Learning Shape Symmetries and UV-maps for 3D Mesh Reconstruction

Research Internship Project

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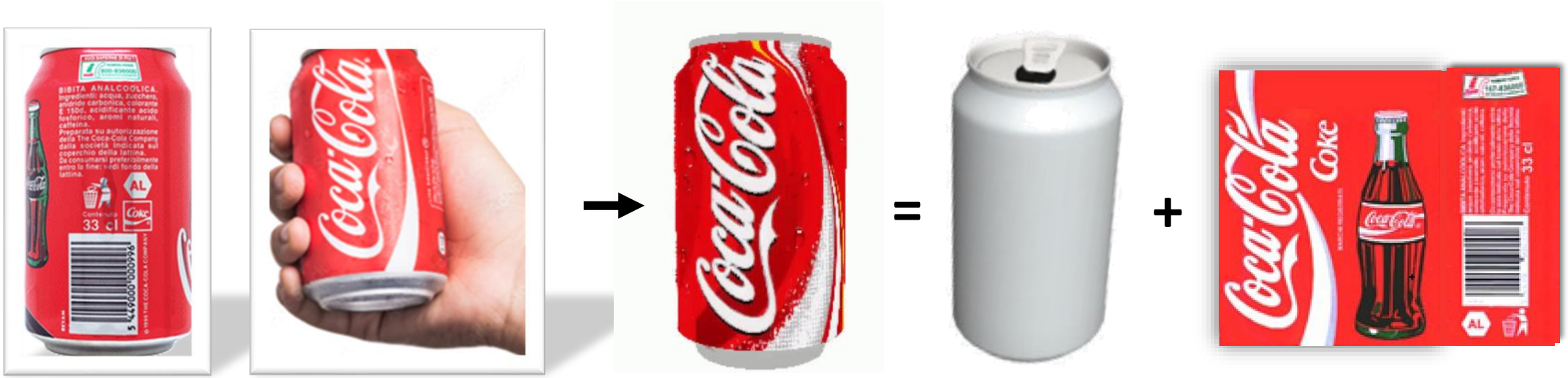
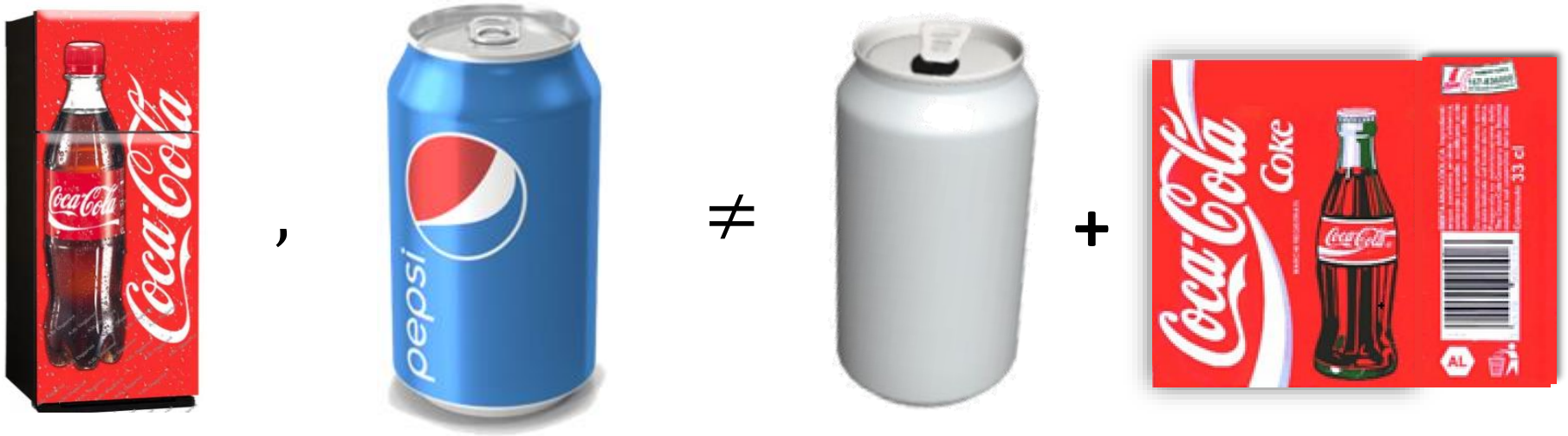
Learning Shape and Color Representation

- Reconstruct 3D shape & texture from RGB
- Shape-texture encoding for recognition signature
  - View invariance and consistency



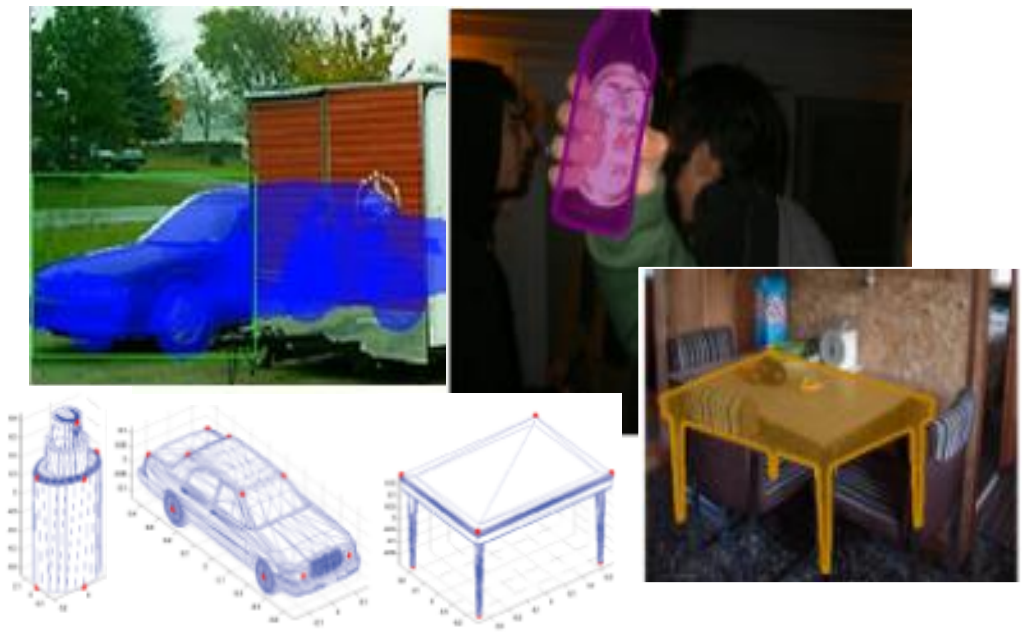
Learning Shape and Color Representation

- Reconstruct 3D shape & texture from RGB
- Shape-texture encoding for recognition signature
  - View invariance and consistency
  - Shape-color uniqueness

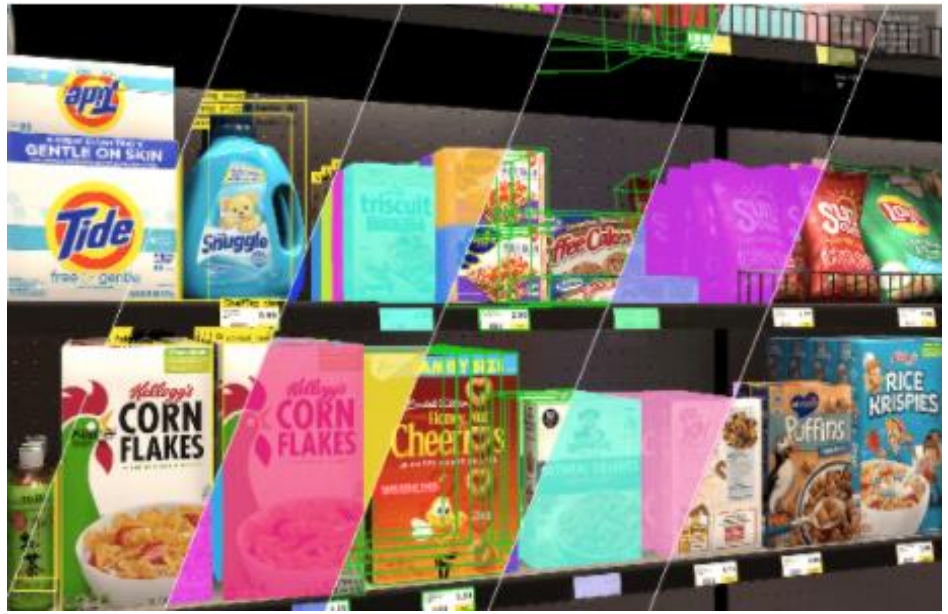


Learning Shape and Color Representation

I. Advance state-of-the-art
- Standard benchmarks



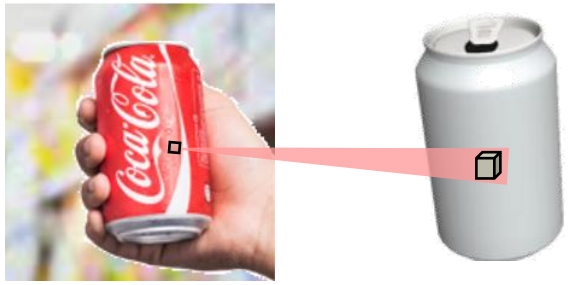
II. Supermarket scenarios
- Synthetic data pipeline

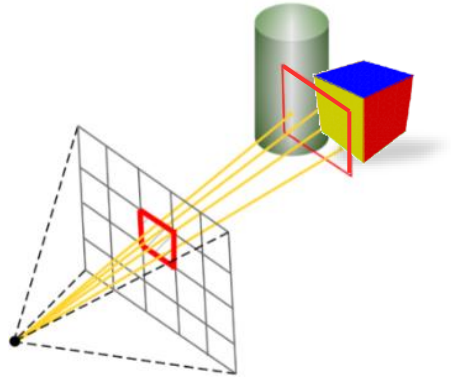


Challenges

3D Ground Truth

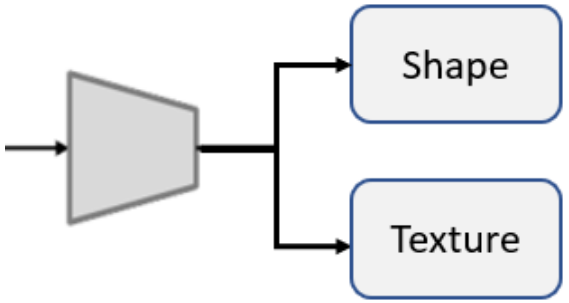
- ➢ synthetic data
- ➢ implicit supervision

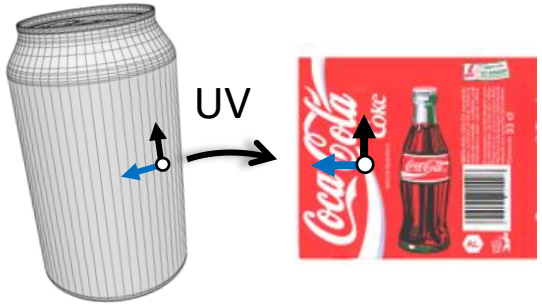




Shape-Color Decomposition

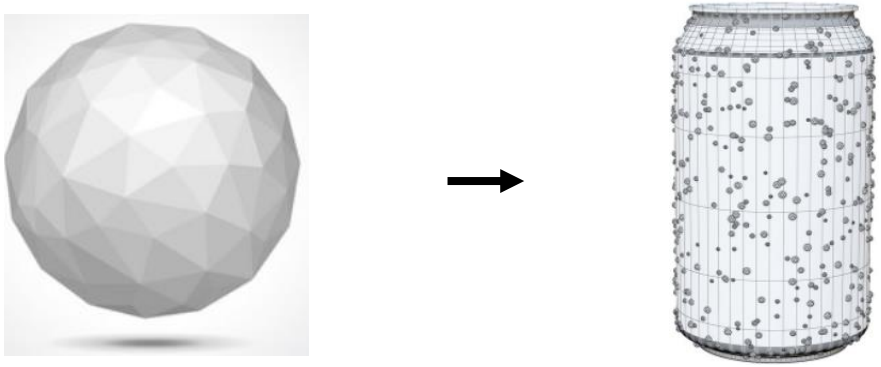
- network modularity
- flexible training
- ➢ UV mapping





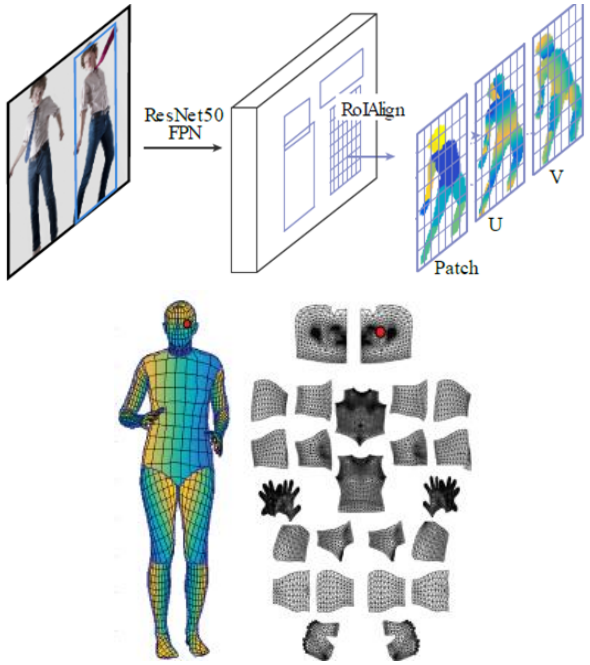
Consistent Representation

- ➢ template deformation



Shape-Texture Reconstruction Overview

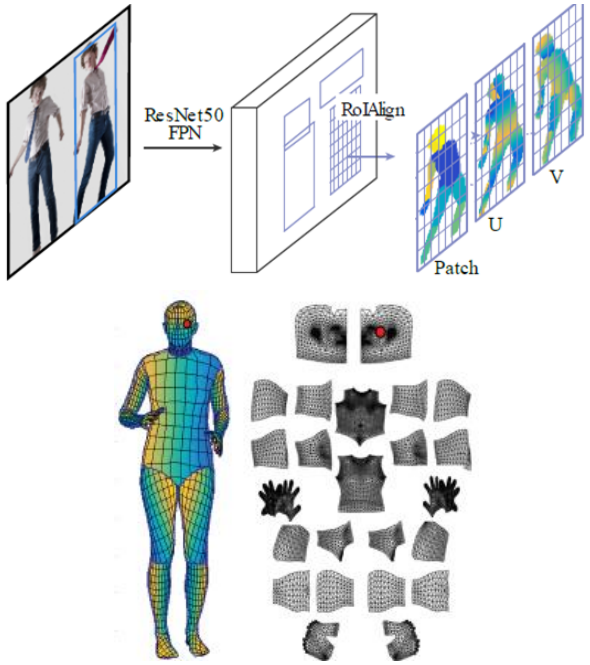
Narrow Domain



[Güler et al. 2018] (Denspose),
[Rempe et al 2021] (HuMor)

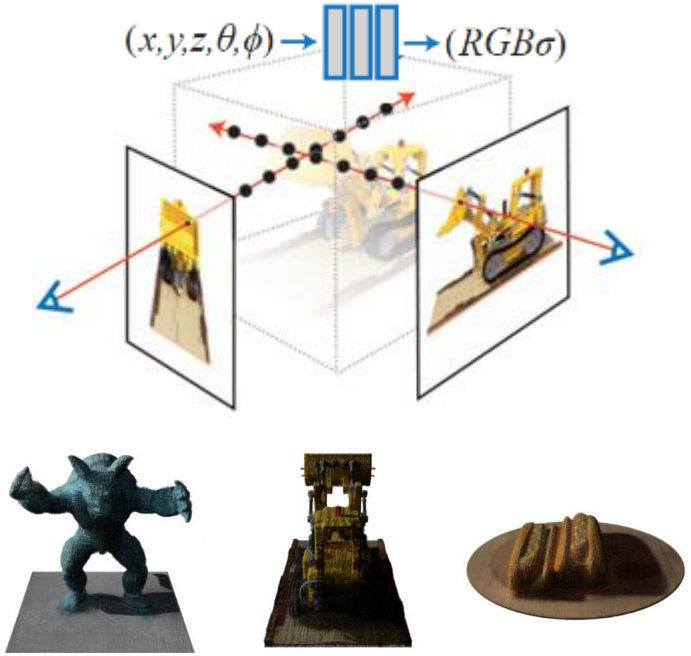
Shape-Texture Reconstruction Overview

Narrow Domain



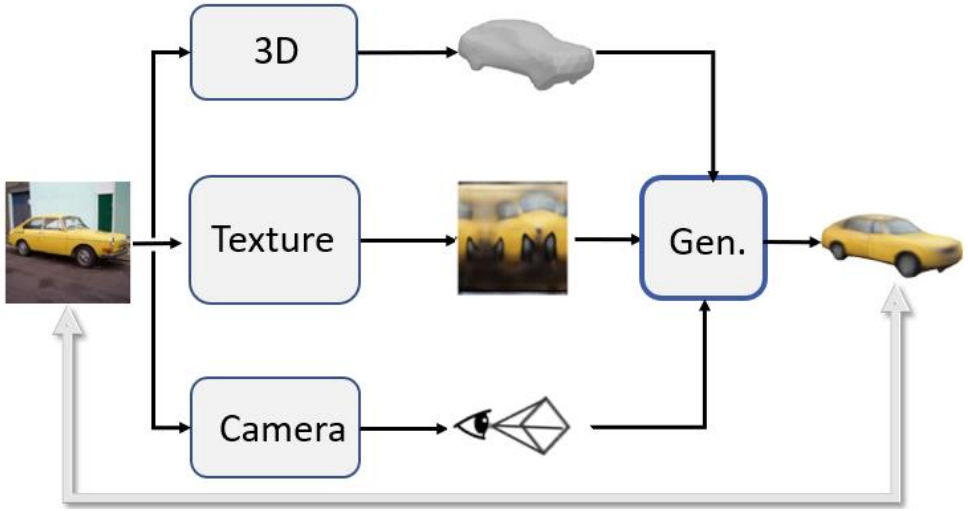
[Güler et al. 2018] (Denspose),
[Rempe et al 2021] (HuMor)

NeRF



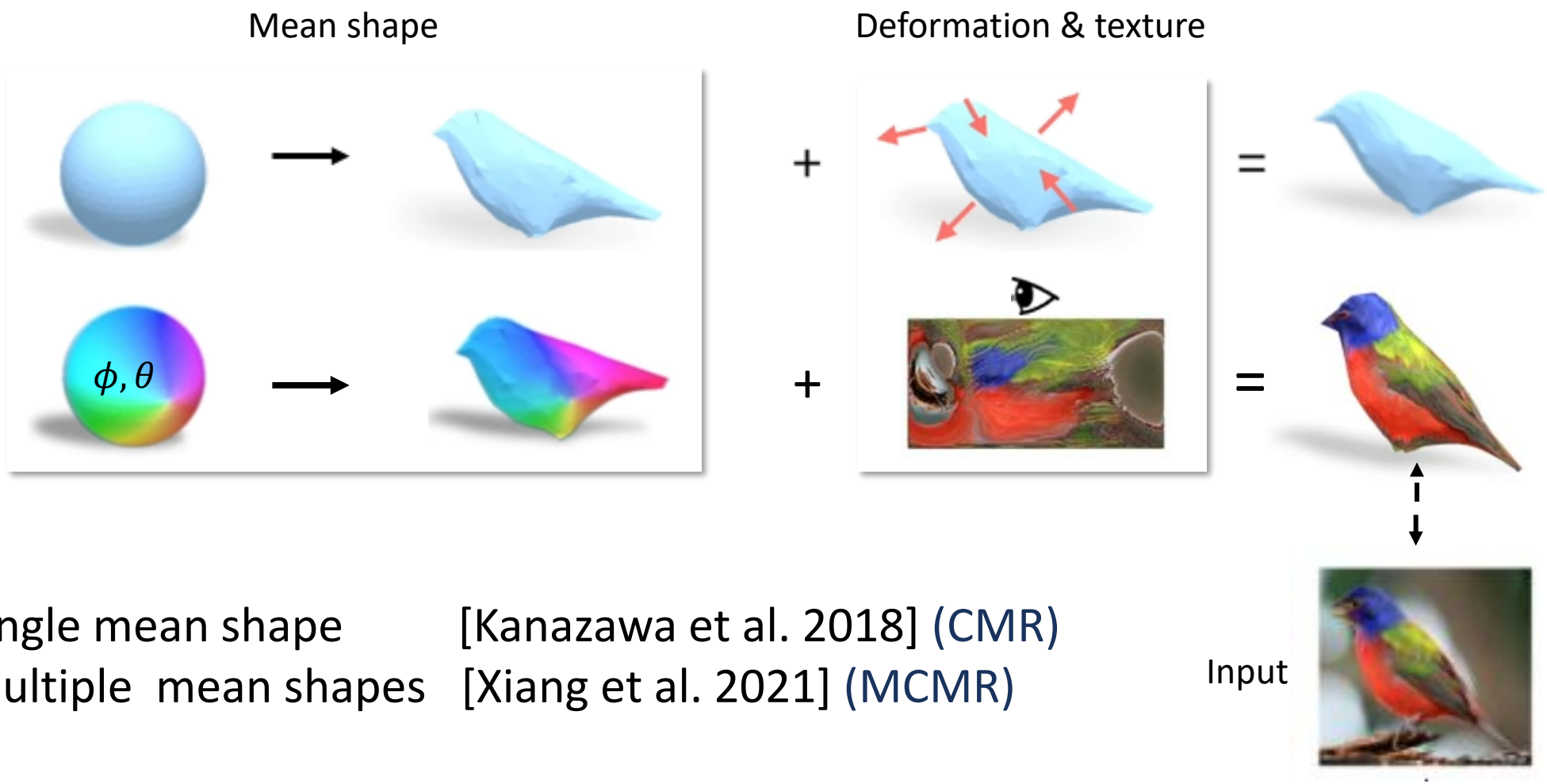
[Mildenhall et al. 2020],
[Xie et al. 2021], [Xiang et al. 2021]

Implicit



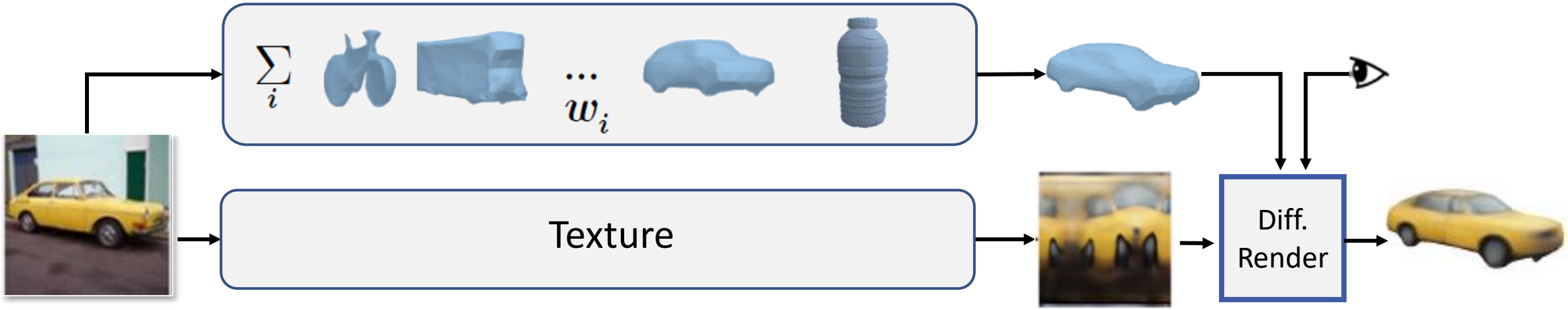
[Mildenhall et al. 2020] (pix2surf),
[Kanazawa et al. 2018] (CMR),
[Xiang et al. 2021] (MCMR)

Mesh-Based Differential Rendering



- Single mean shape [Kanazawa et al. 2018] (CMR)
- Multiple mean shapes [Xiang et al. 2021] (MCMR)

Multi-Class Mesh Reconstruction (MCMR)



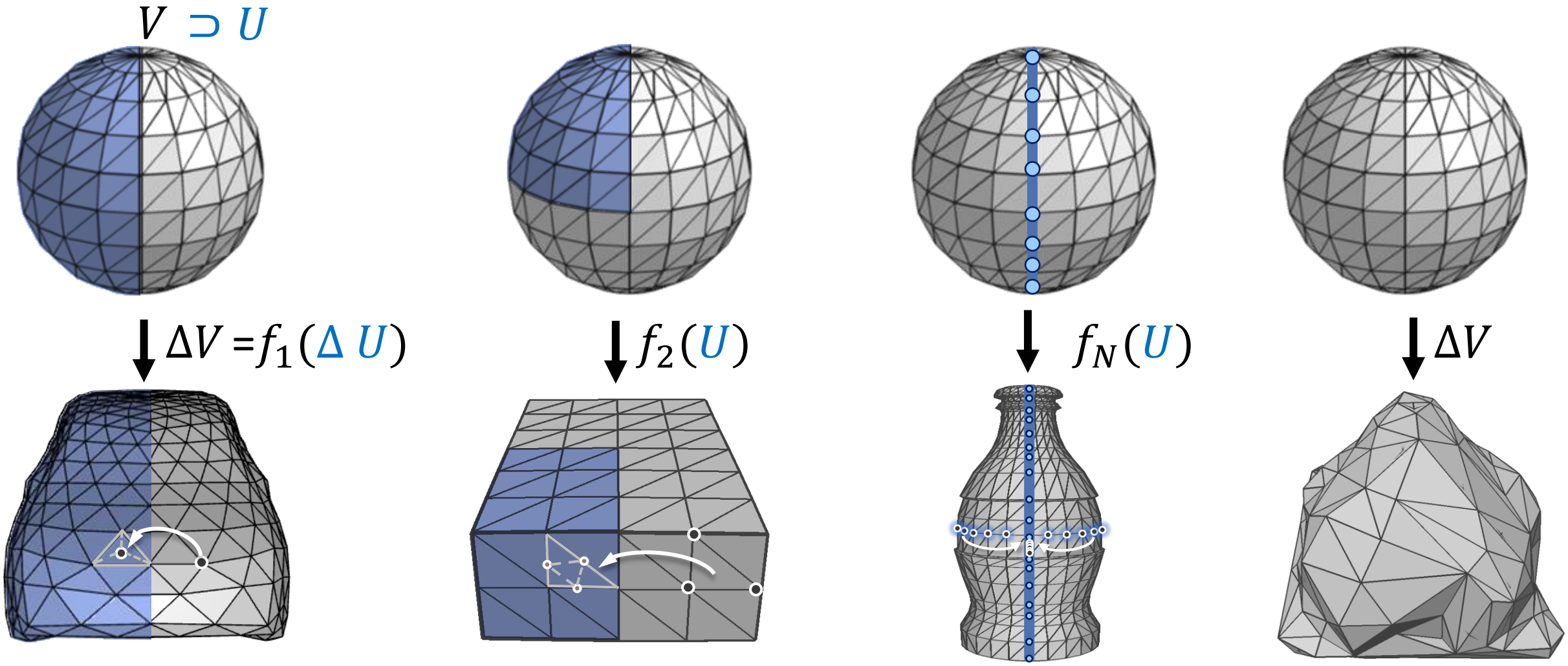
- ✓ General representation
- ✓ Shape-texture modularity
- ✓ Consistent representation

Multi-Class Mesh Reconstruction (MCMR)

- ✓ General representation
- ✓ Shape-texture modularity
- ✓ Consistent representation

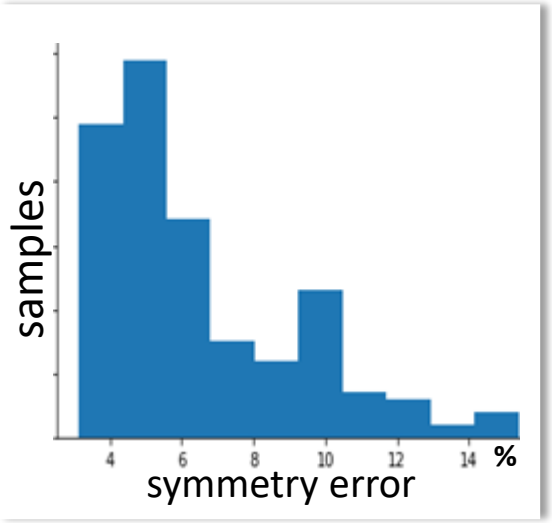
- × Texture quality
  - layout
- × Efficient 3D representation
  - class features

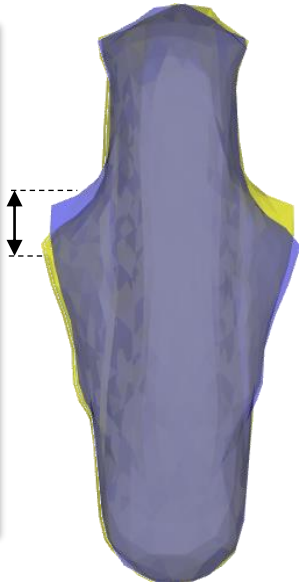
More Efficient Representation

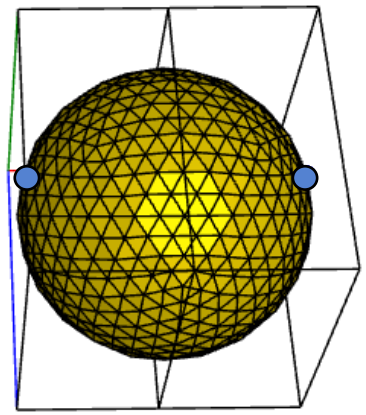


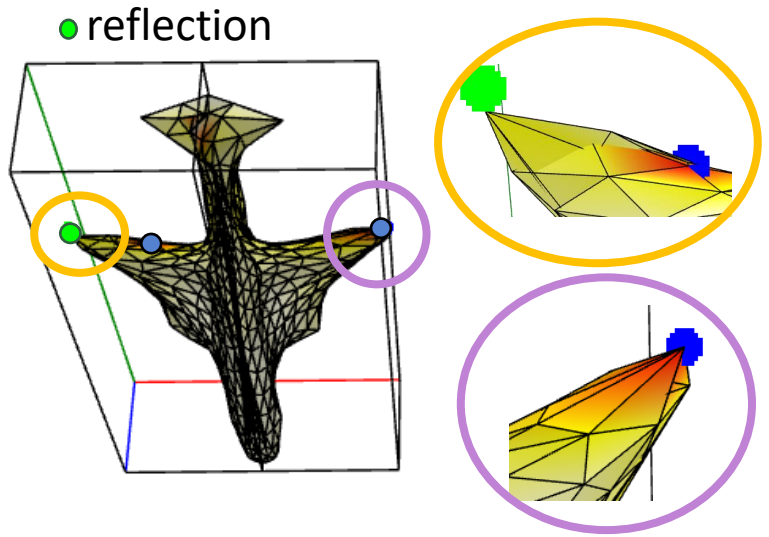
Symmetry-Aware Representation

- Increase 3D accuracy for symmetric objects
- Reduces extra DoF
  - minimal network changes
  - better mesh quality

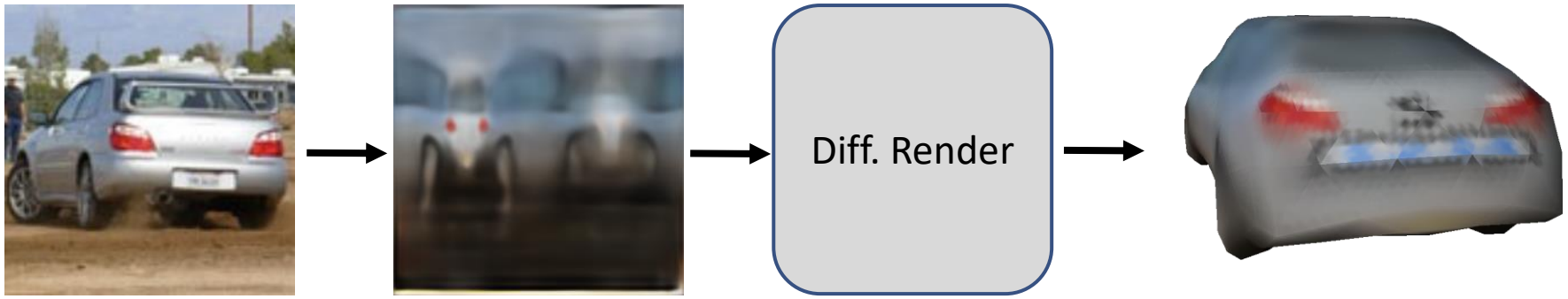






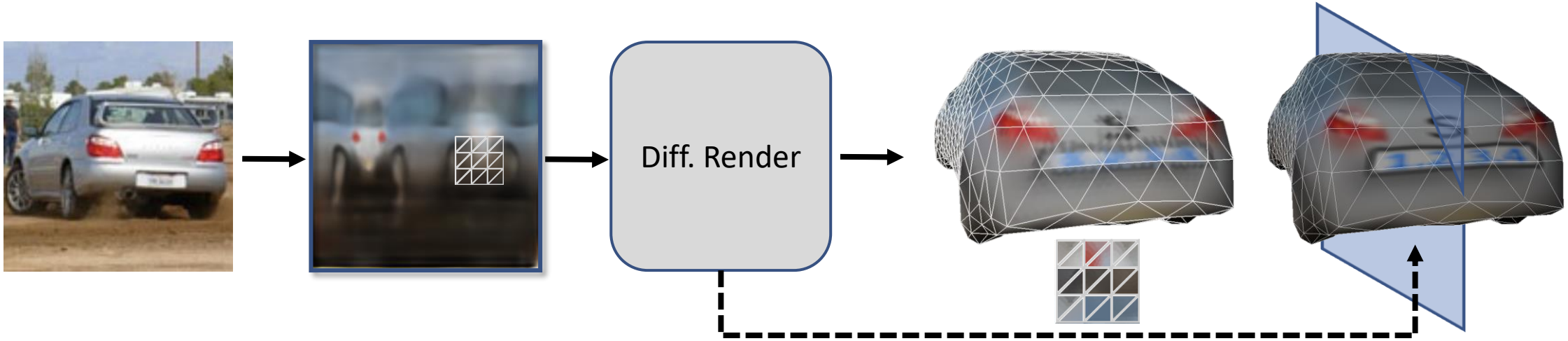


Improved Texture Mapping

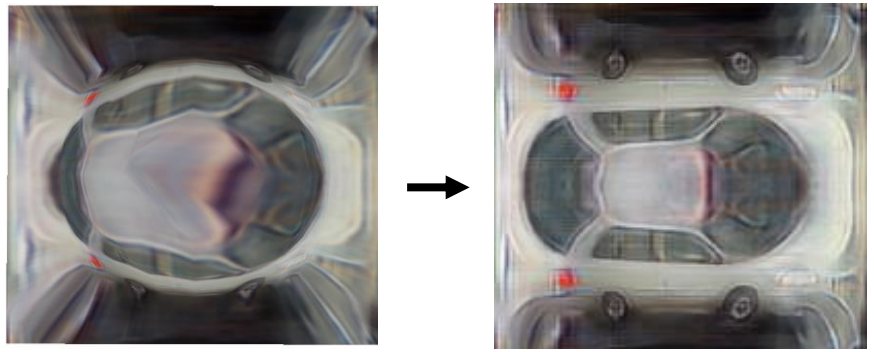


- Differential Rendering Mode

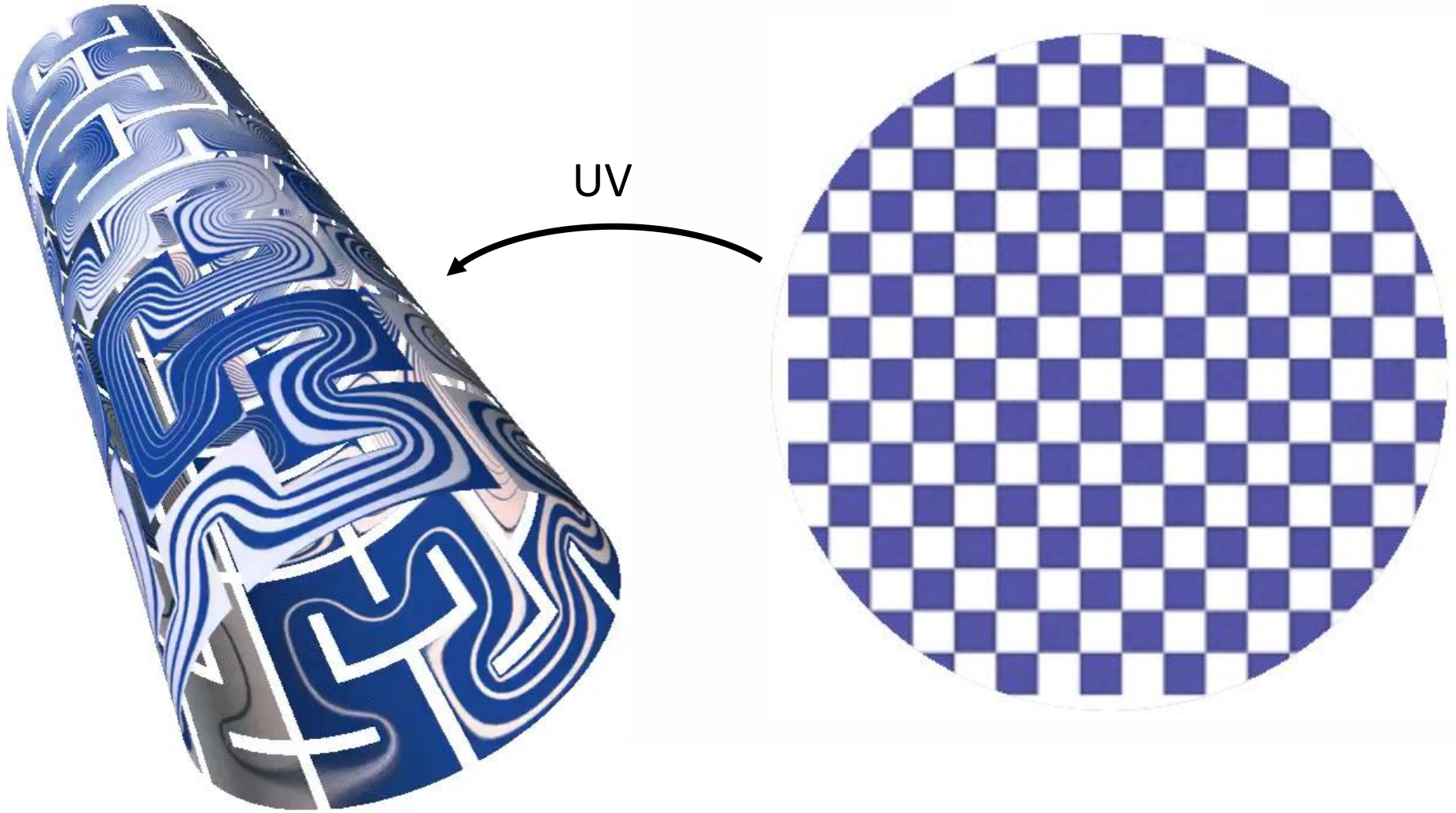
Improved Texture Mapping



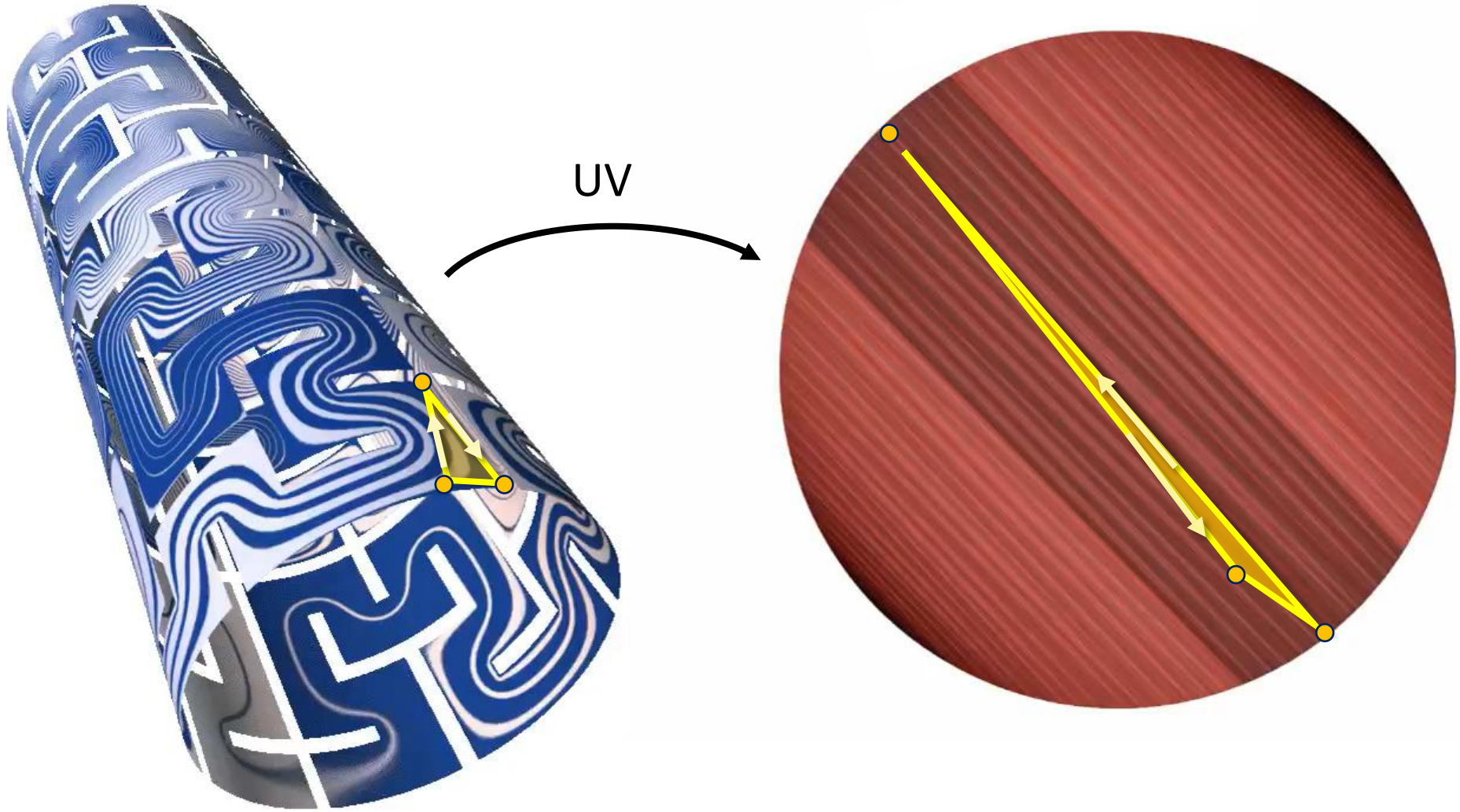
- Differential Rendering Mode
  - Grid vs UV-map sampling
- Texture layout
  - Symmetry-aware cut
  - Supervise UV-map quality



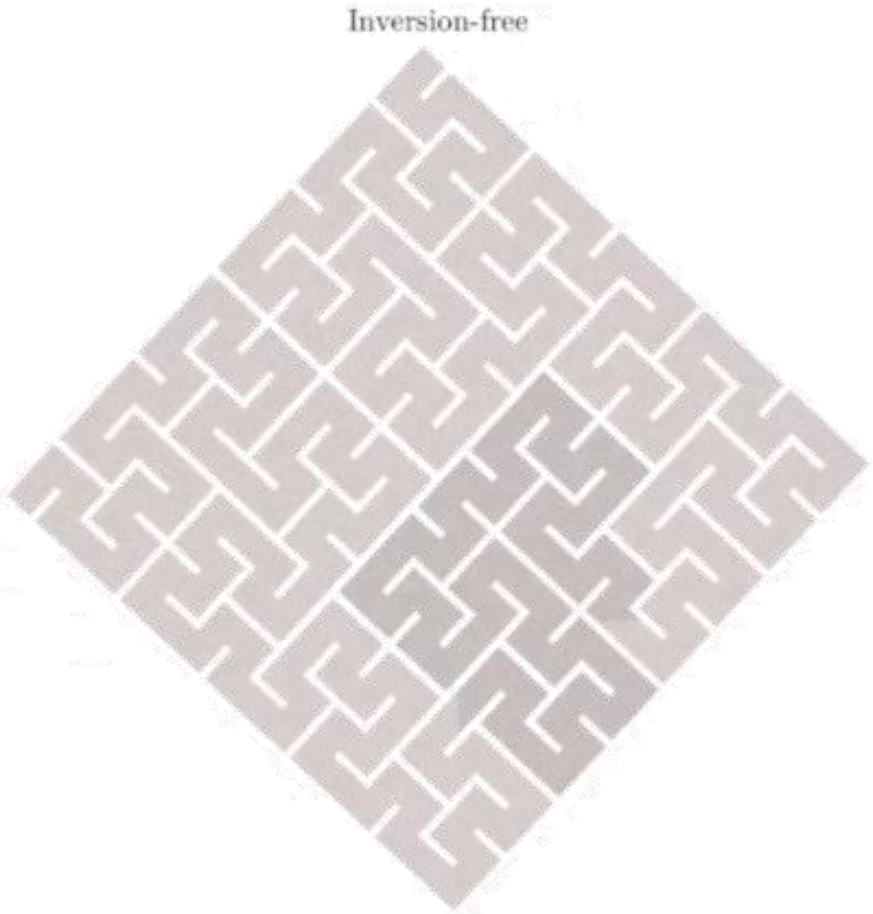
UV-map distortions



UV-map distortions



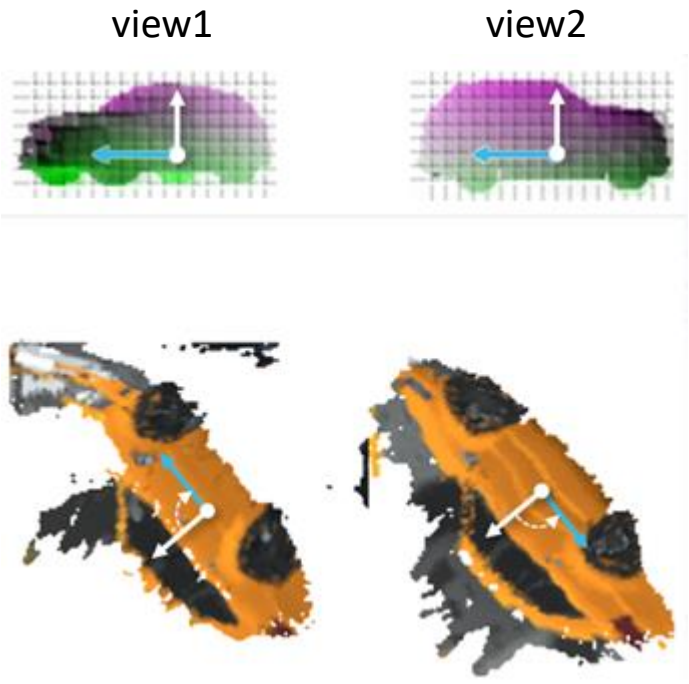
Minimizing UV-map distortions

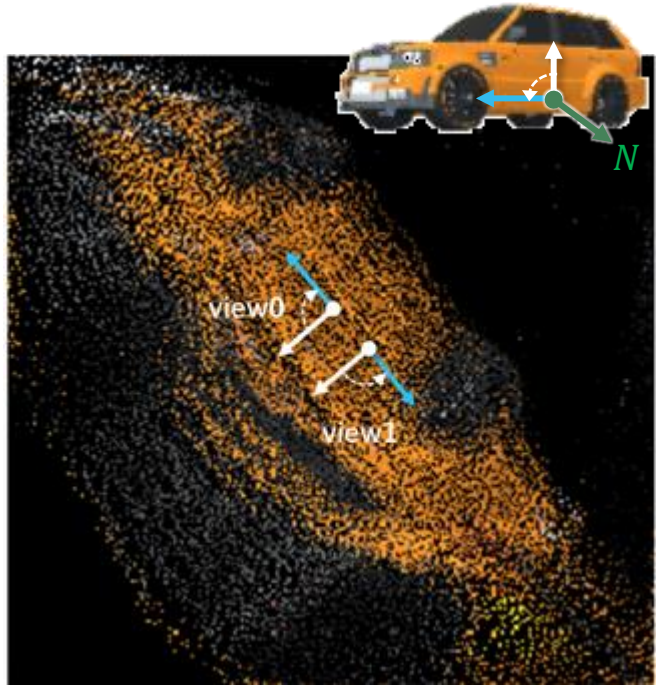


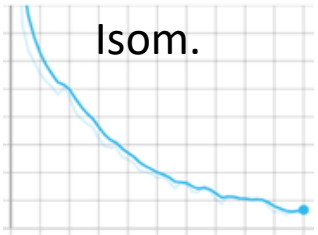
Pix2Surf distortion losses

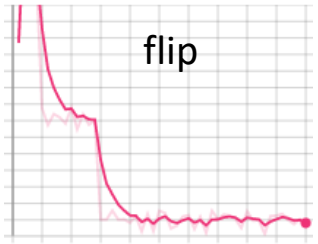
$$L_{\text{isom}} = \sum_{pk \sim ij} \left| \|xyz_{ij} - xyz_{pk}\| - \|uv_{ij} - uv_{pk}\| \right|$$

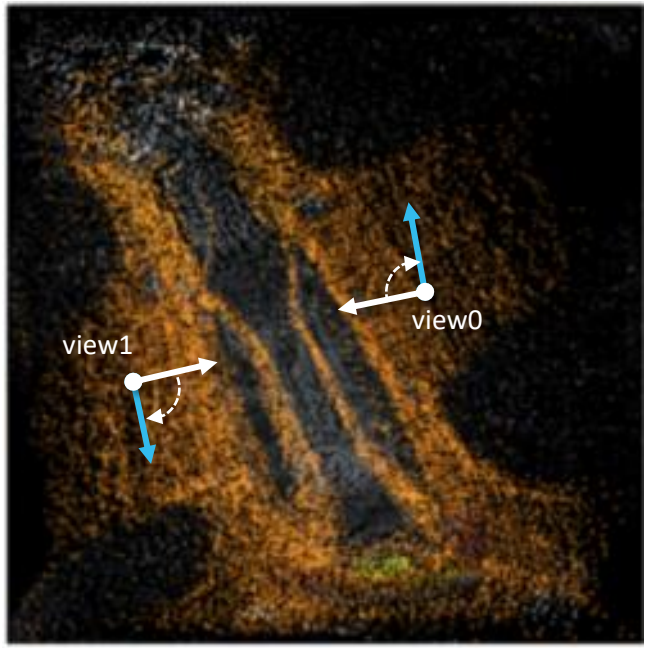
$$L_{flip}^{1/p} = \|Relu((\widehat{\Delta_1 uv} \times \widehat{\Delta_2 uv})_Z)^p\|_1$$











Bibliography

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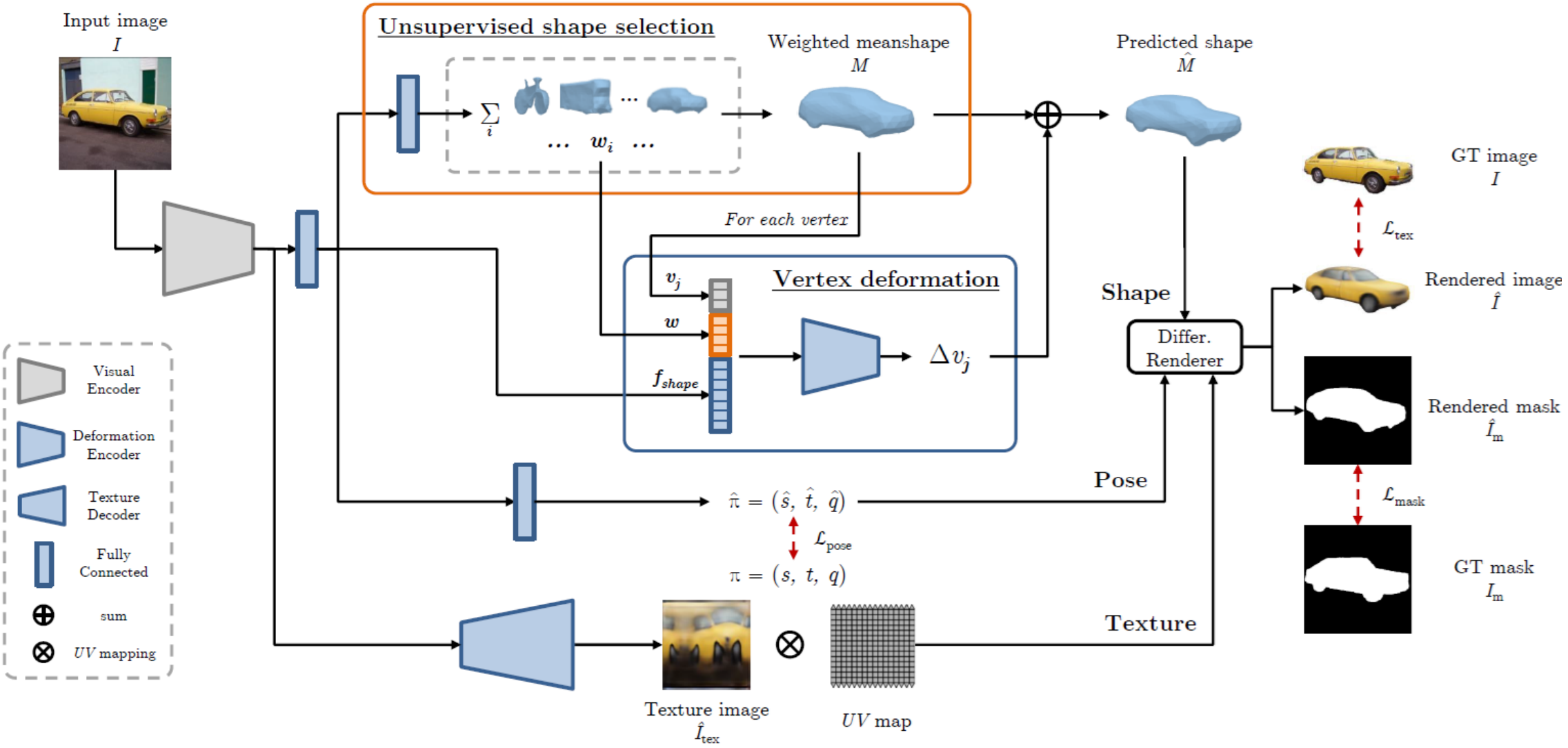
Appendix: MCMR architecture



Appendix: Pix2Surf architecture