Reconstructing and Rendering Shiny Surface with Hybrid Neural Fields
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Motivation

Problem: Reconstructing high-quality shiny 3D objects is still a problem for NeRF. Surface quality and rendering quality cannot be obtained at the same time (i.e., appearance & geometry ambiguity [5]).
• Some work achieves higher rendering quality but has erroneous surface.
• Some work achieves smooth surface reconstruction but lacks object details.

Existing work that tackle this problem:
Ref-NeRF [1], VolSDF [2], NeuS [3], …
These methods rely on fully implicit MLP and take very long time to train (days of).
However, simply replacing pure MLP model with hybrid model (e.g., Instant-NGP [4]) for speedup will deteriorate the surface quality a lot because of discrete neural feature in hybrid model. Hence,
• Extra constraints need to be considered.

Goal: We want to achieve better rendering and surface reconstruction results for shiny objects, with much faster speed by using hybrid NeRF models.

Overview

SDF Constraints

Additional constraints for hybrid NeRF models:
• SDF continuity regularization
\[ \mathcal{L}_c = \sum ||\Delta d(x_i) - (\mathbf{t} \cdot \mathbf{n})||^2 \]
• Back face suppression
\[ \mathcal{L}_b = \sum \max(\Delta d_i, 0) \frac{w_i \Delta d_i}{\Delta d_i^2 + \Delta t^2} \]
• No Eikonal loss used.

Observations

What if we simply replace the fully implicit MLP with Instant-NGP and keep the rest parts unchanged (including Eikonal regularization)?

References


Our Decomposition:

<table>
<thead>
<tr>
<th>Method</th>
<th>PSNR↑</th>
<th>SSIM↑</th>
<th>LPIPS↓</th>
<th>MAE↓</th>
</tr>
</thead>
<tbody>
<tr>
<td>NeRF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VolSDF</td>
<td>28.28</td>
<td>0.966</td>
<td>0.015</td>
<td>0.046</td>
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<tr>
<td>RefNeRF</td>
<td>33.06</td>
<td>0.970</td>
<td>0.021</td>
<td>0.022</td>
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<tr>
<td>Ours</td>
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<td>0.972</td>
<td>0.020</td>
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<tr>
<td>NeRF*</td>
<td>30.08</td>
<td>0.969</td>
<td>0.024</td>
<td>0.025</td>
</tr>
</tbody>
</table>

PSNR↑: PSNR↑ of normal, diffuse color, and specular color rendering.
SSIM↑: SSIM↑ of normal, diffuse color, and specular color rendering.
LPIPS↓: LPIPS↓ of normal, diffuse color, and specular color rendering.
MAE↓: MAE↓ of normal, diffuse color, and specular color rendering.
RefrNeRF* are the report scores in the original paper.