



Overview



Figure 1: Existing methods reconstruct 3D scenes with either explicit or implicit geometry. **SDFoam** jointly learns a signed distance field and a 3D Voronoi diagram during ray tracing, balancing rendering speed, fidelity, and reconstruction accuracy.

Our contribution

- A **single representation** for view synthesis and geometry, producing cleaner and more view-consistent surfaces.
- A hybrid **implicit–explicit** representation combining Voronoi cells with local SDFs for better geometry alignment.
- Fast mesh extraction, up to **5× faster** than naive density-based thresholding on Radiant Foam.

Ray traversal

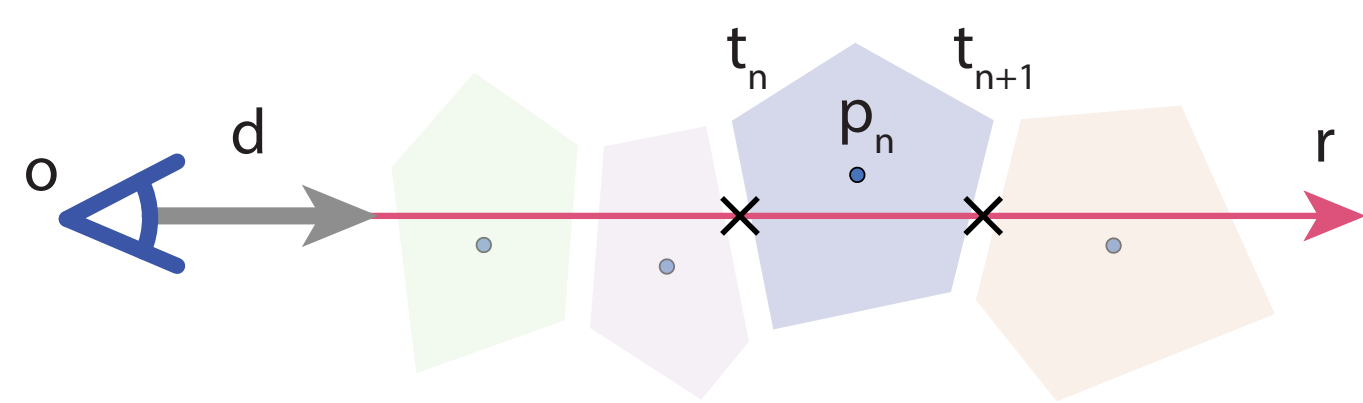


Figure 2: Ray traversal through Voronoi cells. The ray intersects the n -th cell (centered at site p_n) at positions t_n (entry) and t_{n+1} (exit), defining the segment length δ_n . Spatial and visual information are piecewise constant within δ_n . The ray r is defined by its origin o and direction d .

Architecture

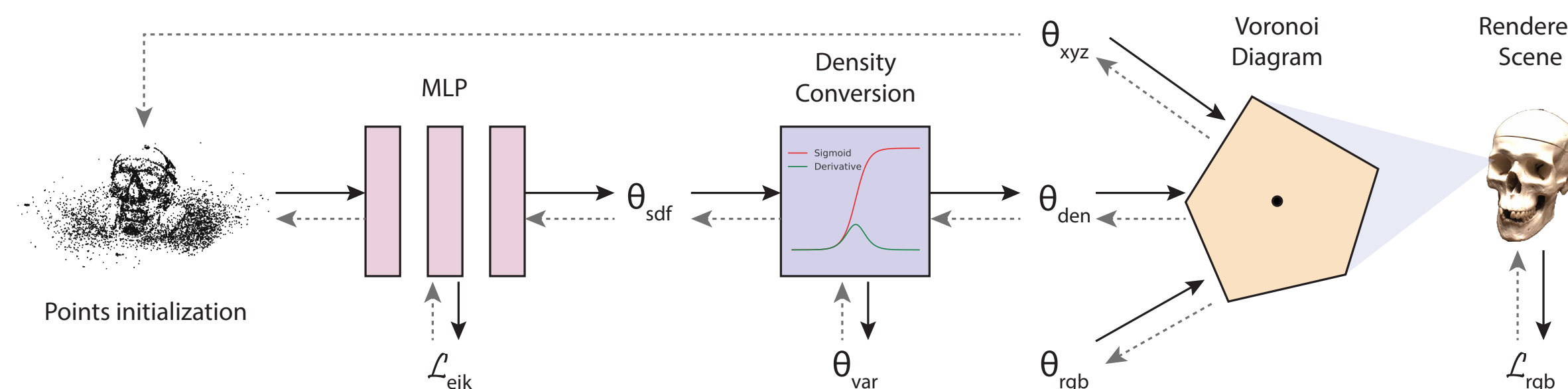


Figure 3: **SDFoam Architecture**. A point cloud is refined by learning an SDF from its points. SDF values are converted to density and optimized jointly with color and position parameters to learn a ray-traced scene.

Quantitative 3D Reconstruction

ScanID	Chamfer Distance (w/ mask) ↓					PSNR ↑		SSIM ↑	
	IDR	NeRF	NeuS	RF*	SDFoam	RF	SDFoam	RF	SDFoam
scan24	1.63	1.83	0.83	6.13	1.86	31.28	29.80	0.877	0.848
scan37	1.87	2.39	0.98	3.53	2.87	31.58	30.42	0.921	0.899
scan40	0.63	1.79	0.56	6.02	1.80	32.12	30.68	0.886	0.851
scan55	0.48	0.66	0.37	1.31	0.86	33.04	32.01	0.957	0.946
scan63	1.04	1.79	1.13	7.10	2.23	35.97	35.26	0.969	0.962
scan65	0.79	1.44	0.59	2.10	1.52	32.96	32.43	0.958	0.952
scan69	0.77	1.50	0.60	2.84	1.30	29.18	28.17	0.937	0.907
scan83	1.33	1.20	1.45	7.54	1.27	33.10	32.82	0.974	0.970
scan97	1.16	1.96	0.95	5.41	1.53	31.25	30.12	0.974	0.931
scan105	0.76	1.27	0.78	8.16	2.16	32.37	32.15	0.953	0.945
scan106	0.67	1.44	0.52	6.79	1.67	29.08	28.41	0.948	0.931
scan110	0.90	2.61	1.43	2.54	3.03	29.86	29.37	0.954	0.941
scan114	0.42	1.04	0.36	1.78	1.15	32.28	31.01	0.946	0.930
scan118	0.51	1.13	0.45	1.96	1.52	31.73	31.01	0.968	0.951
scan122	0.53	0.99	0.45	1.82	1.34	34.82	34.12	0.976	0.969
mean	0.90	1.54	0.77	4.33	1.74	32.04	31.18	0.947	0.929

Figure 4: DTU evaluation. ***RF** has large Chamfer distances because floaters are difficult to filter with naive density thresholding. SDFoam gives a good trade-off between reconstruction and visual fidelity.

Qualitative 3D Reconstruction

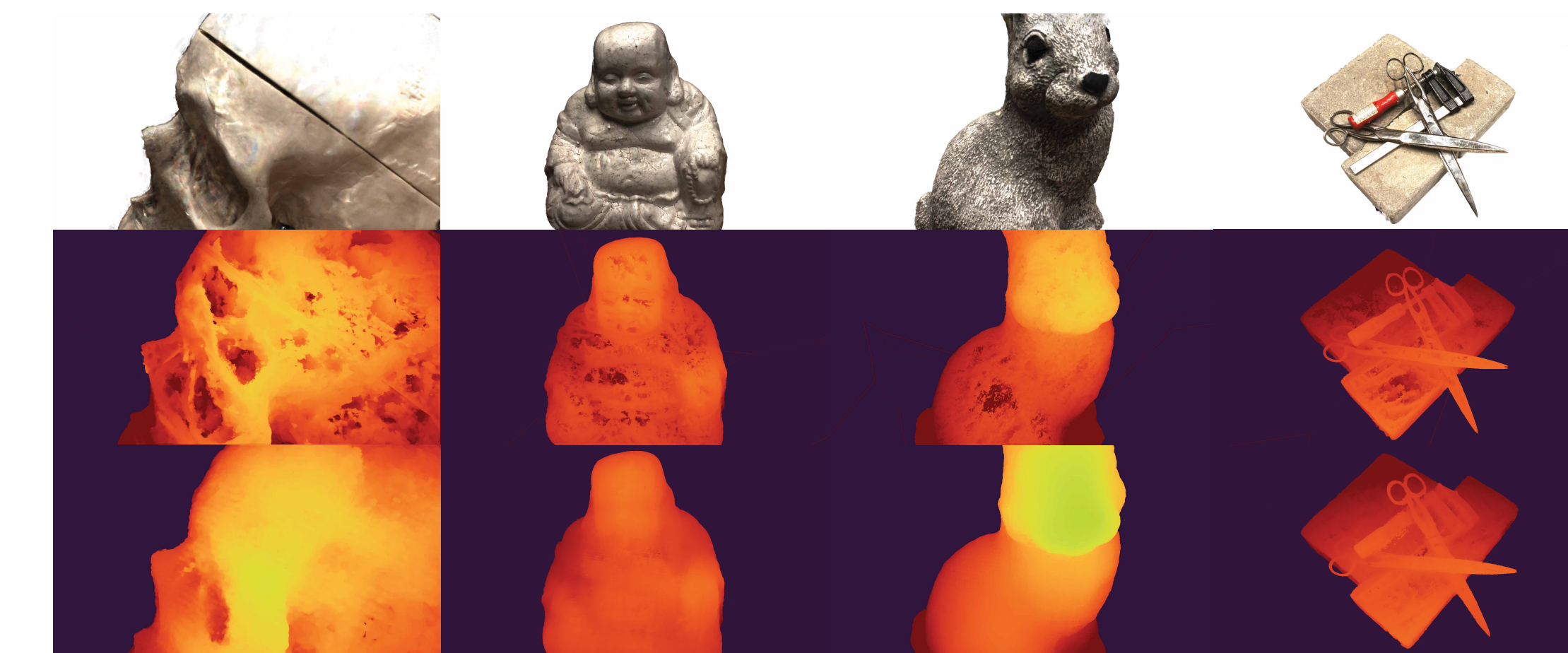


Figure 5: Mesh reconstruction results. Top to bottom: ground truth, Radiant Foam, SDFoam. Local SDFs improve extracted-surface consistency and fill holes produced by RF ray tracing.

Results – Novel View Synthesis

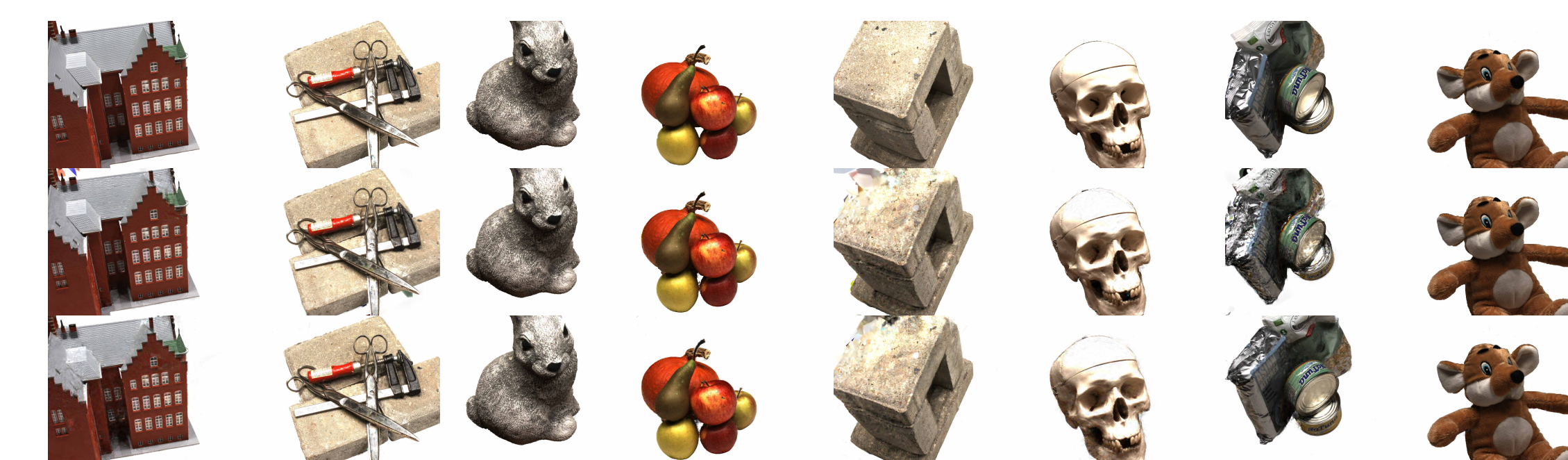


Figure 6: Novel view synthesis. Top: ground truth. Center: RF. Bottom: SDFoam.

Scan ID	24	37	40	55	63	65	69	83	97	105	106	110	114	118	122	Mean
PSNR (RF_M)	24.36	22.39	26.34	26.77	28.38	24.81	22.96	28.33	21.33	27.03	23.72	24.21	24.78	25.93	28.84	25.34
PSNR ($SDFoam_M$)	25.59	24.96	26.55	26.27	28.81	25.78	23.77	28.90	26.12	28.30	24.08	25.80	27.13	27.58	29.29	26.60
SSIM (RF_M)	0.796	0.770	0.823	0.925	0.942	0.901	0.880	0.952	0.839	0.917	0.892	0.907	0.866	0.927	0.938	0.885
SSIM ($SDFoam_M$)	0.803	0.828	0.814	0.900	0.937	0.911	0.870	0.949	0.904	0.914	0.886	0.904	0.884	0.922	0.939	0.891

Figure 7: The joint Voronoi–SDF formulation improves visual quality and reduces occasional floaters.

