

Learning to generate Signed Distance Fields from Voxels

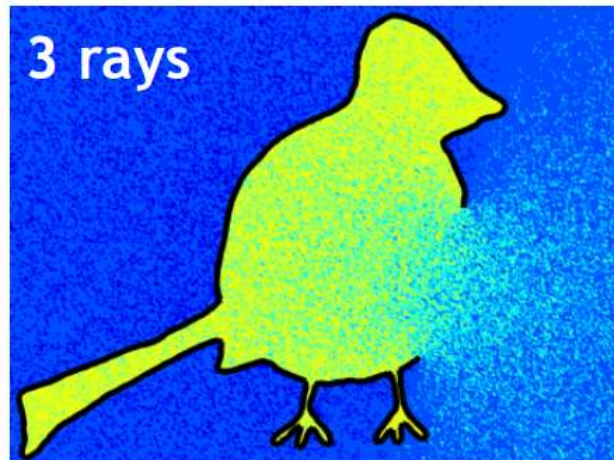
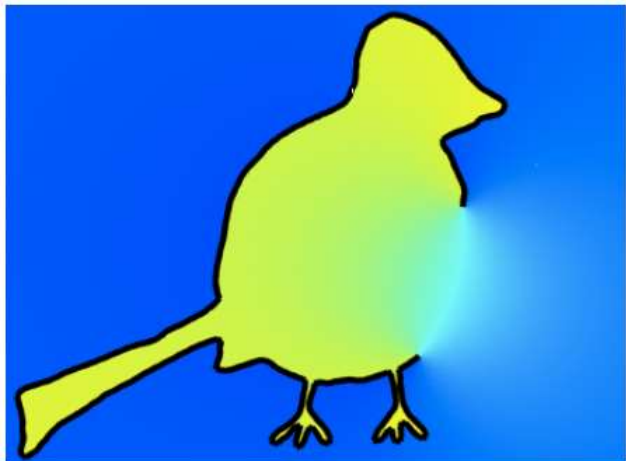
Amlan Kar, Yihuan Mao

Overview

- Input : meshes
- Output : signed distance field
- Signed distance
 - Pseudonormal test
 - Ray cast
- Inside-outside segmentation
 - Get the sign from signed distance
 - Generalized winding number

Main problems

- Large scale data
 - $n*n*n$ voxels
 - $|F|$
- Robustness on bad meshes



Our solution

- Meshes



Voxelization: Flood fill+generalized winding number

- Voxels



Machine Learning: 3d-Unet

- SDF (signed distance field)

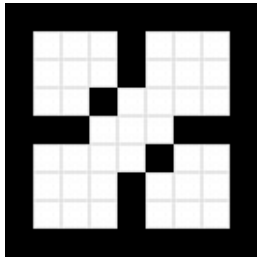
Data

- Data source: Thingi10K



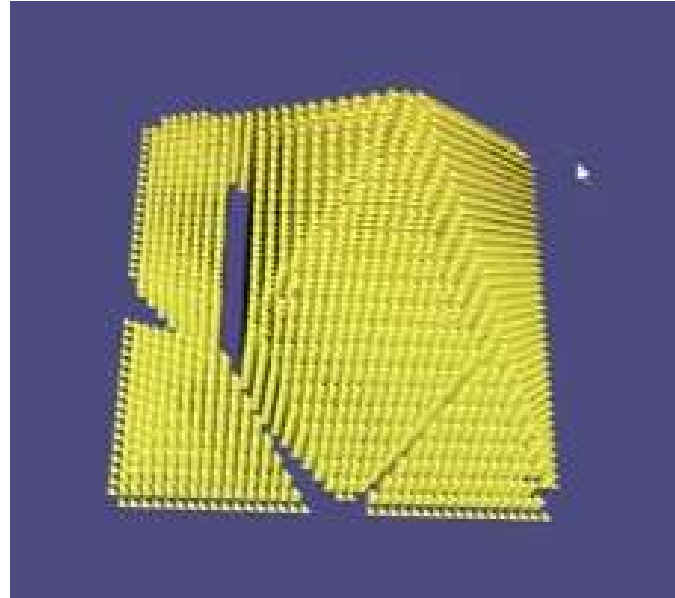
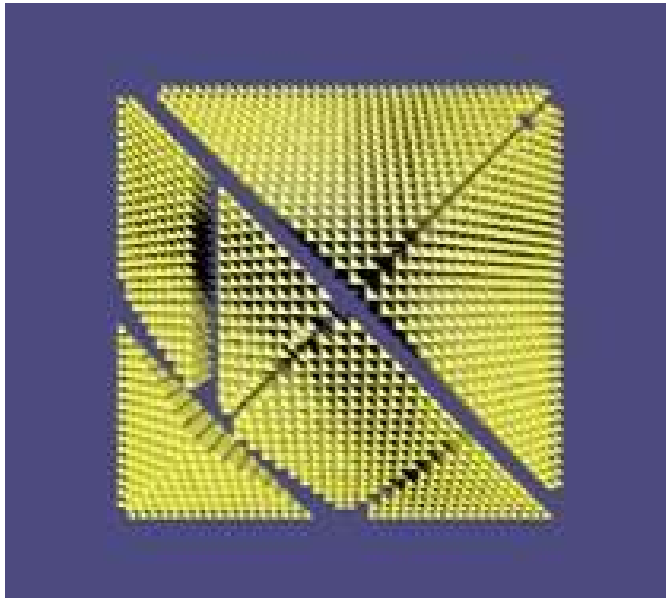
First step: Voxelization

1. Flood fill



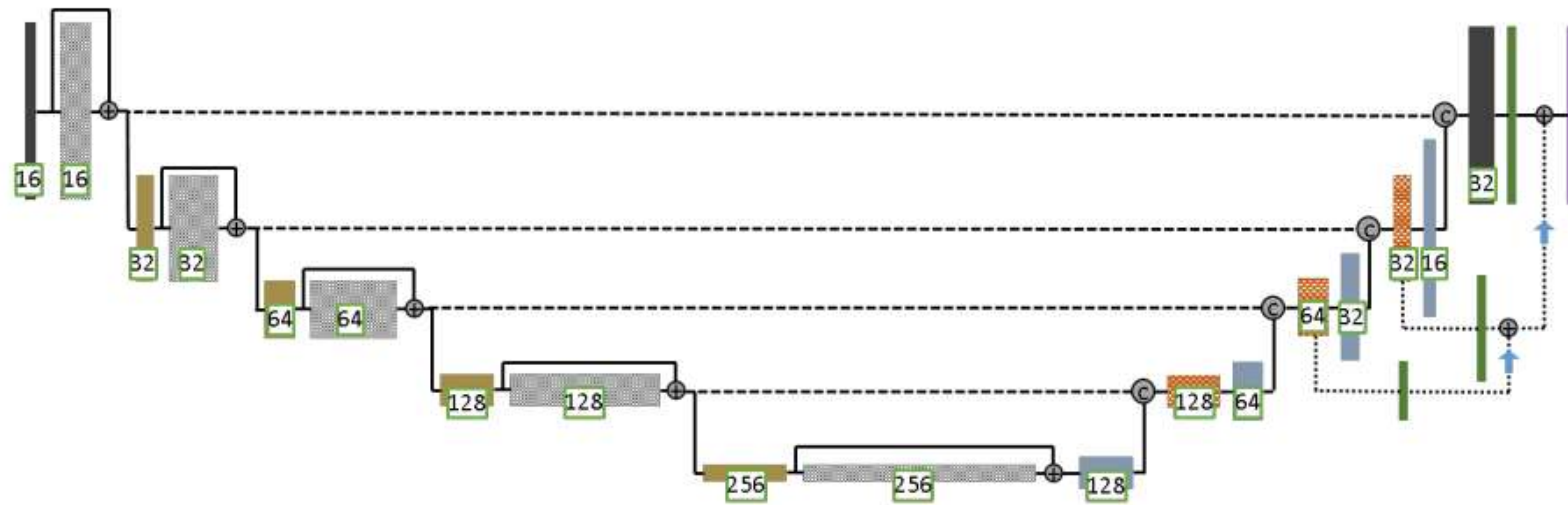
2. Inside-outside segmentation
 - Applied only on boundary

First step: Voxelization



Second step: Learn SDF

- Model: 3d-Unet

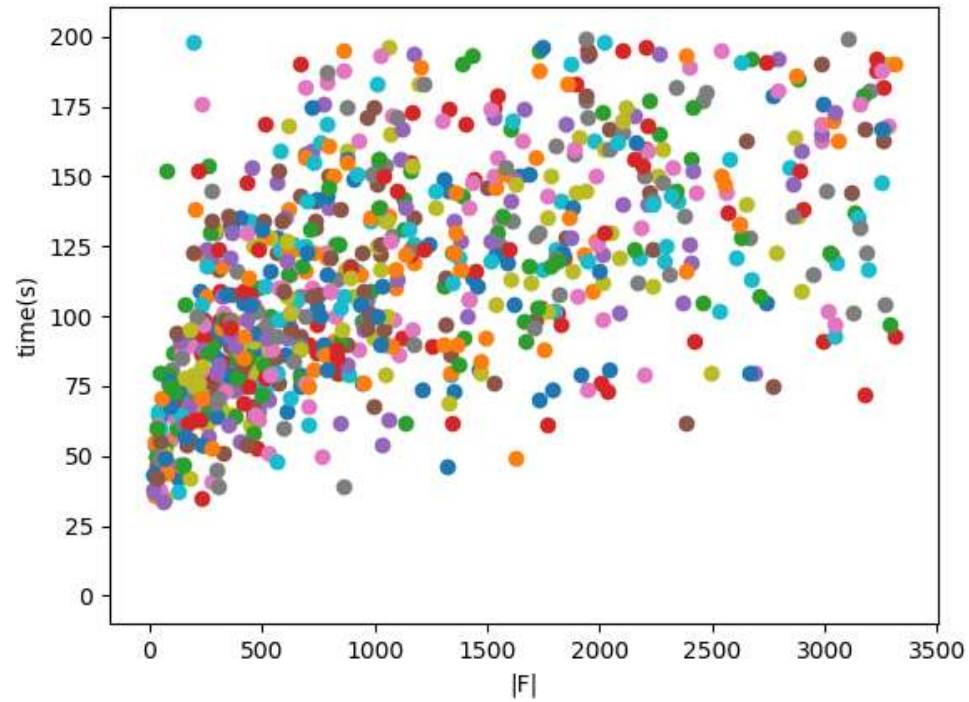


Comparison

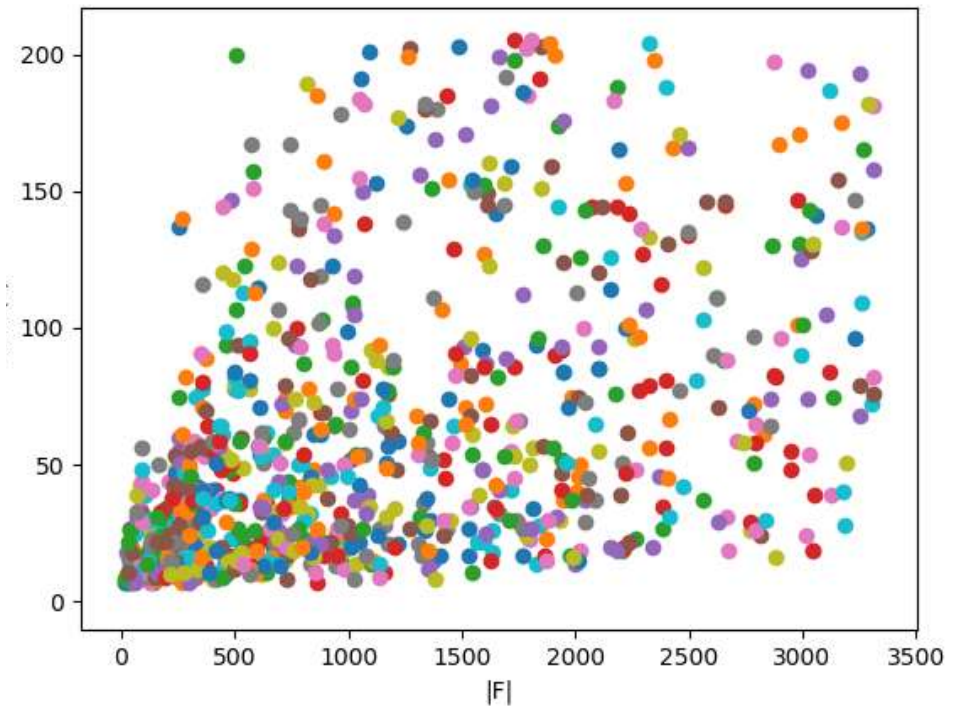
	Pseudonormal test	Ray cast	Voxelization+machine learning	
Robustness on bad meshes	Not robust	Not robust More reliable when sample more	Voxelization: Robust using generalized winding number	ML:
Time complexity	$O(n^3 \log F)$	$O(n^3 \log F)$	$O(n^2 * F + n^3)$ (GWN)	$O(c * n^3)$ Large const c
			Accelerate mainly in the term $n^2 * F $	

Time consumption

SDF using pseudonormal

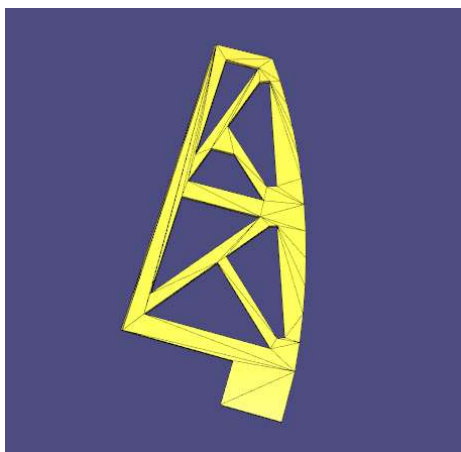


SDF using voxelization+ML

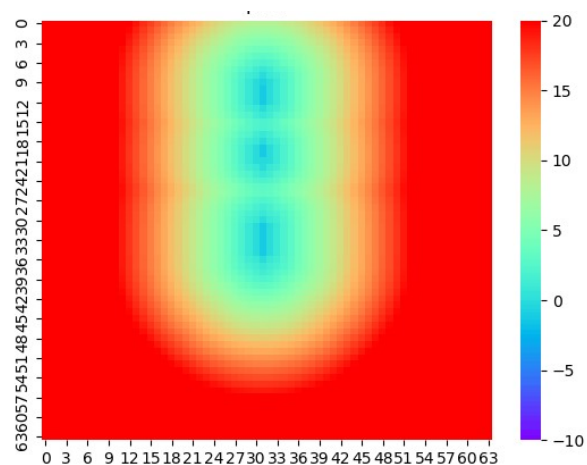


Results

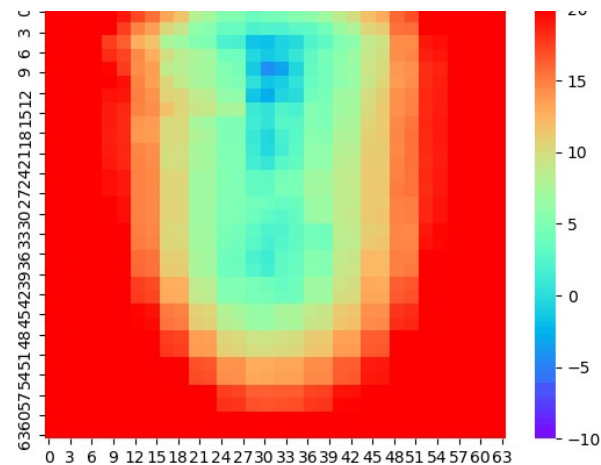
original mesh



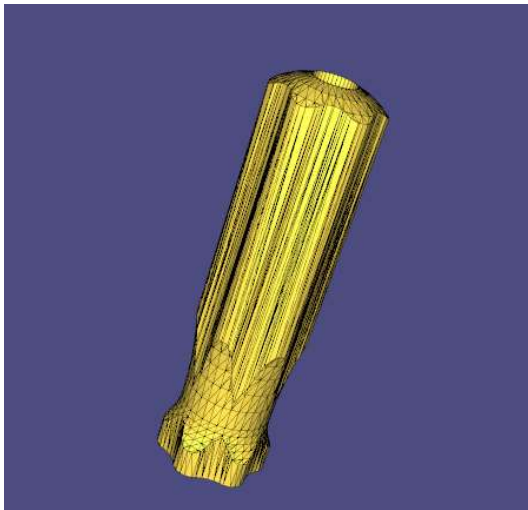
SDF groundtruth



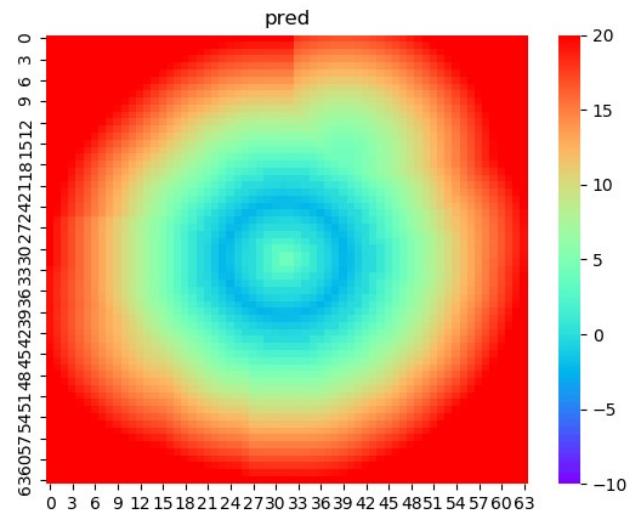
learned SDF



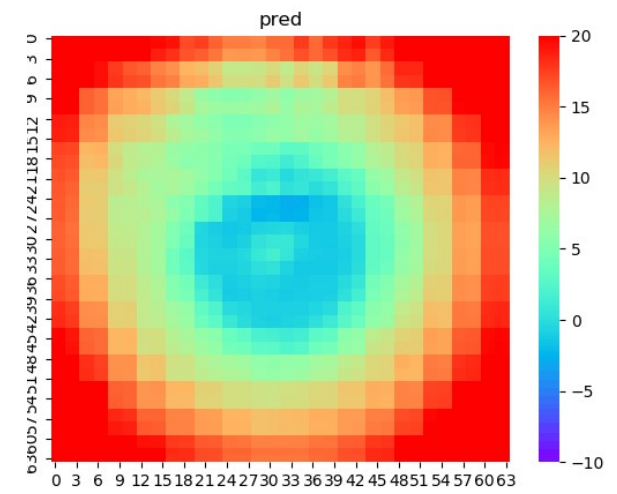
original mesh



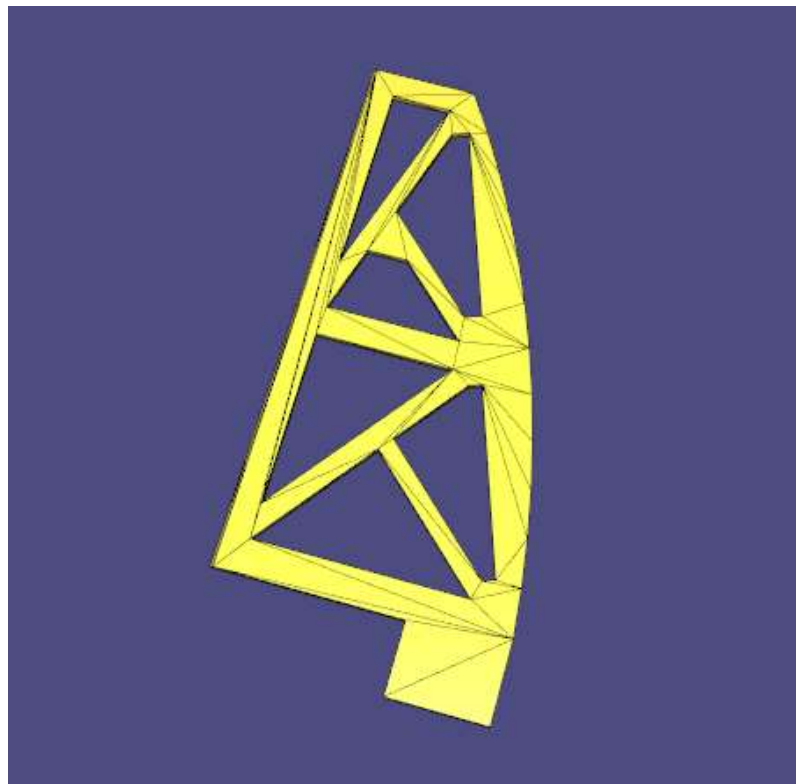
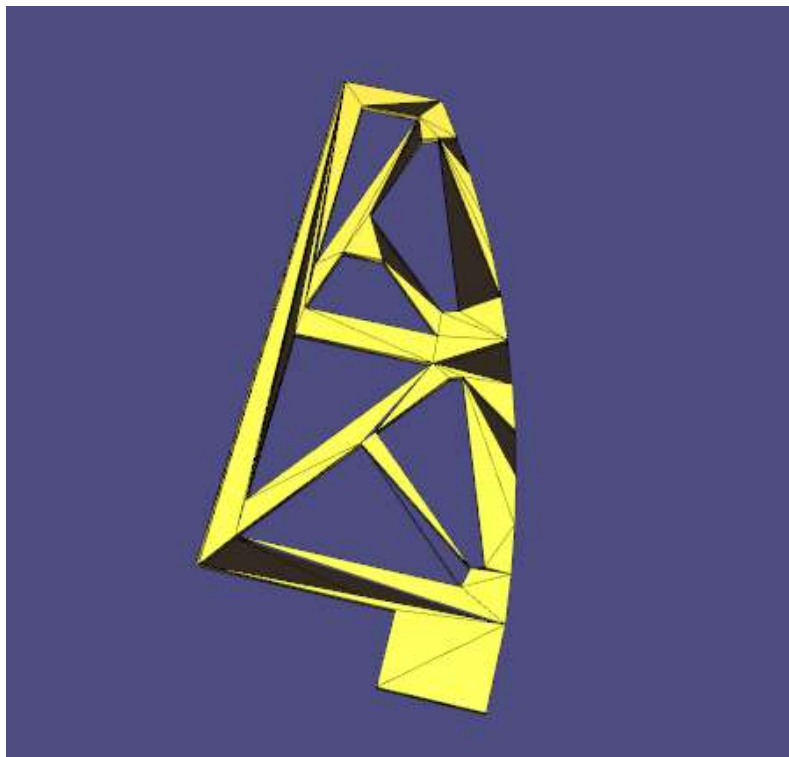
SDF groundtruth



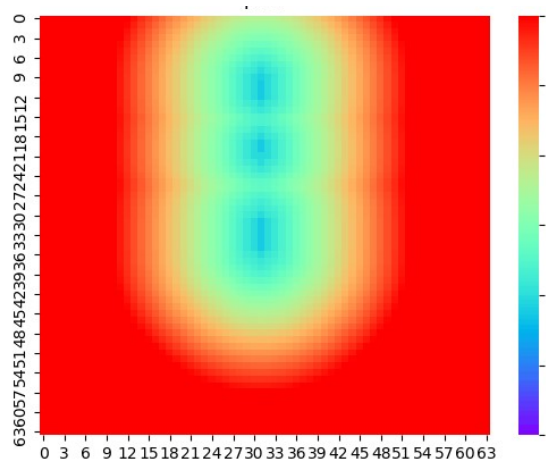
learned SDF



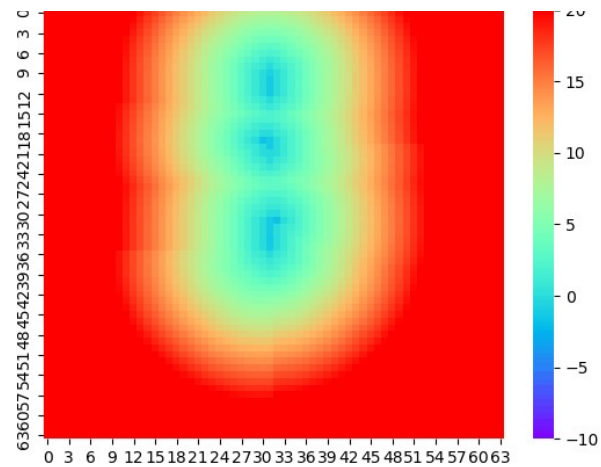
Performance on bad meshes



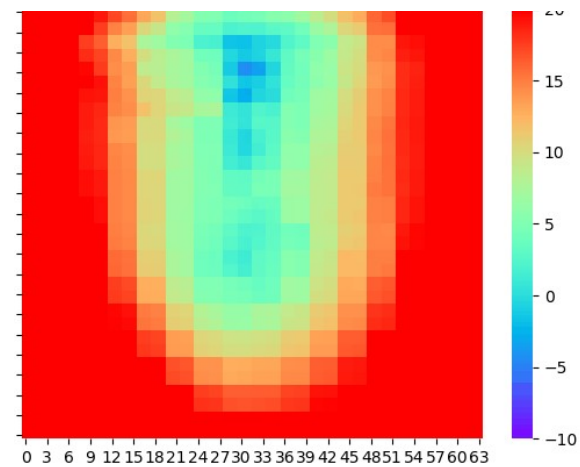
fine meshes



broken meshes



learned SDF



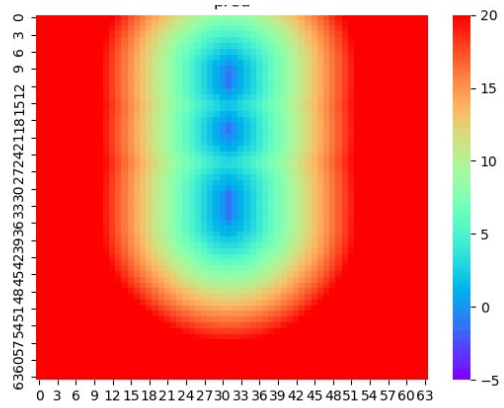
Truncated signed distance field(TSDF)

- Clamp the sdf between a smaller interval
- 3 | 3 | 3 | 3 | 2 | 1 | 0 | -1 | -2 | -3 | -3 | -3 | -3
- Obtain better performance near the boundary

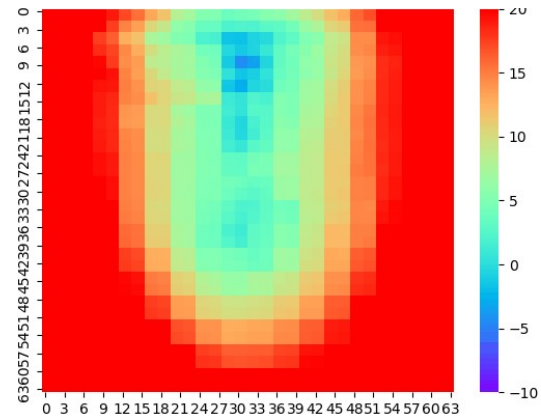
MSE Loss

	SDF	TSDF
Train loss	7.3	2.6
Test loss	9.62	3.7

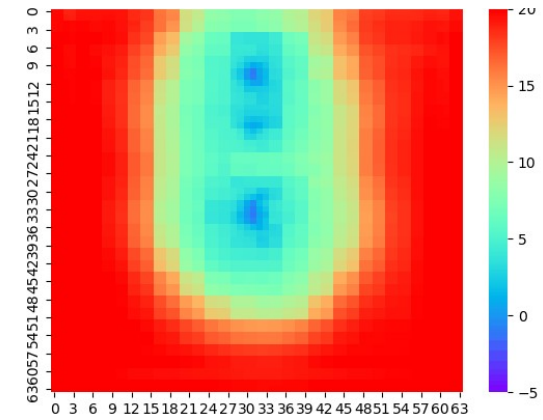
SDF groundtruth



learned SDF



learned TSDF



Future steps

- Parallel processing
- More data augmentation

