TARS: Topologically-Aware Deformation Fields for Single-View 3D Reconstruction

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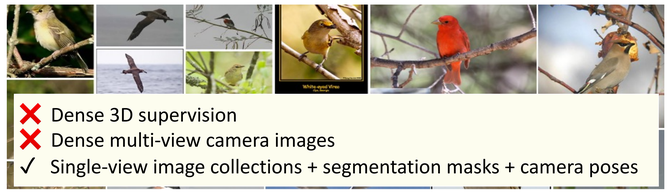
Project page: https://shivamduggal4.github.io/tars-3D/

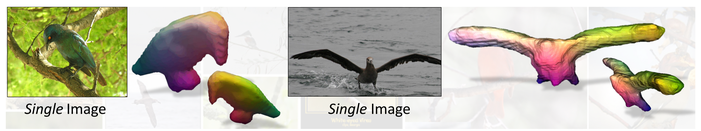
Motivation

To truly scale 3D reconstruction algorithms, it would be *ideal to learn from internet data (large image collections)* in a manner which allows easy knowledge transfer across objects.

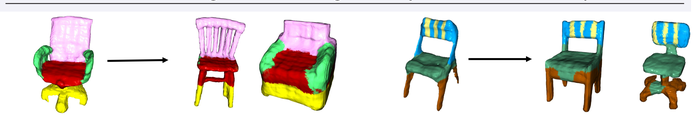
Training: Learn *3D + Correspondences* from single image collection of a category



Inference: *3D Shape + Correspondences* just from single image at test time



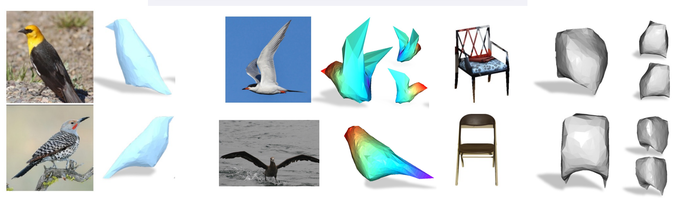
Texture Transfer using learned 3D geometry and dense correspondences



Related Work

Type	Prior Work	High-Fidelity	Correspondences	Large Deform.	Topologically-varying
Mesh Recons.	NMR, SoftRas, DIB-R				
Deformable Mesh Recons.	CMR [1]		✓		
Implicit Recons.	SDF-SRN [2]	✓		✓	✓
Deformable Implicit Recons.	TARS (Ours)	✓	✓	✓	✓

Prior Work: Deformable Reconstruction



Perform well on categories w/ ***less structural/ topological variations***

Fail to generalize to categories with ***larger articulations/ deformations***

Fail to generalize to categories with ***larger structural & topological variations***

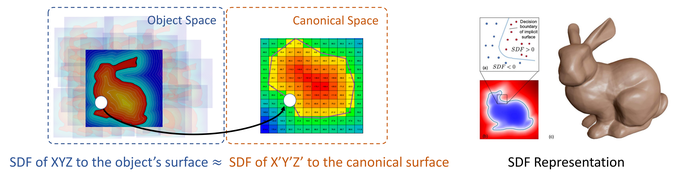
[1] *Kanazawa*, Tulsiani* et al.* Learning Category-Specific Mesh Reconstruction from Image Collections

[2] *Lin et al.* SDF-SRN: Learning Signed Distance 3D Object Reconstruction from Static Images

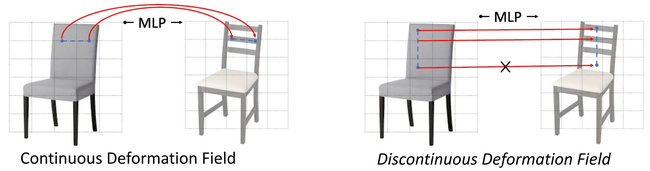
Implicit Deformable Reconstruction

Implicitly map a 3D point in the object space to the category-specific canonical space and learn the shape (as SDF field) in the canonical space.

How to get the *shape of an object*, given its image ? What's the SDF of point XYZ to the object's surface ?

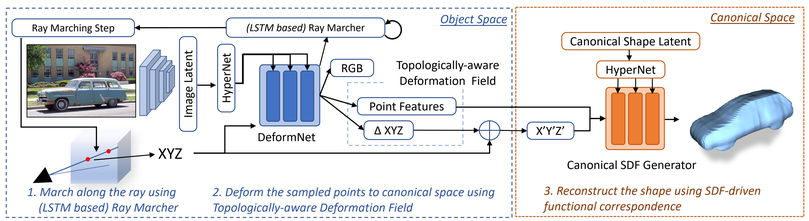


By learning the deformation field implicitly, the implicit deformation field have a strong tendency to ***continuously deform the 3D points, leading to over-smooth shapes.***

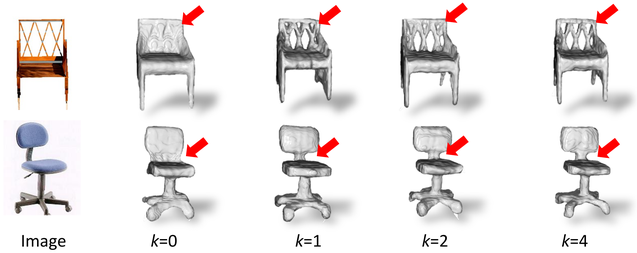


Topologically-Aware Deformable Reconstruction

Inspired by the kernel theory or level set theory, we ***lift the 3D canonical points to a higher-dimension*** by learning additional point features.



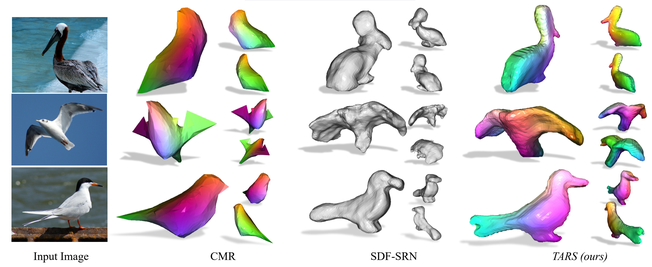
Additionally learning ***k point features*** (alongside 3D deformation field), we can recover finer structural/ topological details.



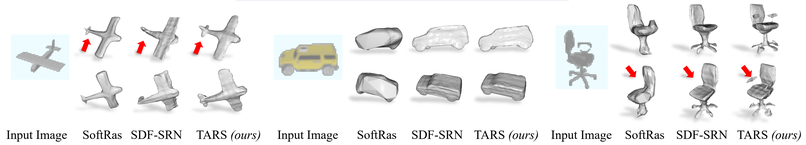
Results

CUBS-200-2011

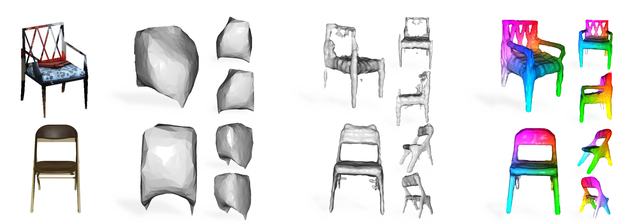
**Color denotes Correspondence*

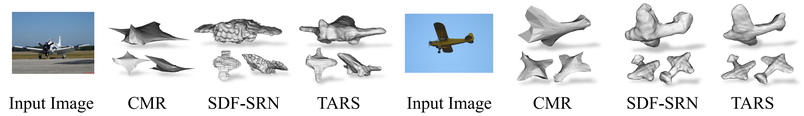


Shapenet (Airplanes, Cars, Chairs)



Pascal3D+ (Chairs & Airplanes)





Pix3D Chairs (Trained on Shapenet)