



# **SDFDiff: Differentiable Rendering of Signed Distance Fields for 3D Shape Optimization**

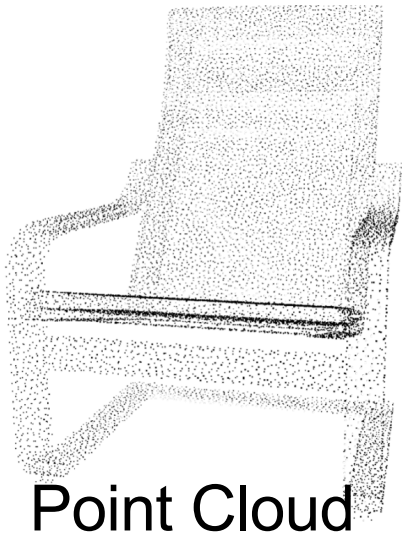
**Yue Jiang**

Advisor: Prof. Matthias Zwicker

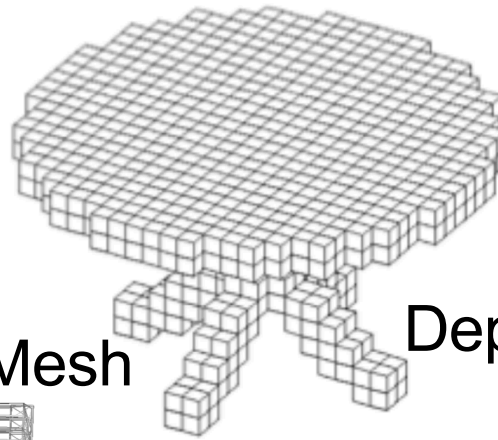
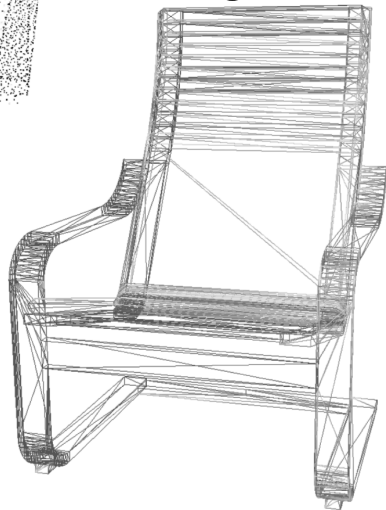


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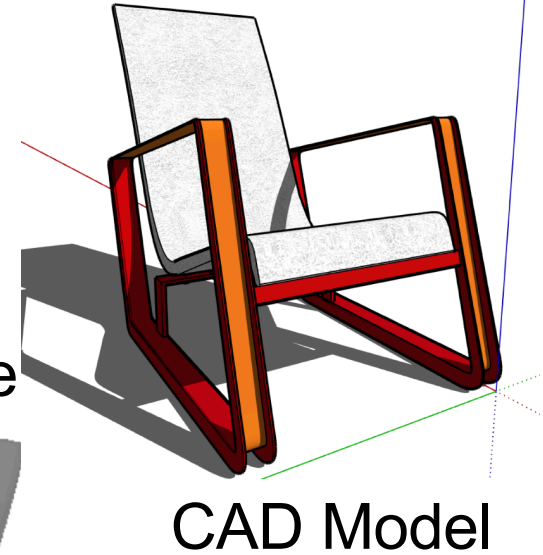
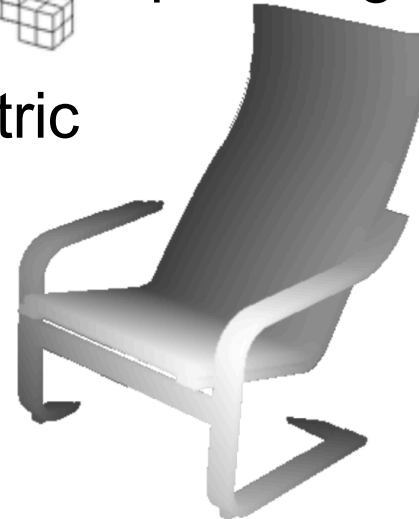
# 3D Representations



Triangle Mesh



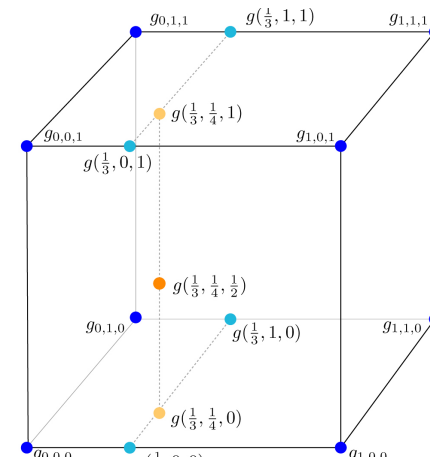
Depth Image



# SDF --- Signed Distance Function

A **distance function** represents the distance between a point and the surface of the object.

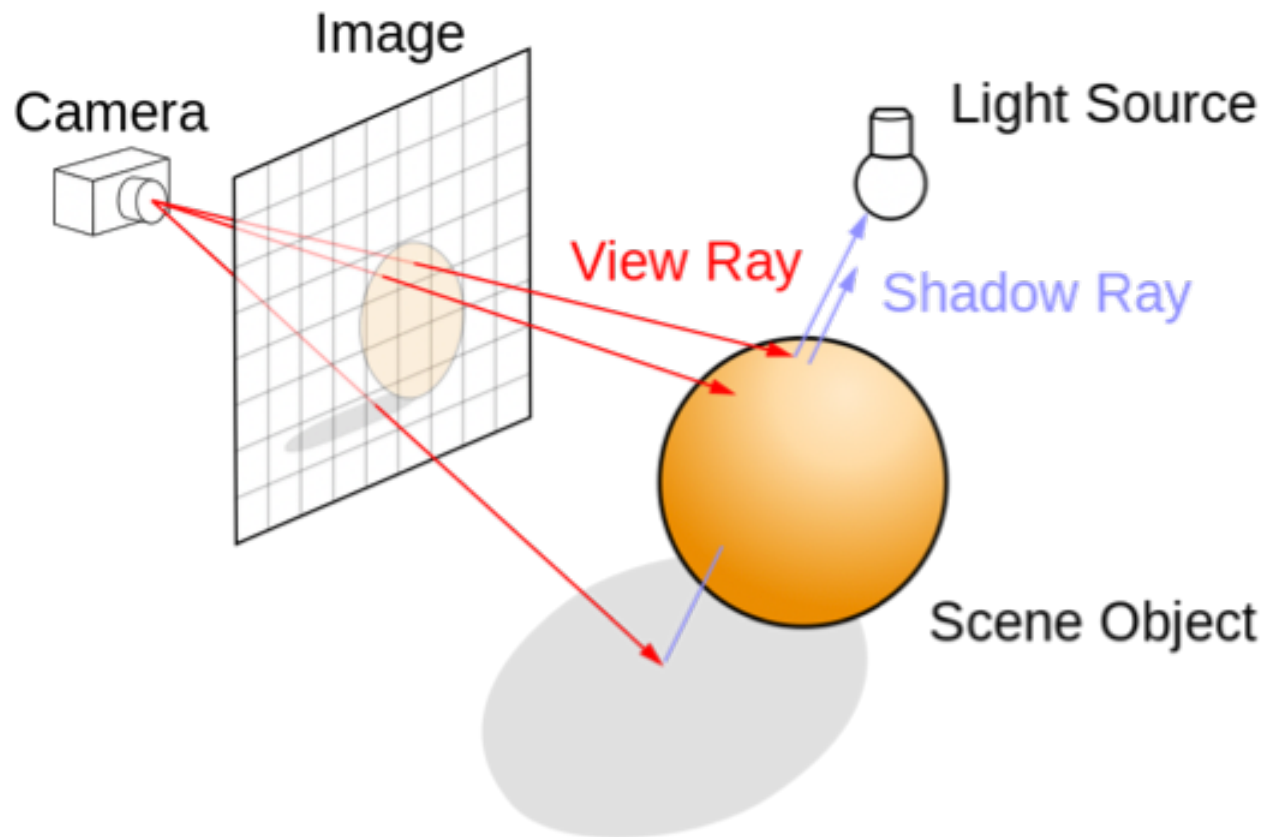
$$d(\vec{x}) = \min(|\vec{x} - \vec{x}_I|) \text{ for all } \vec{x}_I \in \partial\Omega$$



A **signed distance function**  $s$  is a function such that  $s(x) = d(x)$  if the point  $x$  is outside the object and  $s(x) = -d(x)$  if the point  $x$  is inside the object.

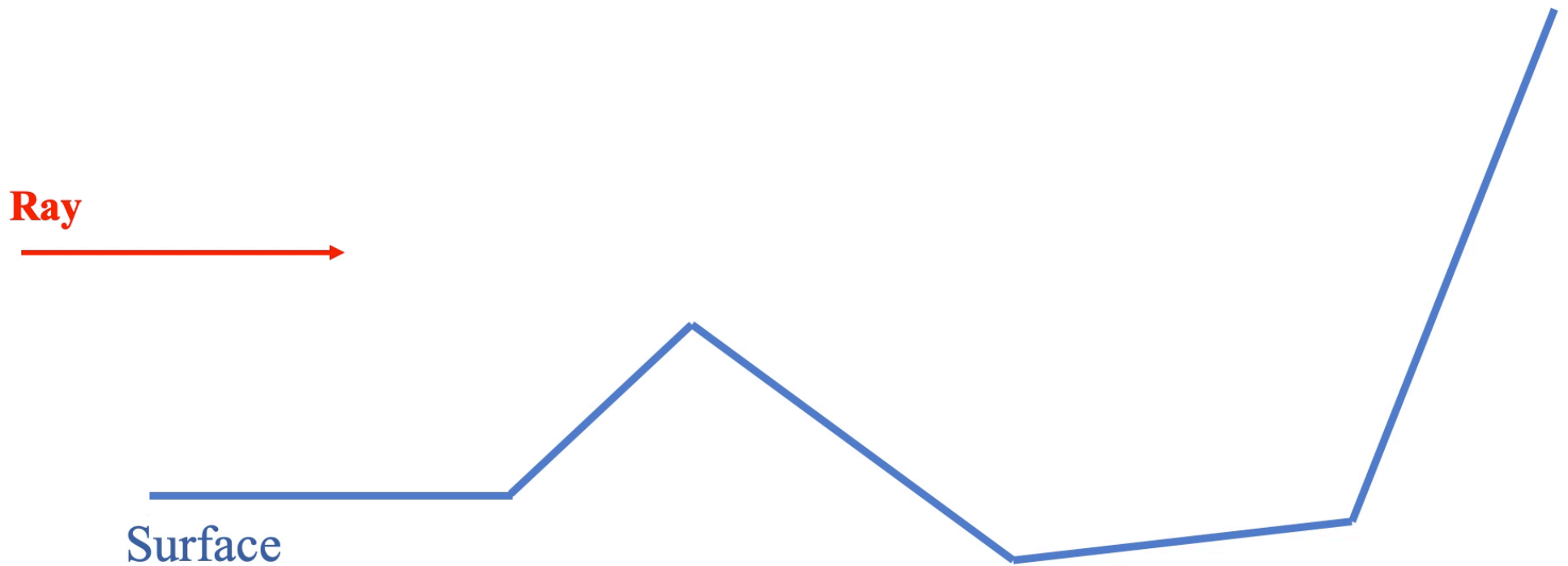
# Differentiable Rendering

We make the ray tracing process be differentiable so that the pixel values of the rendered image are differentiable with respect to the SDF values of the 3D object.



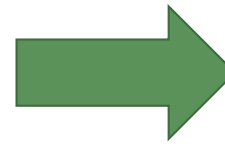
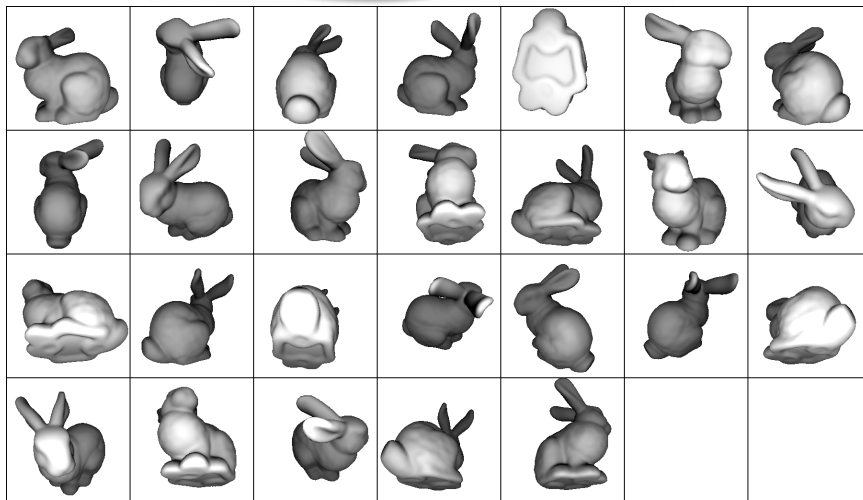
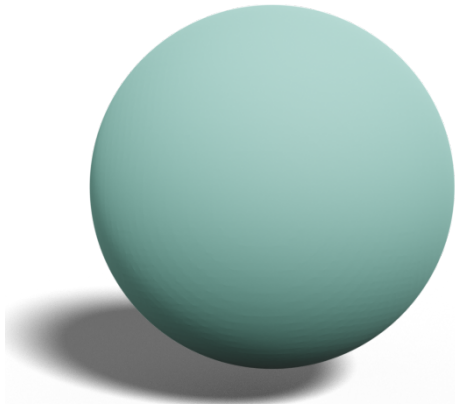
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## Phase 1: Sphere Tracing For Differentiable SDF Rendering



Input: Initial Object + Multi-view Images

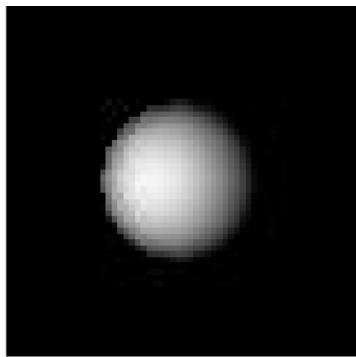
Output: Target Object



# 3D Reconstruction

The image can be differentiable with respect to upstream parameters, so the renderer is able to backpropagate the loss function to the signed distance function.

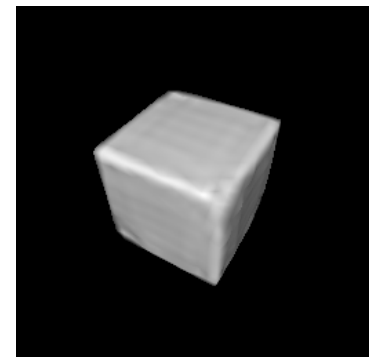
Our loss function consists of a pixel-wise image loss term measuring the distance between the target images and the rendered images from the 3D object and also a regularization term to make sure the output is still a valid SDF.



Initial SDF



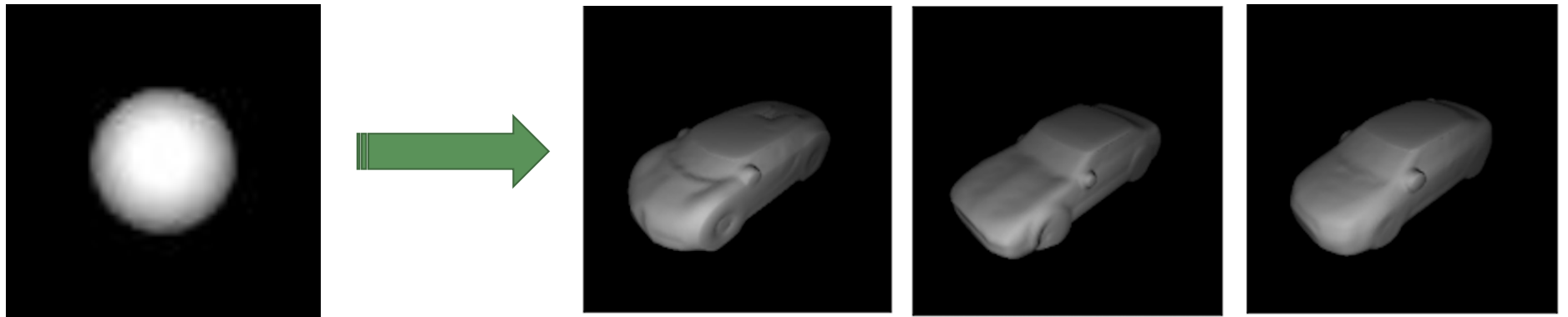
Multi-view images  
of the target object



Target SDF

# 3D Reconstruction

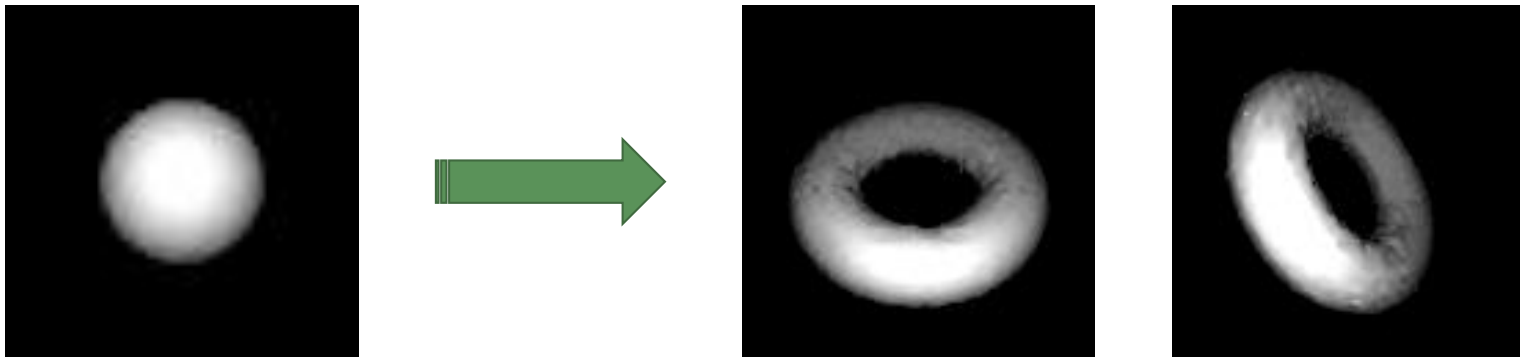
We can achieve our target object from the initial object by backpropagation based on the multi-view images of the target object and can achieve high reconstruction quality.





# 3D Reconstruction

Our SDF-based differentiable renderer can offer a higher level of freedom for topological changes compared to triangle meshes. which means that It can transform between objects with large topological differences.



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# Challenges on Sketches

Our **long-term goal** is to enable interactive modifications on 2D sketches which can directly lead to modifications on 3D geometry.

