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FD-NeuS: Fine-Detailed Neural Indoor Scene Reconstruction Using Multi-Level Importance Sampling and Multi-View Consistency

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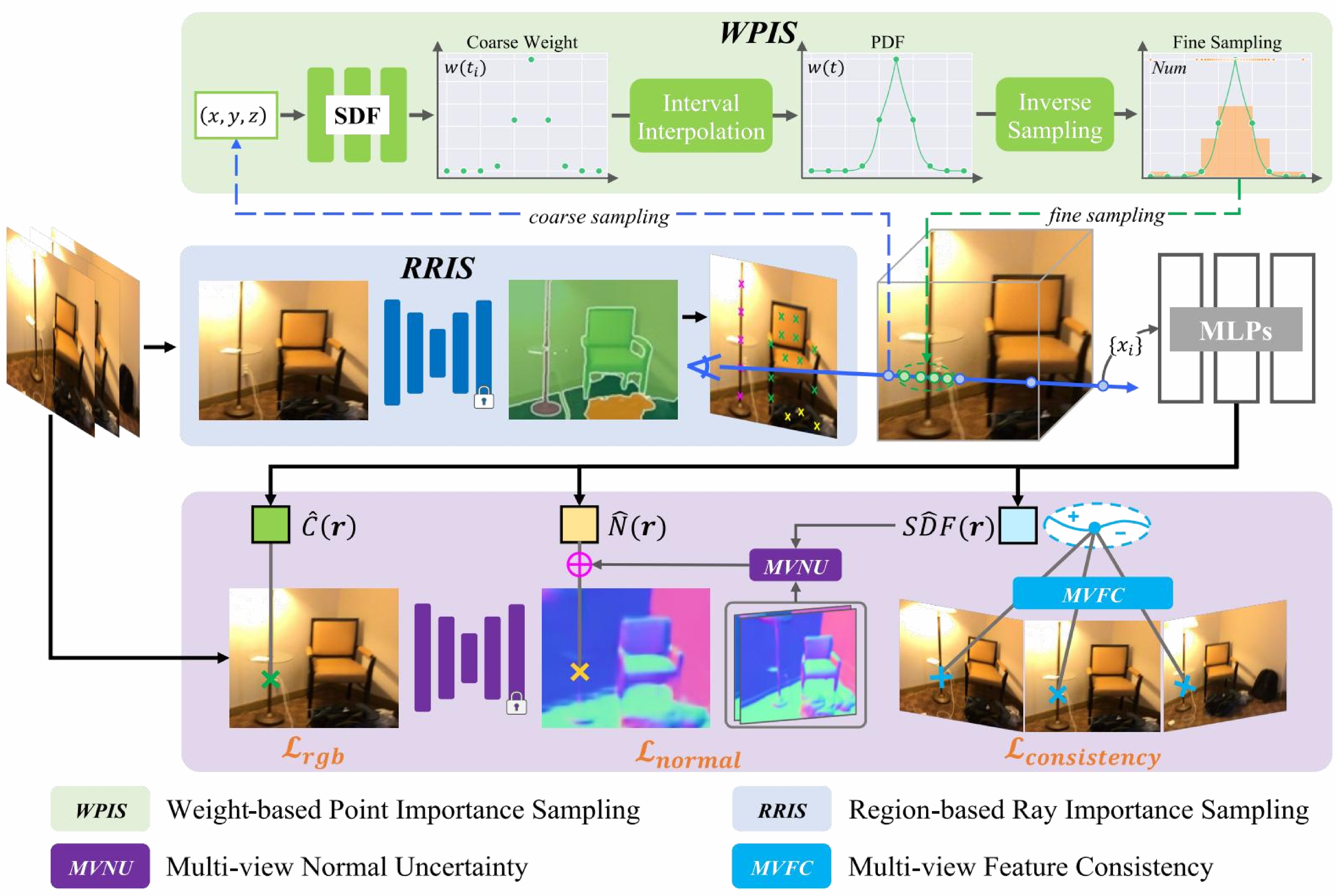
Introduction

Recently, neural implicit 3D reconstruction in indoor scenarios has become popular due to its simplicity and impressive performance. Previous works could produce complete results leveraging monocular priors of normal or depth. However, they may suffer from over-smoothed reconstructions and longtime optimization due to unbiased sampling and inaccurate monocular priors. In this work, we propose **FD-NeuS**, a novel neural implicit surface reconstruction method that can recover fine details for complex indoor scenes.

Methods



- **Multi-Level Importance Sampling**
  - Region-Based Ray Sampling: Prioritizes rays in detailed regions using segmentation maps, enhancing the focus on fine details.
  - Weight-Based Point Sampling: Uses piecewise exponential functions to better distribute sampling points near surfaces.
- **Multi-View Consistency**
  - Feature Consistency: Leverages deep image features for better supervision of textured regions.
  - Normal Consistency: Uses multi-view uncertainty to filter unreliable normal estimates and guide sampling in uncertain areas.

Conclusions

We propose FD-NeuS, a novel neural implicit surface reconstruction method using multi-level importance sampling strategy and multi-view consistency methodology, to recover indoor scenes with fine details. Extensive experiments show our method achieves superior performance compared with existing methods on multiple metrics and various scenes.

Results

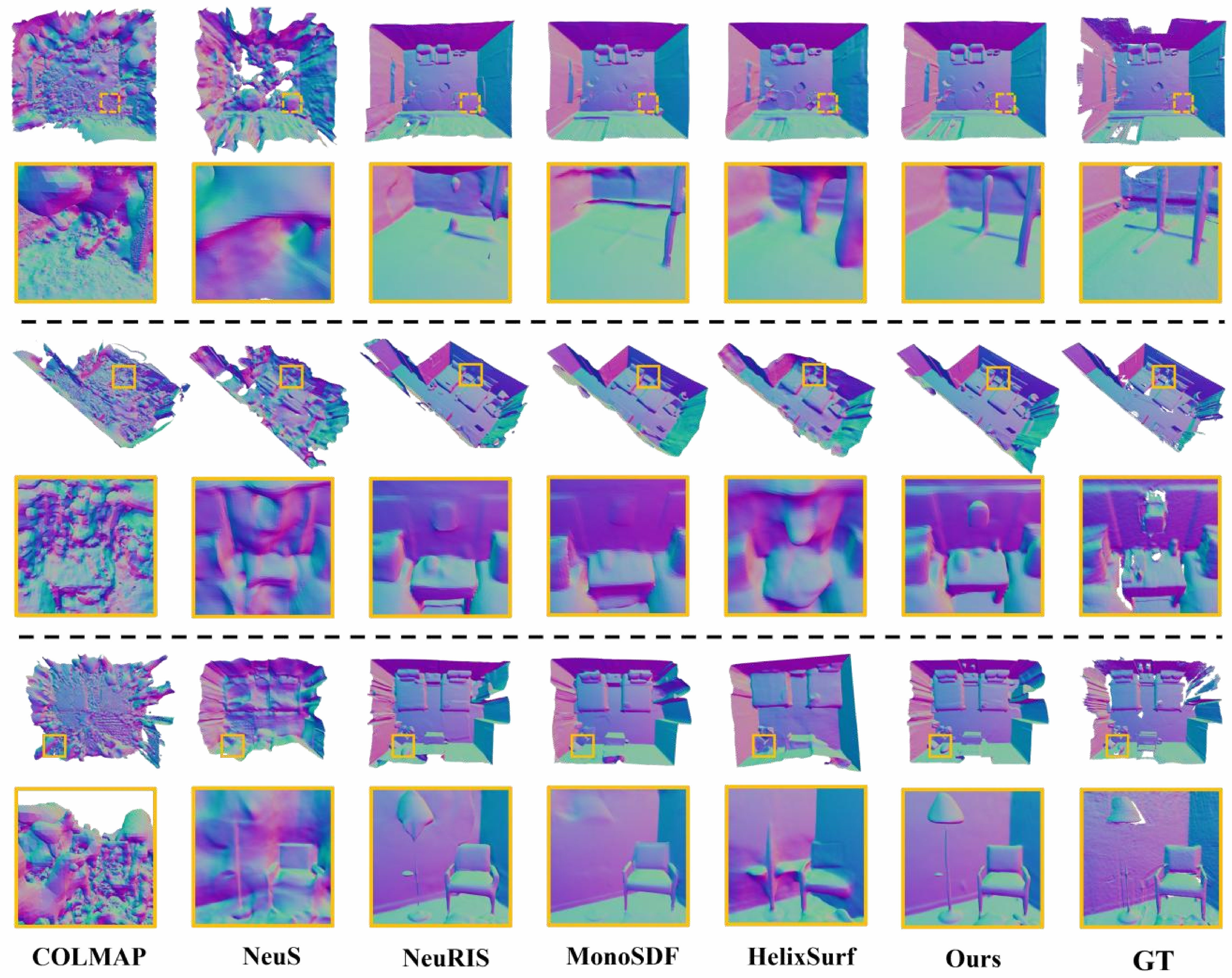
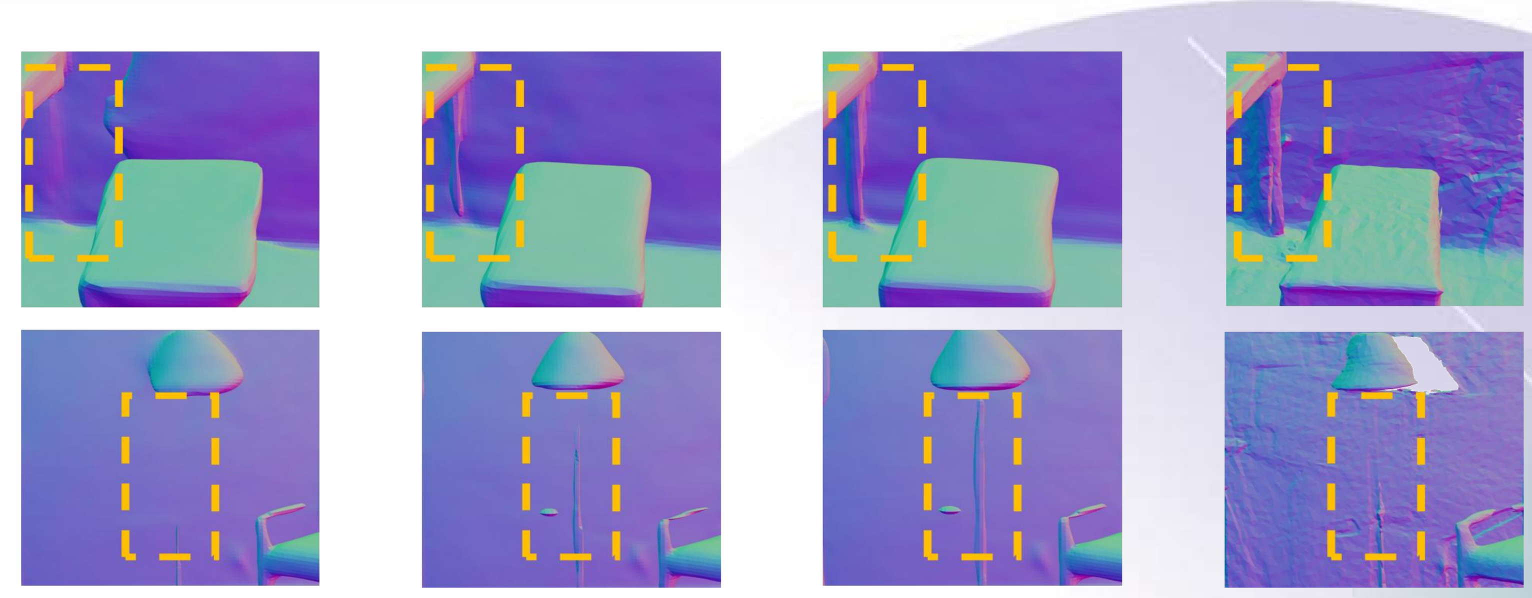


Table 1: Quantitative comparison results

Method	Acc. ↓	Comp. ↓	Prec. ↑	Recall ↑	F-score ↑
COLMAP [19]	0.062	0.090	0.640	0.569	0.600
NeuralRecon [4]	0.042	0.090	0.747	0.574	0.648
NeRF [5]	0.160	0.065	0.378	0.576	0.454
NeuS [6]	0.105	0.124	0.448	0.378	0.409
Manhattan-SDF [8]	0.052	0.072	0.709	0.587	0.641
MonoSDF [9]	0.048	0.068	0.673	0.558	0.609
NeuRIS [10]	0.053	0.053	0.717	0.662	0.688
HelixSurf [20]	0.063	0.134	0.657	0.504	0.567
Ours	**0.038**	**0.043**	**0.831**	**0.761**	**0.794**

Table 2: Ablation study on ScanNet

	RRIS	WPIS	MVFC	MVNU	Prec. ↑	Recall ↑	F-score ↑
Base					0.756	0.686	0.719
Model-A	✓				0.800	0.734	0.765
Model-B	✓	✓			0.821	0.746	0.781
Model-C	✓	✓	✓		0.828	0.754	0.789
Ours	✓	✓	✓	✓	**0.831**	**0.761**	**0.794**



a) Base b) + Importance Sampling c) Ours d) GT