DIST: Rendering Deep Implicit Signed Distance Function with Differentiable Sphere Tracing

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**Motivation & Pipeline**

**Naive Sphere Tracing**

For each camera ray, march at each step with the queried SDF value until convergence.

**Coarse-to-fine Strategy**

We start the sphere tracing over an image with ¼ resolution, and split each ray twice during the marching process, which saves computation at the early stage.

**Aggressive Marching**

Setting $\alpha > 1$ speeds up convergence.

**Convergence Criteria**

A large threshold causes dilation, while a small threshold leads to erosion.

**DIST – Feedforward**

- Image size $= 512 \times 512$
- Marching step $= 50$

**DIST – Backward**

Each query location depends on the previous one, incurring recursive gradients. We make approximations over sphere tracing by omitting high-order gradients.

**Differentiable Silhouette**

We make use of the nice property of signed distance function to optimize the nearest surface geometry.

**Optimization over Camera Parameters**

- Memory issue caused by Recursive Gradients
- Each query location depends on the previous one, incurring recursive gradients.
- We make approximations over sphere tracing by omitting high-order gradients.
- We use the nice property of the signed distance function to optimize the nearest surface geometry.

**Feedforward Rendering**

- Image size $= 512 \times 512$
- Marching step $= 50$

**Reconstruction from Video Sequences**

- Results on synthetic data
- Results on real data

**References**

- Shaohui Liu, Yinda Zhang, Songyou Peng, Boxin Shi, Marc Pollefeys, Zhaopeng Cui

**Project Page**

The recently proposed deep implicit signed distance function [1] is effective on representing 3D shapes. Advantages: infinite resolution, lightweight, etc.

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$\textit{Optimization}$

$\textit{Naive Sphere Tracing}$

$\textit{Coarse-to-fine Strategy}$

$\textit{Aggressive Marching}$

$\textit{Convergence Criteria}$

$\textit{Memory issue caused by Recursive Gradients}$

$\textit{Differentiable Silhouette}$

$\textit{Optimization over Camera Parameters}$

$\textit{Feedforward Rendering}$

$\textit{Reconstruction from Video Sequences}$

$\textit{Input}$

- DeepSDF [1A]
- Ours (w/o mask)
- Ours (w/ mask)

$\textit{Density}$

- 50%
- 10%

$\textit{Quantitative evaluation}$

- Generalization across different focal lengths
- Generalization across different noise levels

$\textit{Results}$

- On synthetic data
- On real data