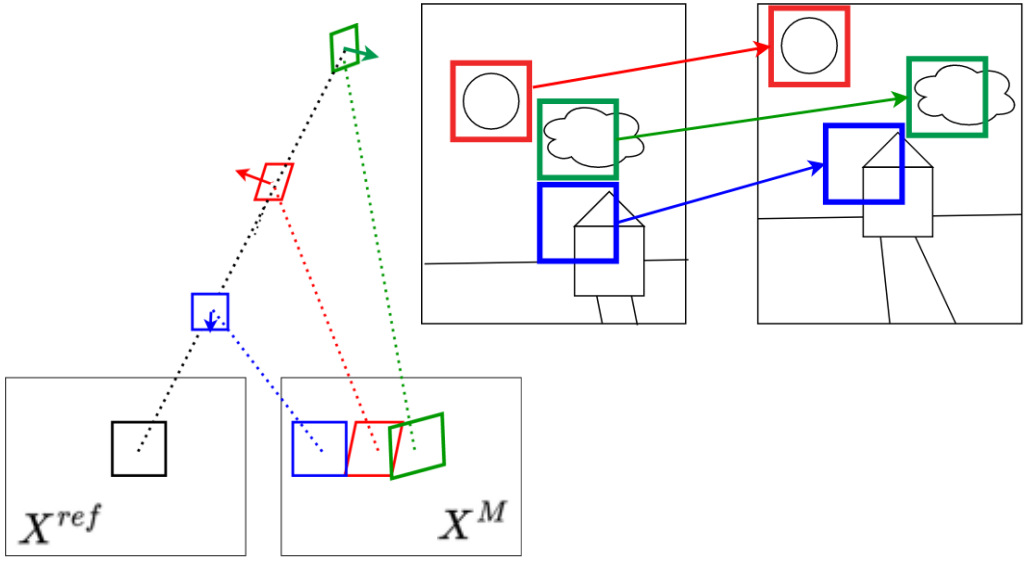


Related Works

PatchMatch based Multi-view Stereo

- Estimate the depth and/or normal of each pixel by exploiting inter-image photometric and geometric consistency;
- Fuse all the depth maps into a global point cloud with the filtering operations.

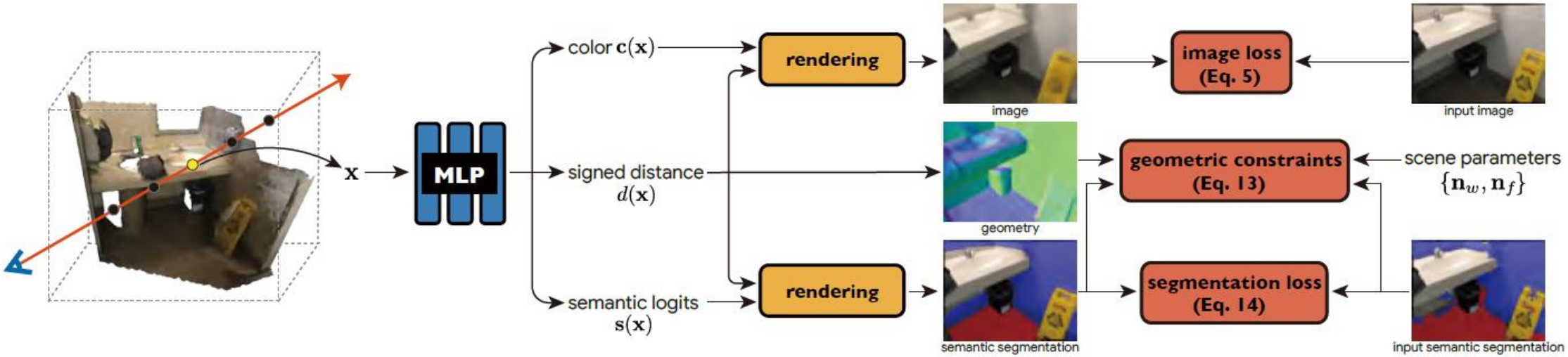




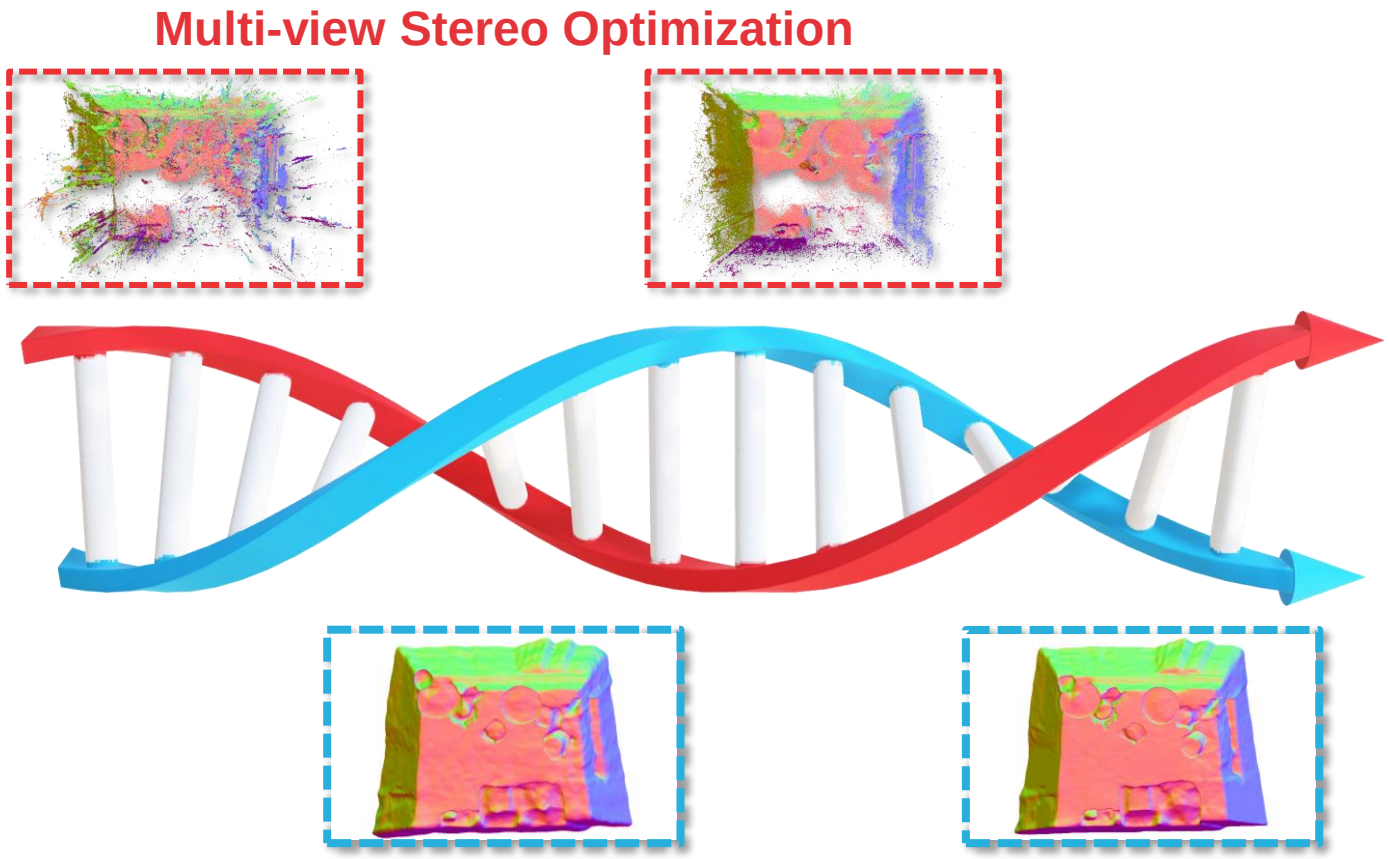
Related Works

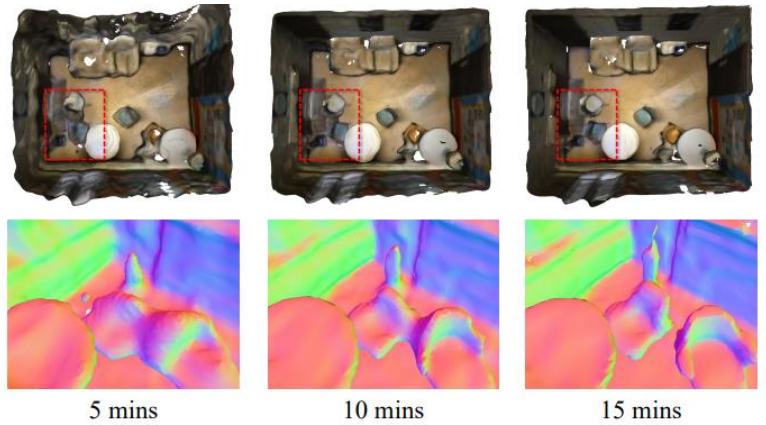
Neural Implicit Surface

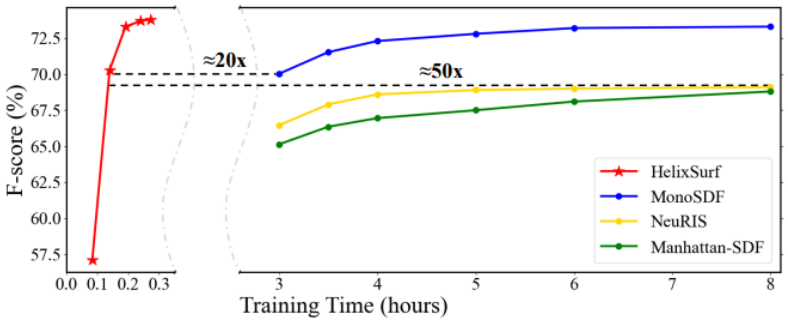
- Represent surfaces via learning neural networks (MLP) implicitly;
- Attach differentiable volume rendering techniques to reconstruction.



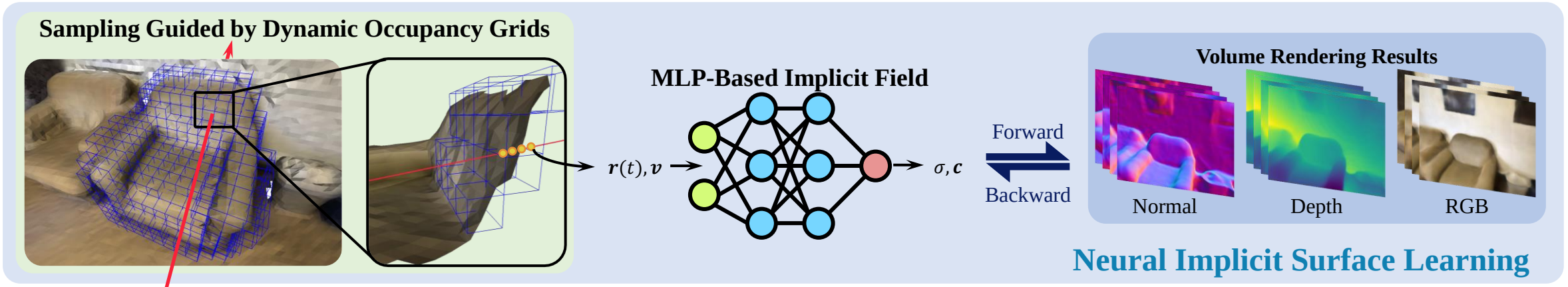
Motivation

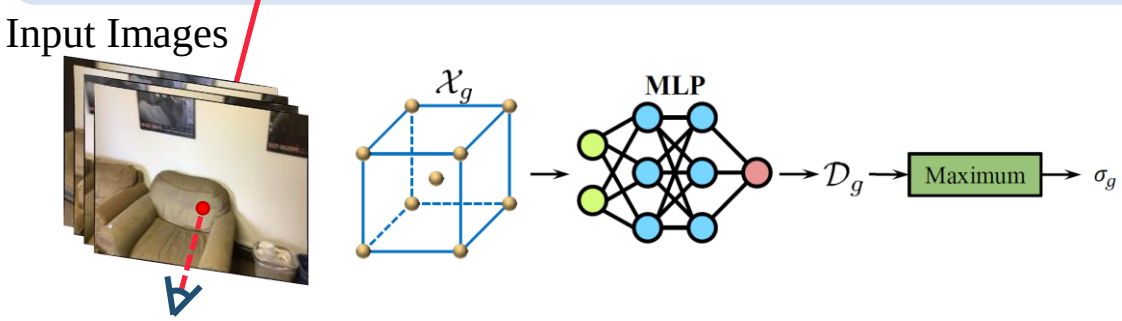

Multi-view Stereo Optimization
Neural Implicit Surface Learning

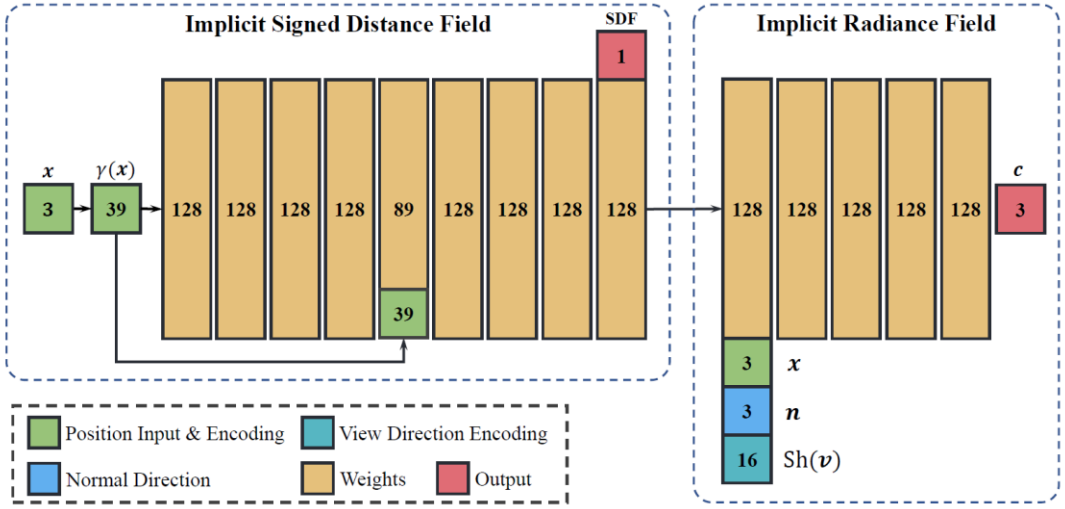

5 mins
10 mins
15 mins


F-score (%)
Training Time (hours)
≈20x
≈50x
HelixSurf
MonoSDF
NeuRIS
Manhattan-SDF

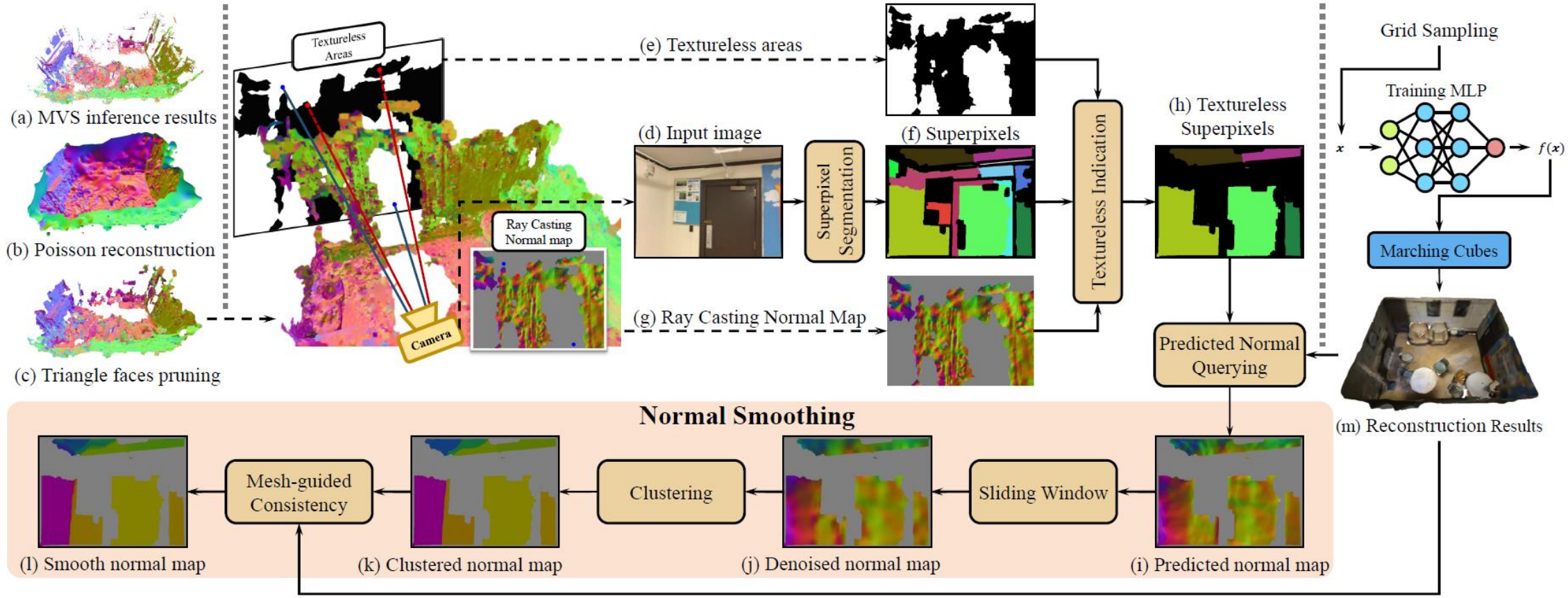
HelixSurf: Neural Implicit Surface







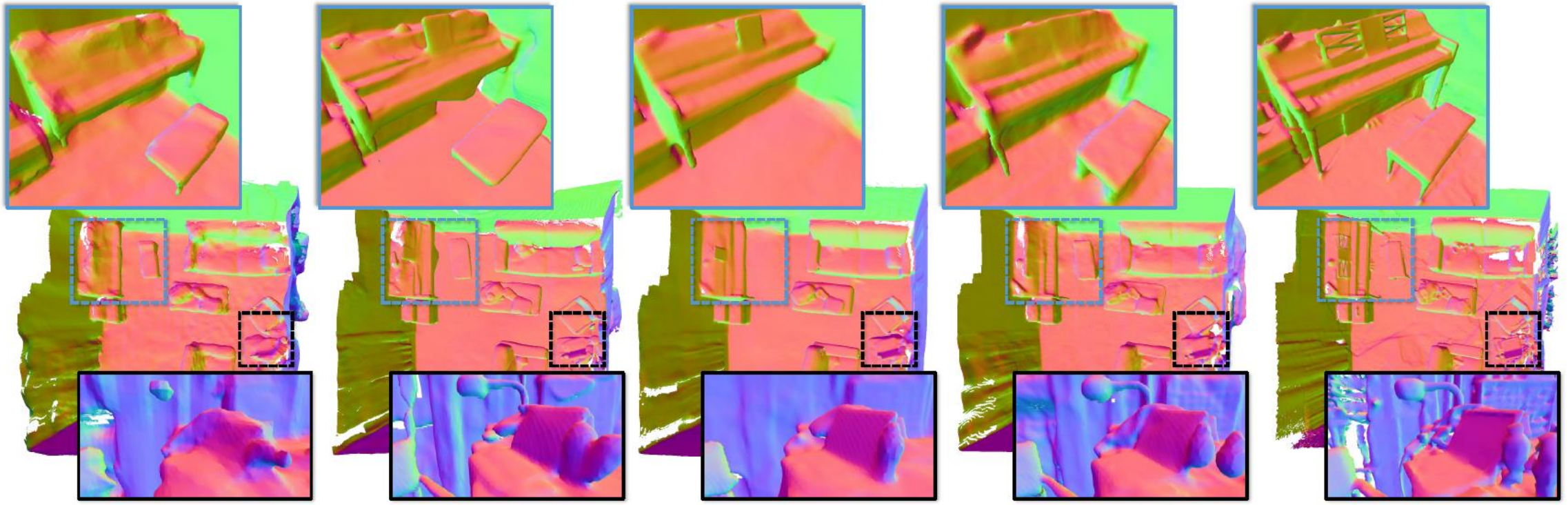
HelixSurf: Handling Textureless Surface Areas



Experiments: Benchmark

Method	Acc↓	Comp↓	Prec↑	Recall↑	F-score↑	Time↓
COLMAP [37]	0.047 ●	0.235	0.711	0.441	0.537	*133*
ACMP [44]	0.118	0.081	0.531	0.581	0.555	*10*
NeRF [28]	0.735	0.177	0.131	0.290	0.176	> 1k
VolSDF [48]	0.414	0.120	0.321	0.394	0.346	825
NeuS [41]	0.179	0.208	0.313	0.275	0.291	531
Manhattan-SDF† [14]	0.053	0.056	0.715 ●	0.664	0.688	528
NeuRIS† [40]	0.050	0.049 ●	0.714	0.670 ●	0.691 ●	406
MonoSDF† [50]	0.035 ●	0.048 ●	0.799 ●	0.681 ●	0.733 ●	708
HelixSurf	0.038 ●	0.044 ●	0.786 ●	0.727 ●	0.755 ●	**33**

Experiments: Visualization



Experiments: Ablation Studies

Quantitative comparison between
the ordinary MVS and our regularized MVS

Method	Depth map			
	Abs Diff↓	Abs Rel↓	Sq Rel↓	RMSE ↓
ordinary	0.067	0.098	0.020	0.147
regularized	0.053	0.085	0.011	0.106
Method	Normal map			
	Mean ↓	Median↓	RMSE↓	Prop_30° ↑
ordinary	35.5°	30.4°	42.6°	51.0%
regularized	27.8°	20.2°	35.3°	67.4%

Qualitative comparison between
the ordinary MVS and our regularized MVS

(a) ordinary MVS.

(b) regularized MVS.

Experiments: Ablation Studies

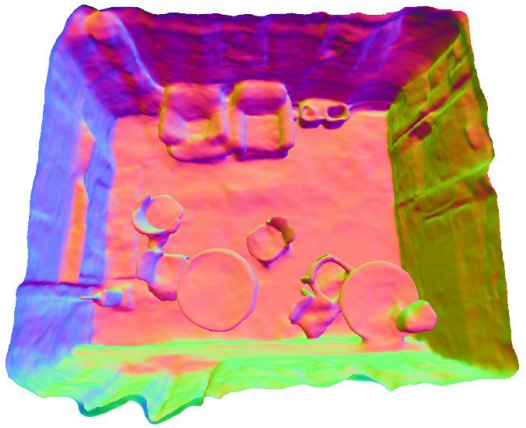
Analysis on the regularization of neural implicit surface learning from MVS predictions

Regularization			Acc↓	Comp↓	Prec↑	Recall↑	F-score↑
oridinary MVS	regularized MVS	Textureless Areas Handling					
			0.179	0.208	0.313	0.275	0.291
✓			0.059	0.076	0.661	0.605	0.632
	✓		0.051	0.066	0.711	0.649	0.679
✓		✓	0.047	0.053	0.768	0.706	0.735
	✓	✓	**0.038**	**0.044**	**0.786**	**0.727**	**0.755**

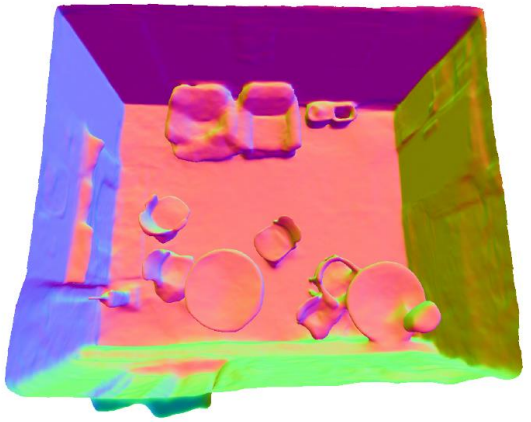
Analysis on different intervals of learning iterations for intertwined regularization

N_{inter}	4000	6000	8000	10000	12000
F-score↑	0.753	0.752	0.755	0.754	0.752

Visualization ofreconstruction without the use of smoothness scheme for textureless areas and with the use of smoothness scheme.



(a) W/O smoothness on textureless surface areas



(b) With smoothness on textureless surface areas

Experiments: Optimization Process

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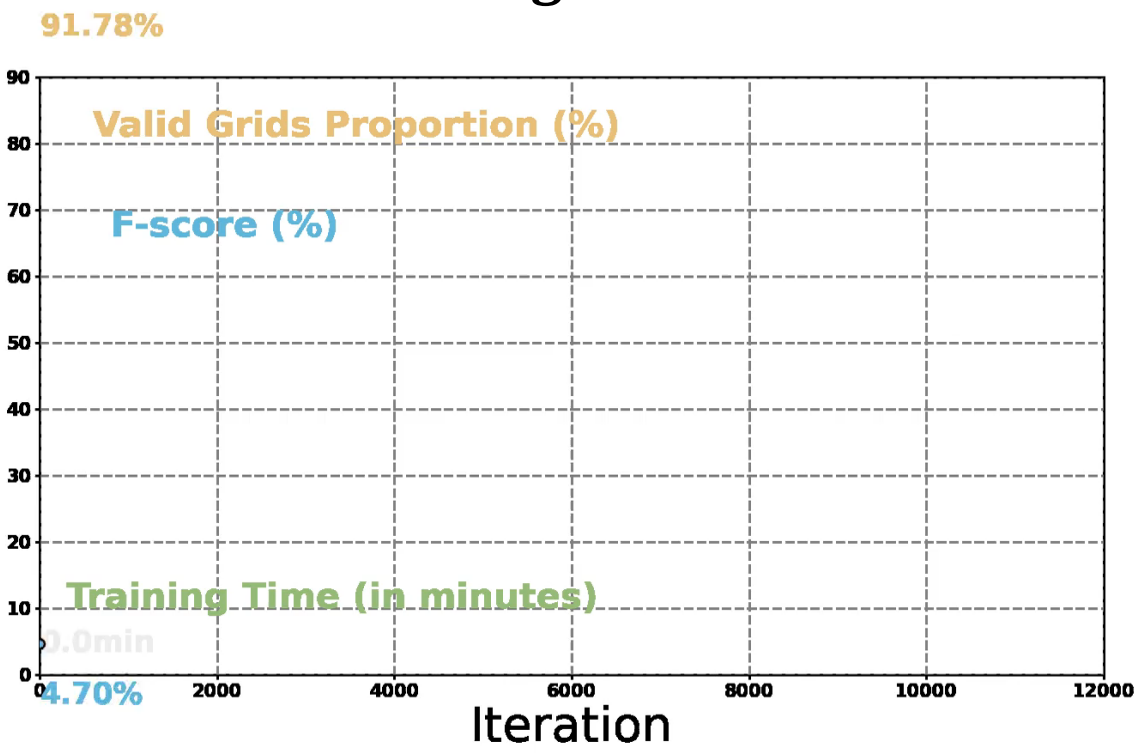
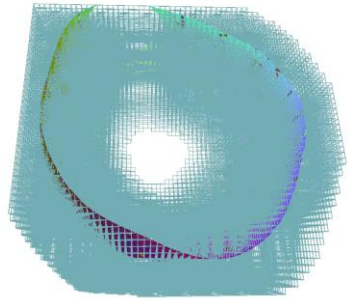
HelixSurf

Training Process



Implicit Surface & Dynamic Occupancy Grids



Implicit Surface

Experiments: Real Captured Data

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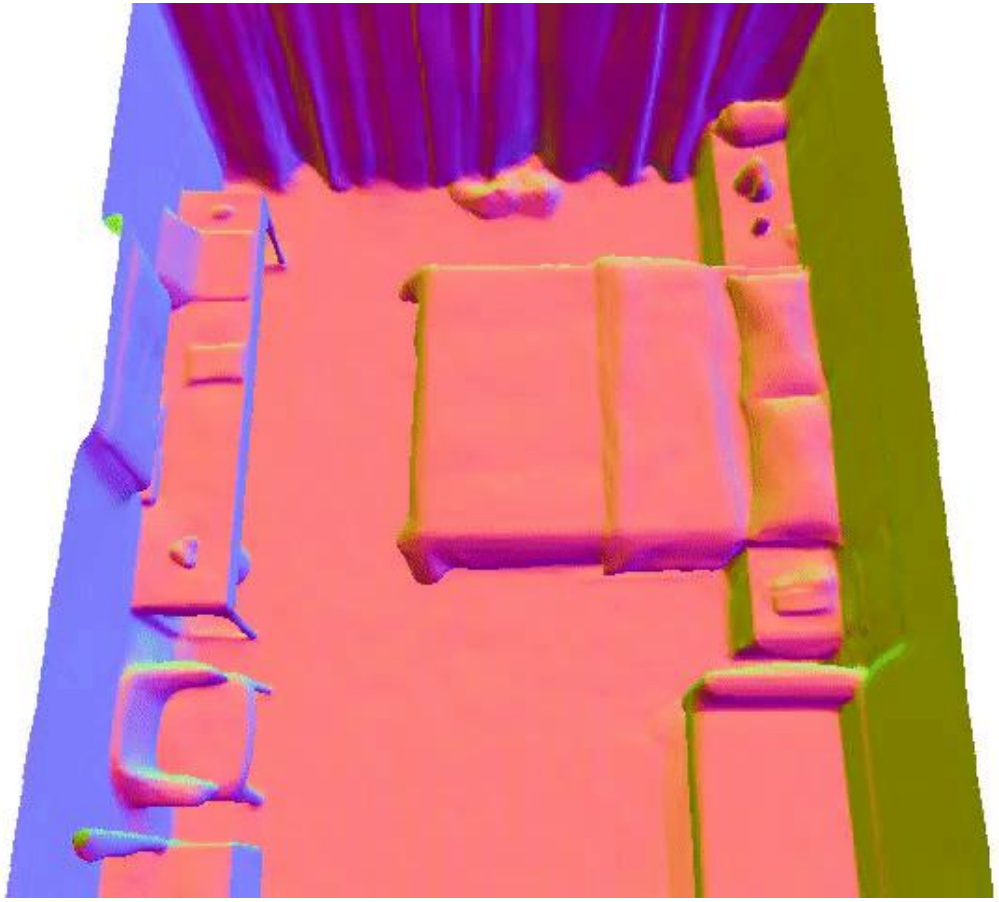

Thank You

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