Learning to Predict Scene-Level Implicit 3D from Posed RGBD Data

Nilesh Kulkarni, Linyi Jin, Justin Johnson, David F. Fouhey
University of Michigan, Ann Arbor

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Project Page

Task Overview

Reconstruct 3D scene, including invisible surfaces from single RGB image
Inference : single, novel unseen RGB image
Input: RGB Image ; Supervision: Posed RGBD Data

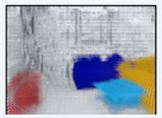
Our method predicts full 3D scene
- visible regions colored with image pixels
- occluded regions are colored by surface normal



Related Work

3D Reconstruction from Single Images

Voxel



Tulsiani et. al
Factored Scenes

Mesh

Gkioxari et. al
Single Objects

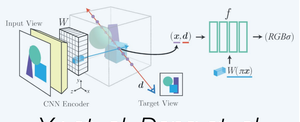
Implicit

Kulkarni et. al
DRDF, Real 3D Scenes

3D Reconstruction from Posed RGB(D) Data

Dai et. al
Bundle Fusion (BF)

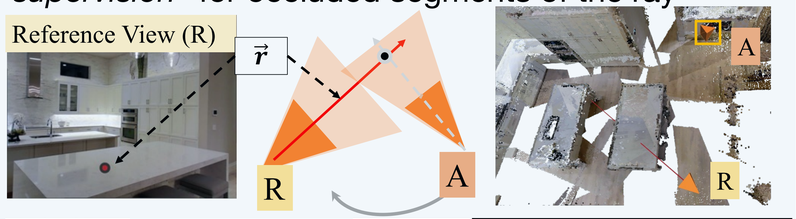
Sun et. al
NeuralRecon (Learned BF)



Yu et. al, Deng et. al
NeRF (gen. novel scenes w/ Depth)

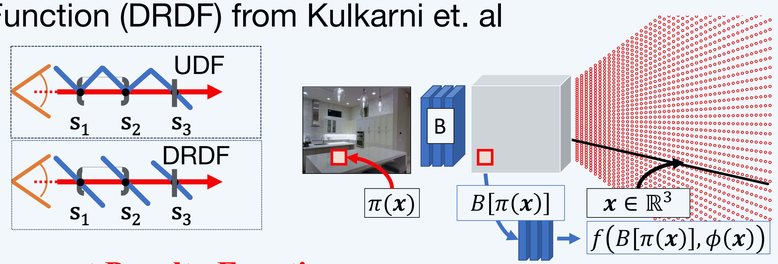
Key Insights

Supervision: Auxiliary depth views provide "*supervision*" for occluded segments of the ray



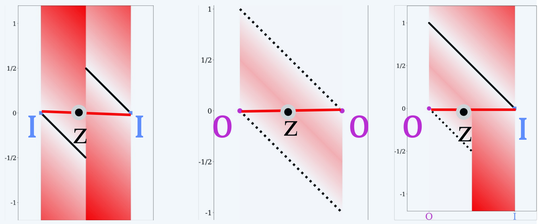
Occlusion-Intersection Segment

Inference: Use the Directed Ray Distance Function (DRDF) from Kulkarni et. al



Segment Penalty Functions

Segment Types:
- II
- OO
- OI
- IO

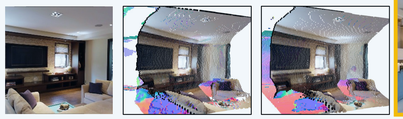


TL;DR: D2-DRDF is method that learns to predict an implicit 3D from a single image that can trained using posed RGBD datasets. **No 3D mesh supervision needed**

Results

Training Dataset: Our method Depth-to-DRDF (D2-DRDF) is trained on Posed RGBD datasets such as Matterport3D, and Omnidata.

Qualitative Results



Qualitative Results (test-time Adapt)

Matteport3d: Sparse Data Results

Im. %	ODS M %	Scene F1 SPR	Scene F1 ODS	Scene F1 Depth	Ray Occ F1 SPR	Ray Occ F1 ODS	Ray Occ F1 Depth
100	100	71.9	71.9	72.1	27.3	27.3	25.1
50	56	55.6	68.4	70.0	21.4	23.6	24.4
25	43	56.8	66.8	70.0	21.5	21.2	24.9

Omnidata: Sparse Data Results

Im. %	ODS M %	Scene F1 SPR	Scene F1 ODS	Scene F1 Depth	Ray Occ F1 SPR	Ray Occ F1 ODS	Ray Occ F1 Depth
25	86	63.9	77.2	72.8	26.2	40.3	32.1
12.5	83	62.8	75.3	70.9	26.1	37.1.	29.3
6.3	78	40.9	73.4	71.8	5.7	32.6	28.1
3	69	42.9	69.8	70.4	3.8	20.3	26.7

SPR: Screen Poisson Reconstruction
ODS: Optimistic Degradation Setup

Matterport3D: Full Data Results

	Method	Scene Acc	Scene Cmp	Scene F1	Ray Acc	Ray Cmp	Ray F1
Mesh	LDI [46]	66.2	72.4	67.4	13.9	42.8	19.3
Mesh	UDF [5]	58.7	76.0	64.7	15.5	23.0	16.6
Mesh	ORF	73.4	69.4	69.6	26.2	20.5	21.6
Mesh	URDF [5]	74.5	67.1	68.7	24.9	20.6	20.7
Mesh	DRDF [27]	75.4	72.0	71.9	28.4	30.0	27.3
	D2-DRDF	73.7	73.5	72.1	28.2	22.6	25.1
	Density Field [57]	45.8	80.2	57.5	24.8	14.0	17.9

LDI: Layered Depth Images
UDF: Unsigned Distance Func.
ORF: Occupancy Ray Func.
URDF: Unsigned Ray Distance Func.