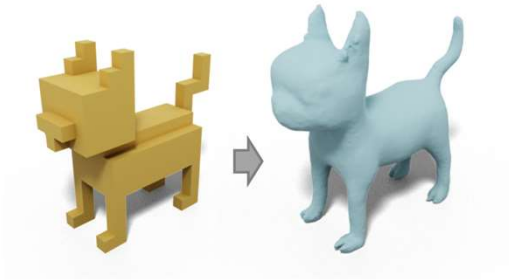
Research works

- **Deep Marching Tetrahedra: a Hybrid Representation for High-Resolution 3D Shape Synthesis.**
  Tianchang Shen, Jun Gao, Kangxue Yin, Ming-Yu Liu, Sanja Fidler
  NeurIPS, 2021



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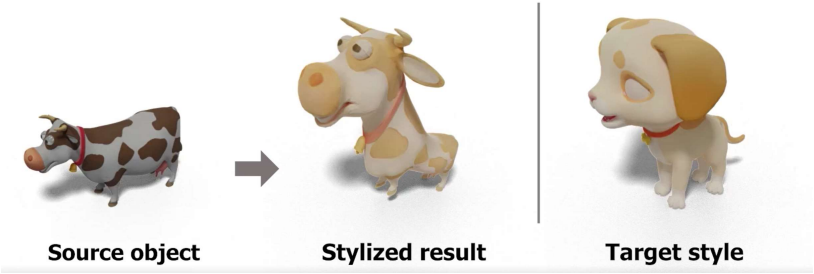

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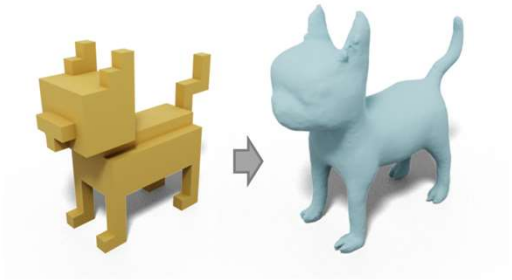
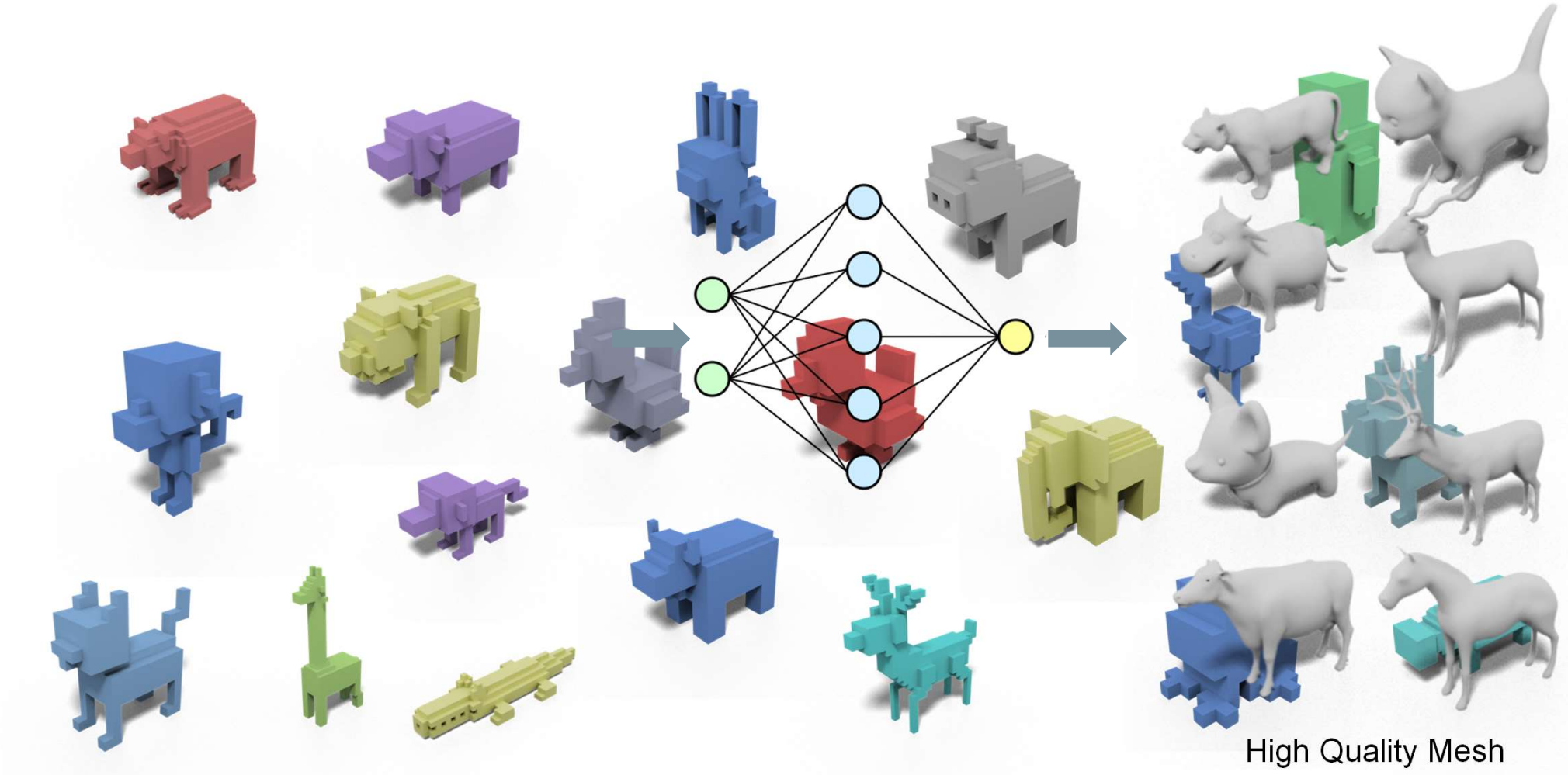


Rough 3D Shapes -> Detailed 3D Shapes



What 3D Representation to Use?

What 3D Representation to Use?

- **Discrete Representations ?**
  - Limited to predefined resolution or topology

Figure from [Gao et al. 2020]

What 3D Representation to Use?

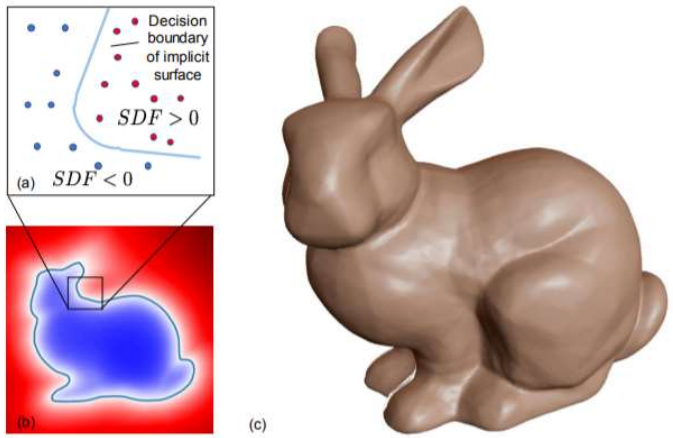
- **Deep Implicit Fields (DIFs) ?**

$$f_\theta(x, y, z) \approx s(x, y, z)$$

Network

Signed distance from (x, y, z) to closest surface

$f_\theta(x, y, z) = 0$ defines the implicit surface



DeepSDF [Park et al. 2019]

What 3D Representation to Use?

- **Deep Implicit Fields (DIFs) ?**

$$f_\theta(x, y, z) \approx s(x, y, z)$$

Pros:

- Represent arbitrary topology
- Continuous

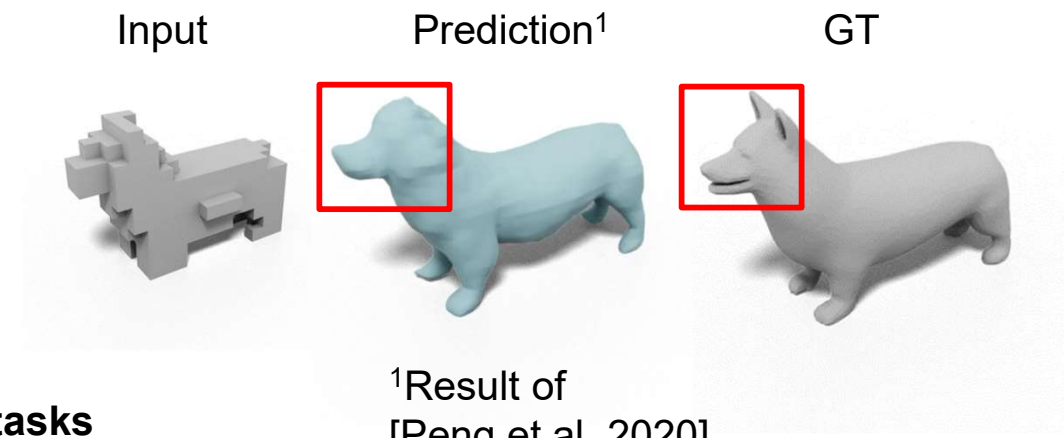
Overfitting

SIREN [Sitzmann and Martel et al. 2019]

What 3D Representation to Use?

- **Deep Implicit Fields (DIFs) ?**

$$f_\theta(x, y, z) \approx s(x, y, z)$$



[1]Result of [Peng et al. 2020]

Pros:

- Represent arbitrary topology
- Continuous

Cons:

- Regressing SDF/OF in **generative tasks** do not capture geometric details.

What 3D Representation to Use?

- **Deep Implicit Fields (DIFs) ?**

$$f_\theta(x, y, z) \approx s(x, y, z)$$

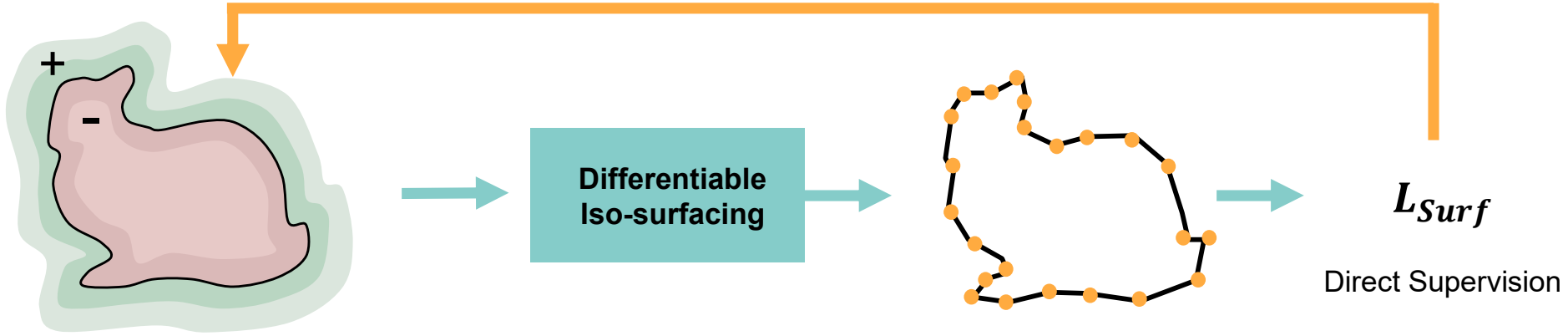
Pros:

- Represent arbitrary topology
- Continuous

Cons:

- Regressing SDF/OF in **generative tasks** do not capture geometric details.
- Requires **costly and lossy meshing** step

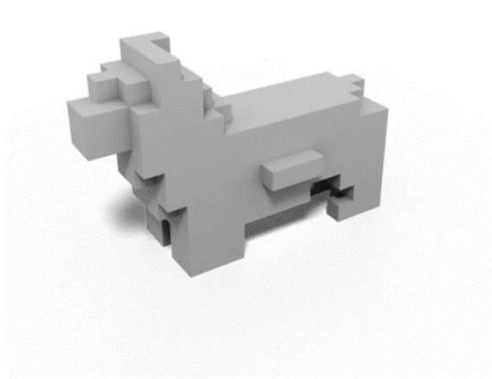
Key Idea: Differentiable Iso-surfacing



Optimizing f_θ for L_{Surf}

- Aware of **quantization error** from meshing
- higher quality shapes with **finer geometric details**

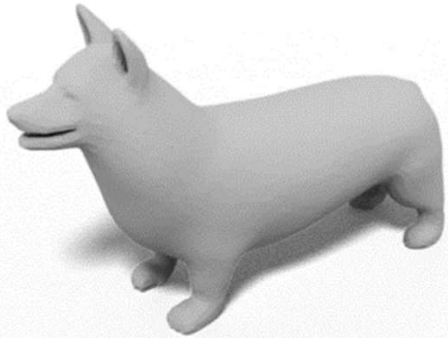
Key Idea: Differentiable Iso-surfacing



Input

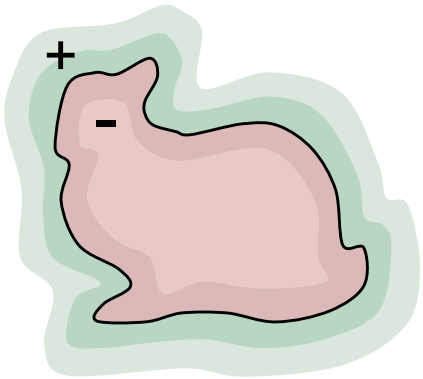
Implicit Approach
[Peng et al. 2020]

Our result



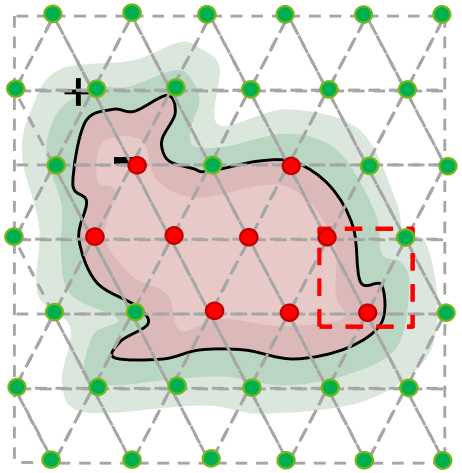
GT

Marching Tetrahedra[2] (MT)

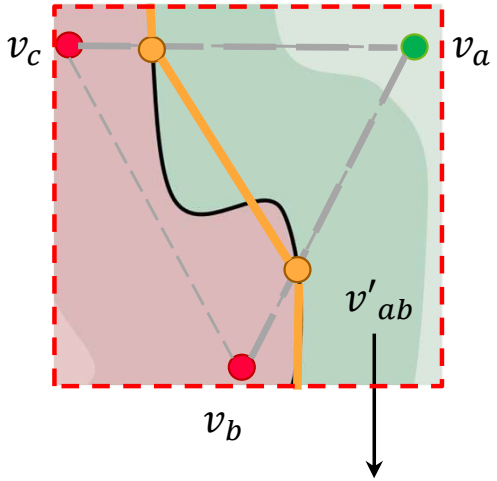


Deep Implicit Field $f = f_\theta$

Evaluate



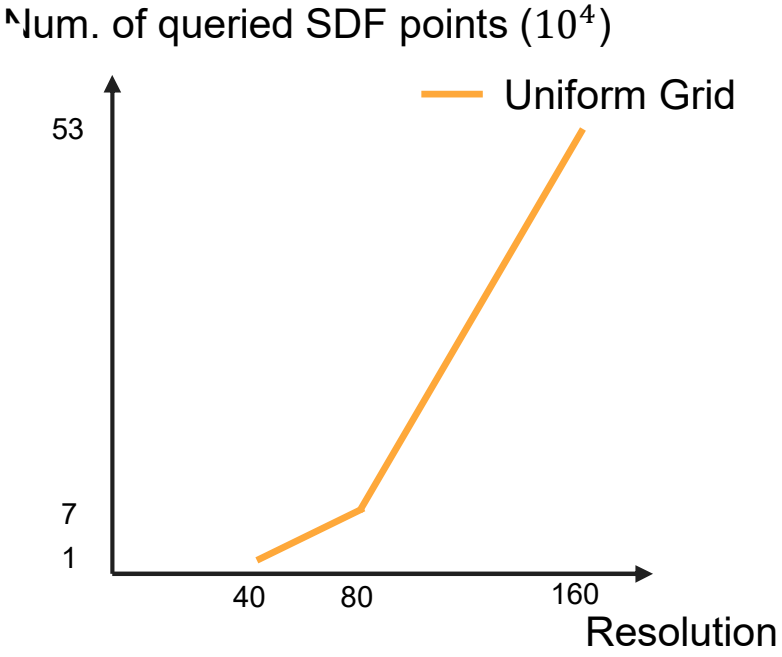
Discrete Implicit Field



$$v'_{ab} = \frac{v_a \cdot f(v_b) - v_b \cdot f(v_a)}{f(v_b) - f(v_a)}$$

[2]An efficient method of triangulating equi-valued surfaces by using tetrahedral [Doi et al. 1991]

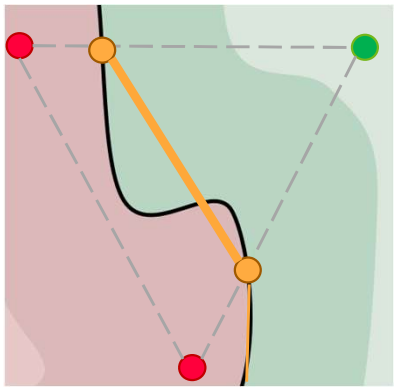
Memory and Computational Cost



However, the computation and memory footprint grows cubically as grid resolution increases

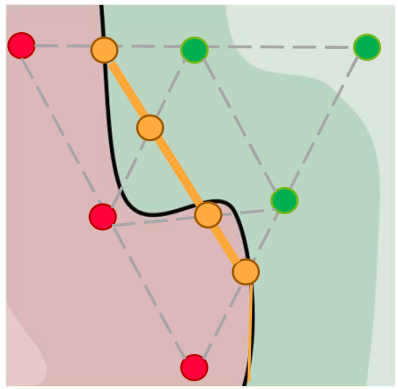
Also a limitation of previous differentiable iso-surfacing methods [Remelli et al. 2020, Liao et al. 2018]

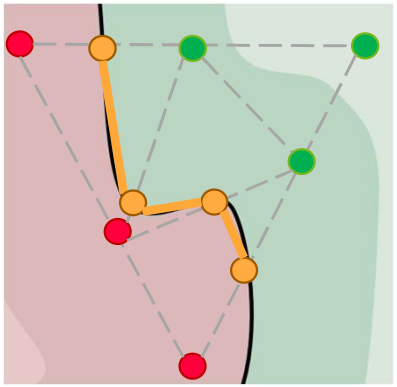
Volume Subdivision



Bad approximation of local surface

Only subdivide surface tets

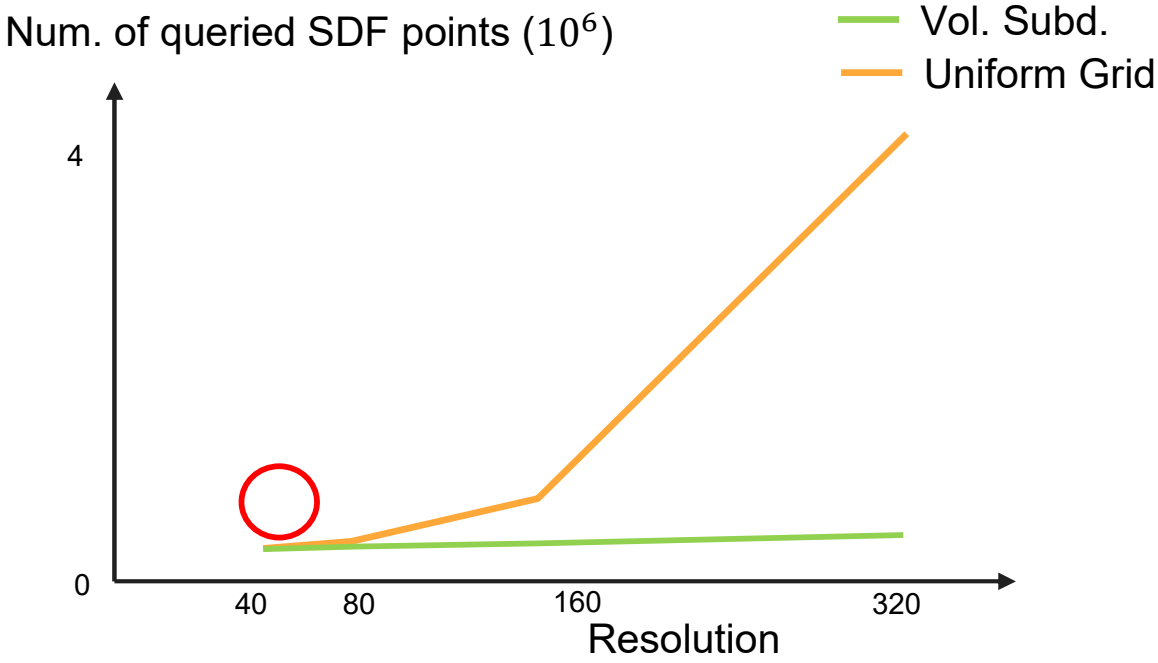




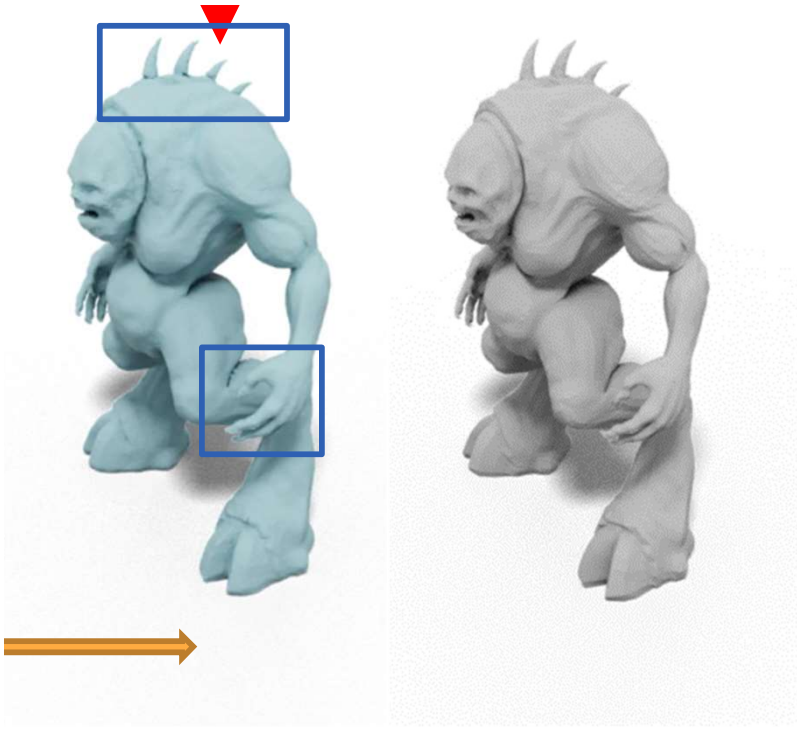
Local updates to SDFs and positions

Volume Subdivision

Automatically learns the subdivision hierarchy



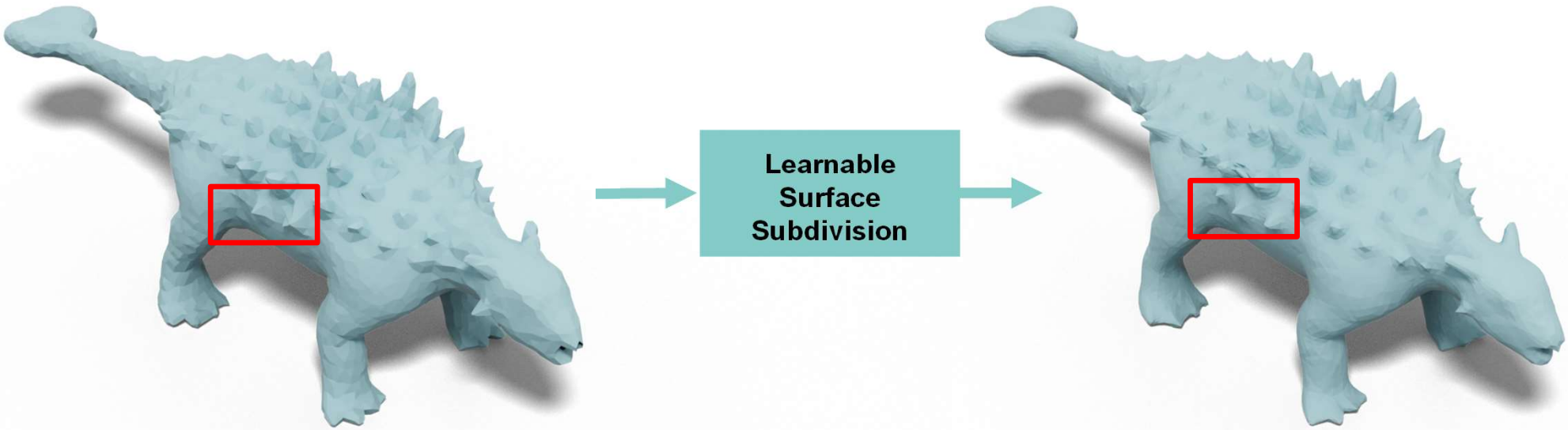
Loss only applied to last layer



Surface Subdivision

End to end trainable

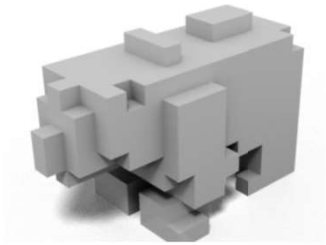
Preserve sharp features



Triangular Mesh

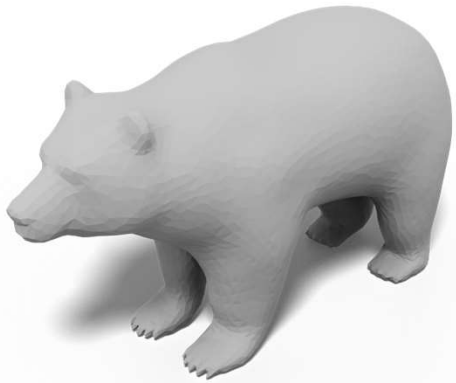
Parametric Surface

Reconstruction Loss Produces Mean Shape

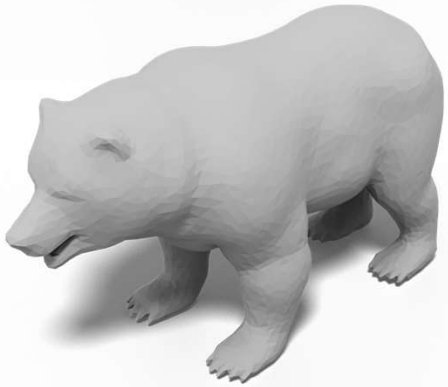


Input

Prediction



Possible Reference 1



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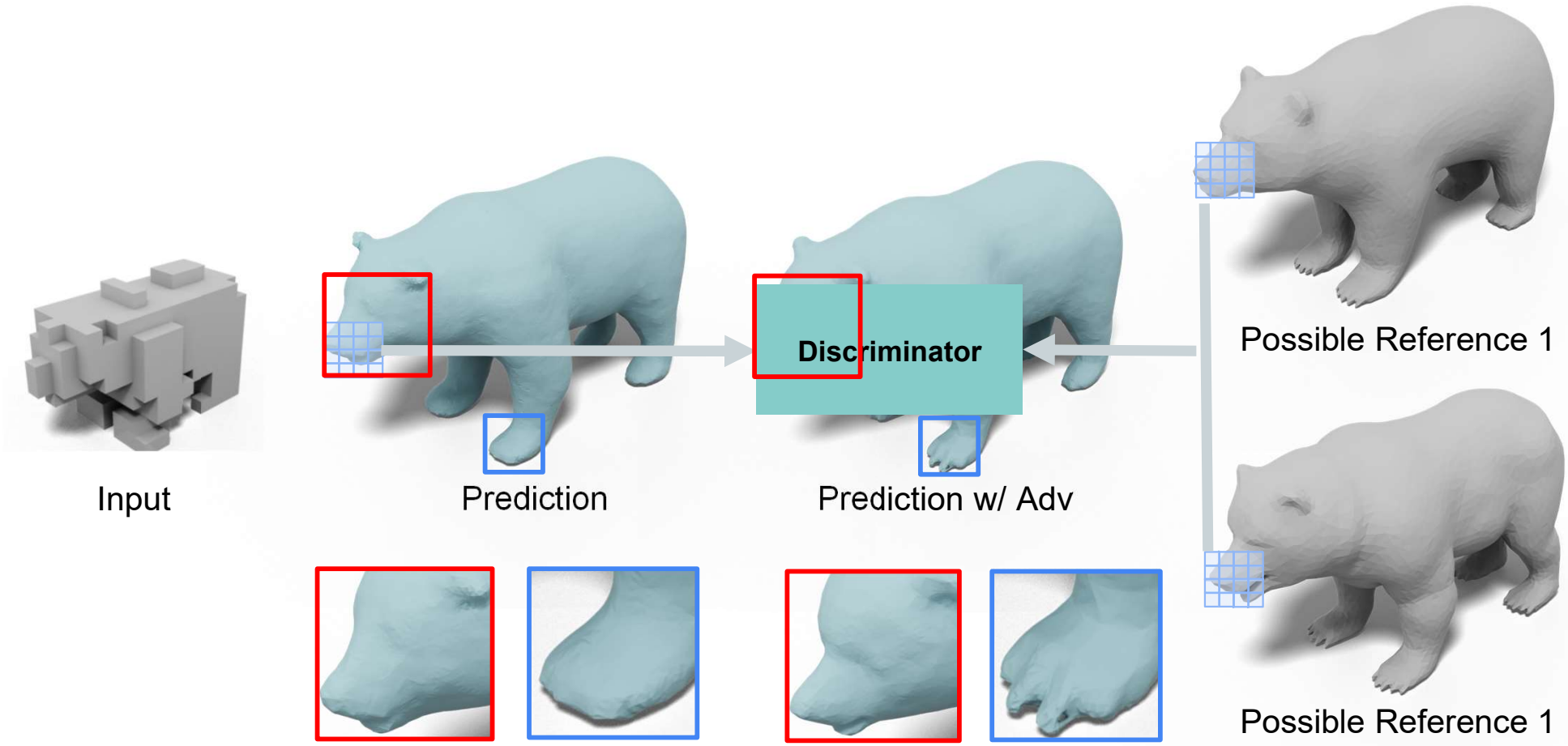
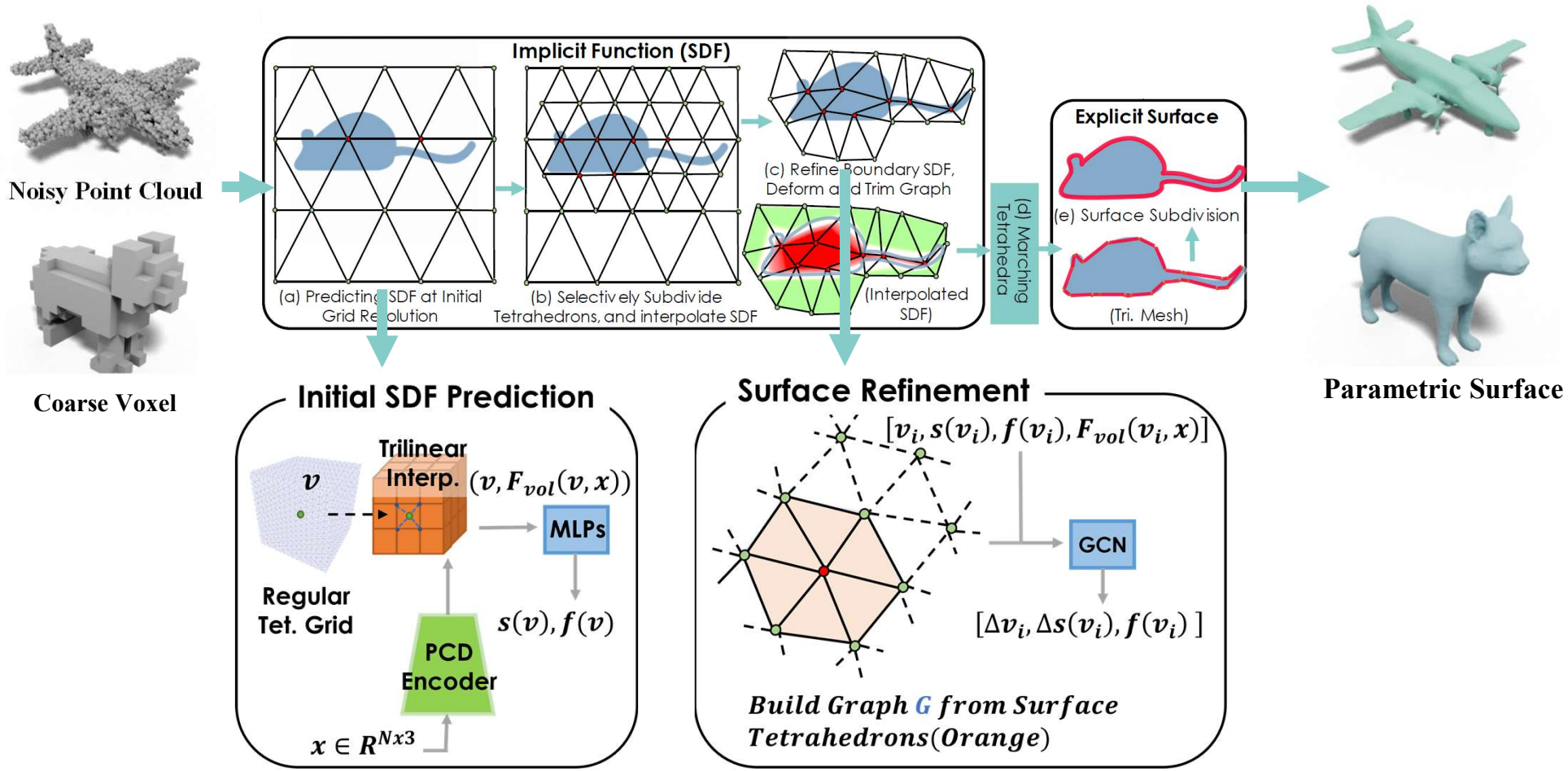
Reconstruction Loss Produces Mean Shape

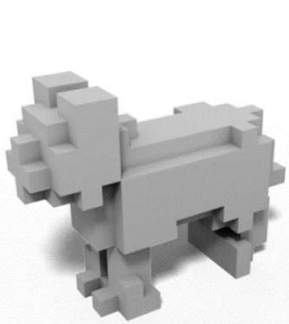


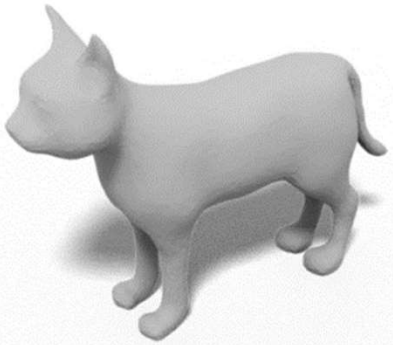
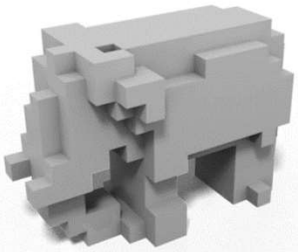
Deep Marching Tetrahedra

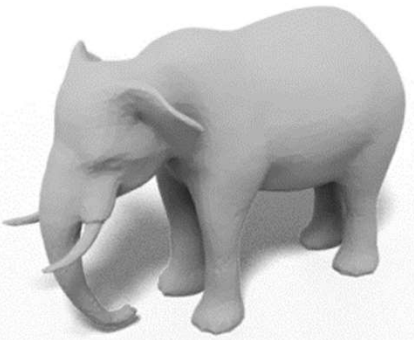
Refer to our paper for more details



Qualitative Results and Comparison

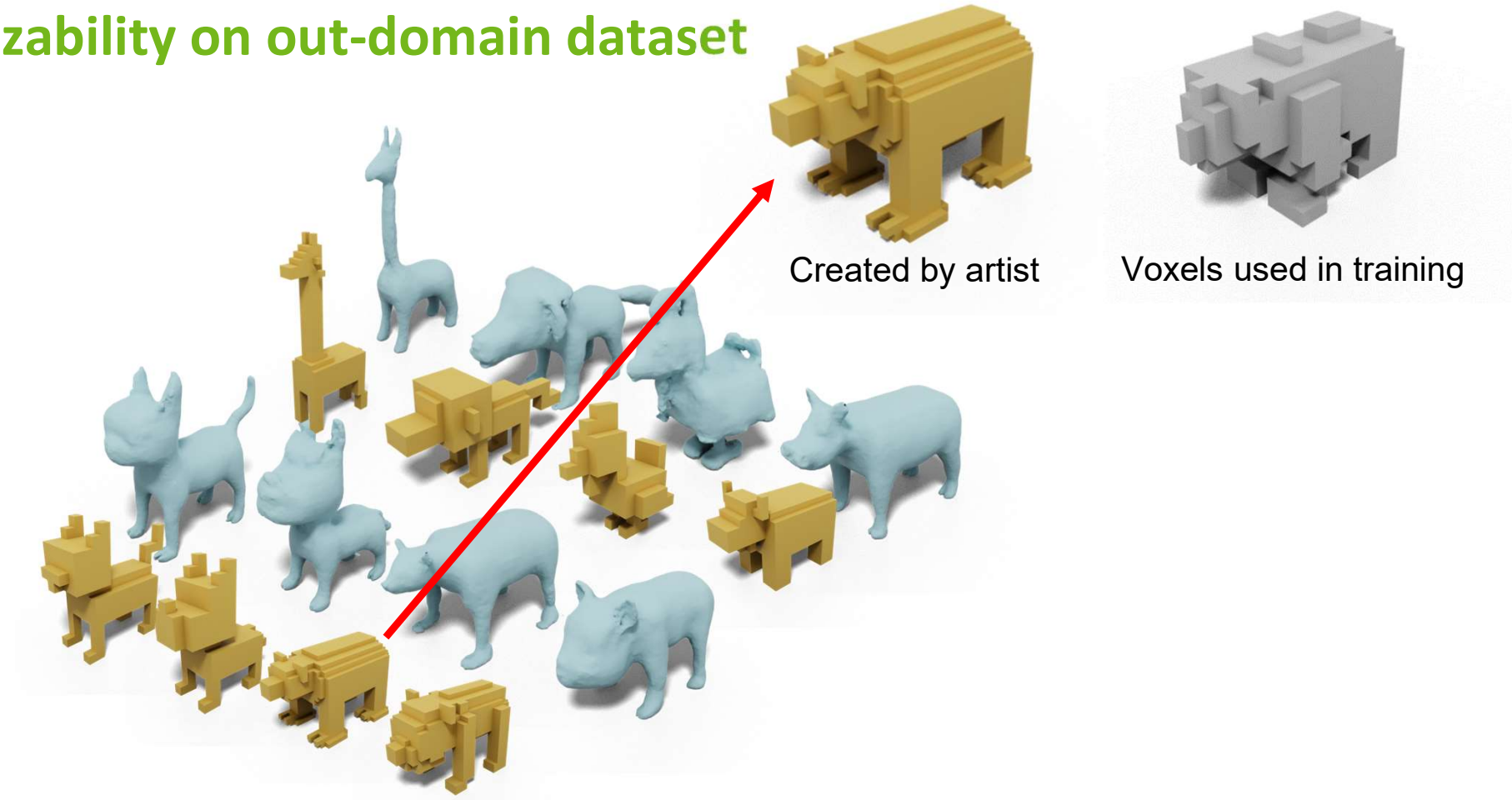


Input | ConvOnet [Peng et al. 2020] | Ours | GT

Generalizability on out-domain dataset



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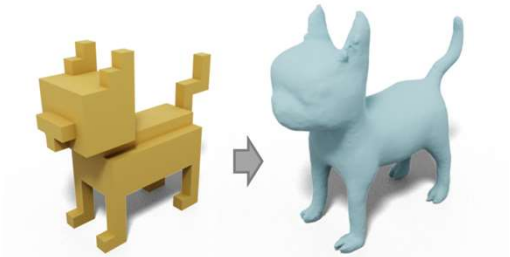

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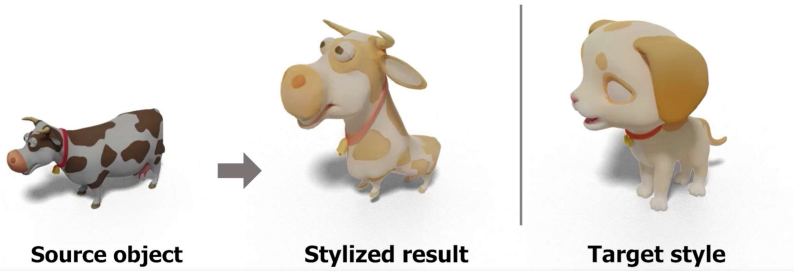
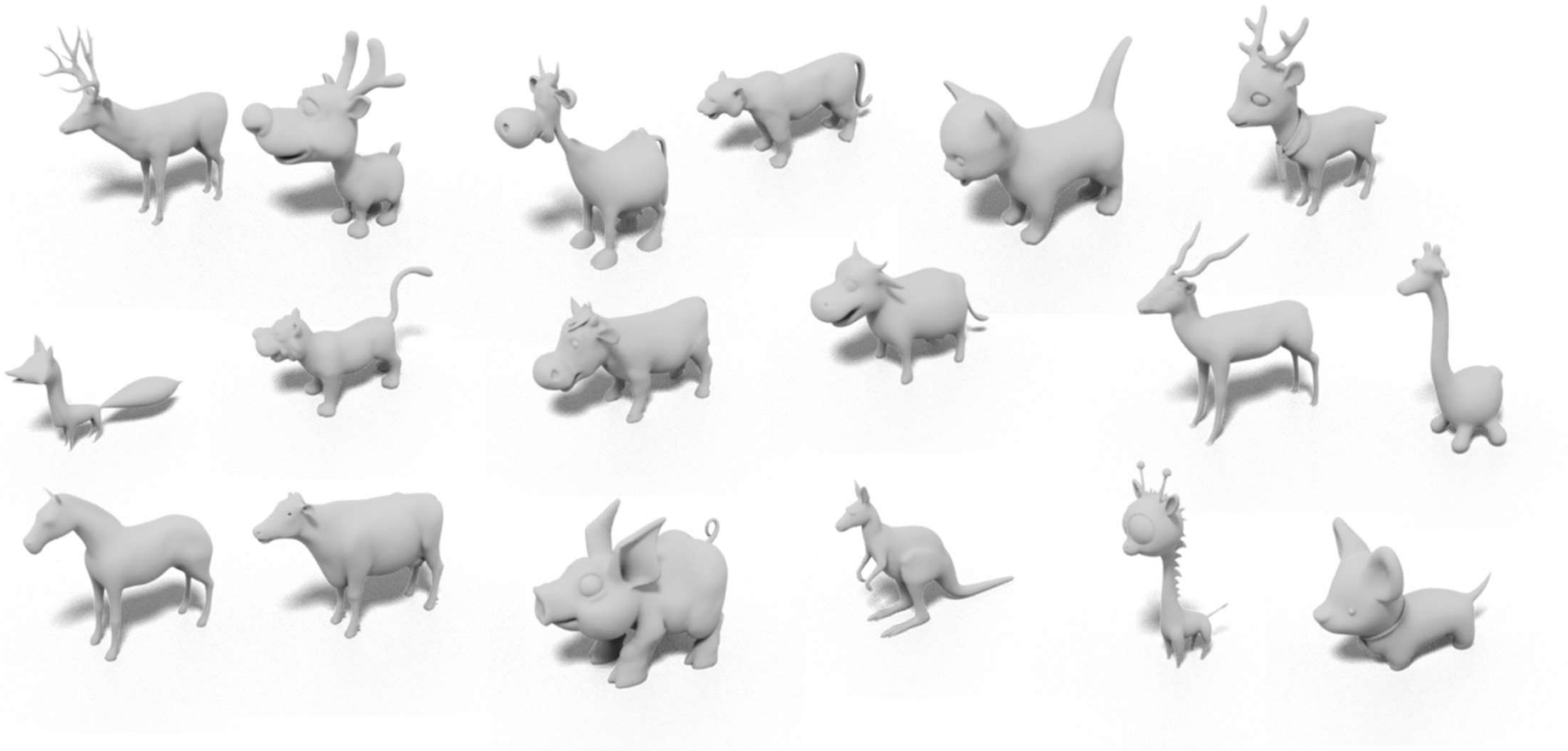


Neural Style Transfer for Images

Photos from [Gatys et al. 2016]

3D Shapes Have Style in both Geometry and Texture

3D Shapes Have Style in both Geometry and Texture



3D Shapes Have Style in both Geometry and Texture

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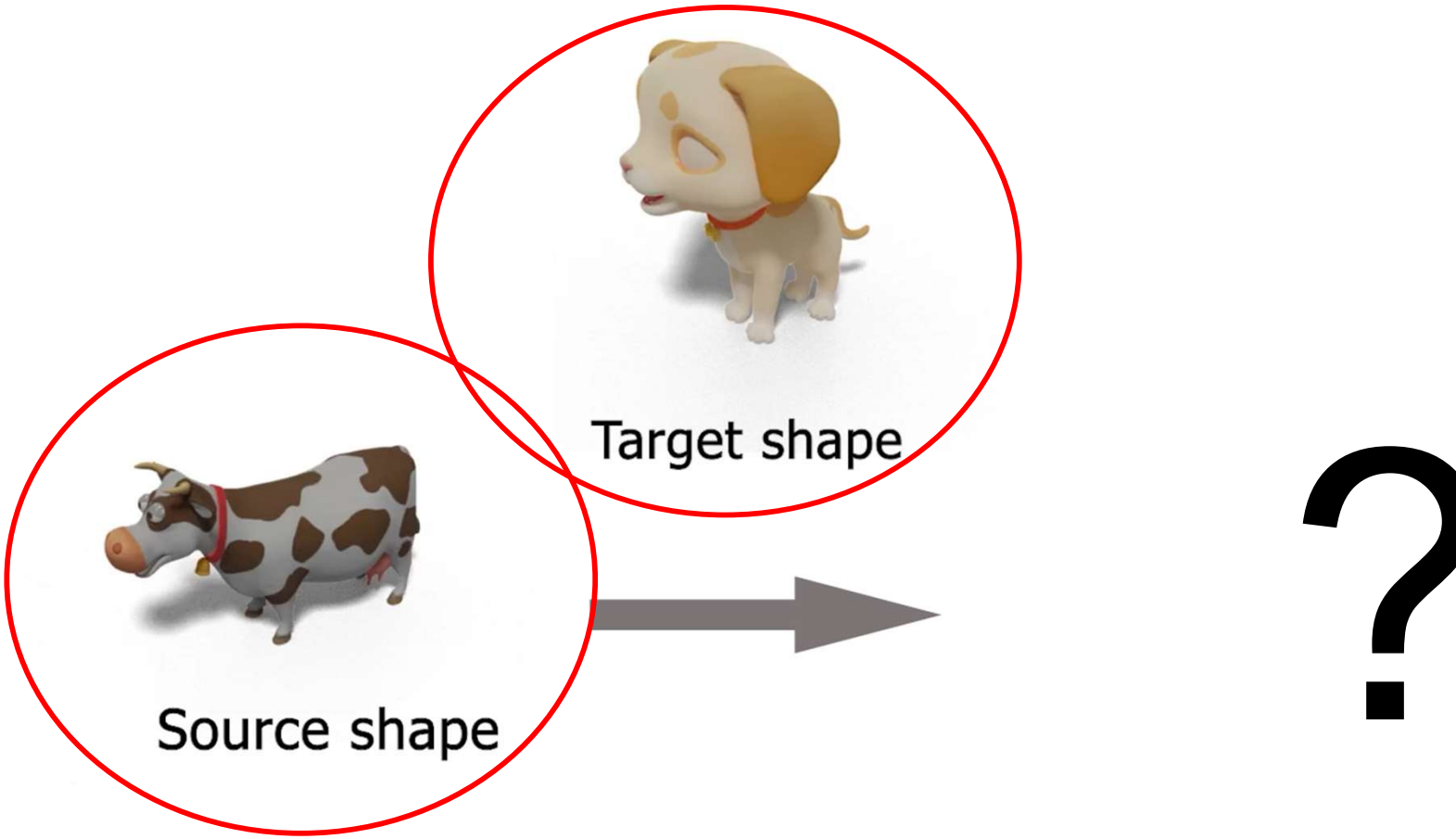
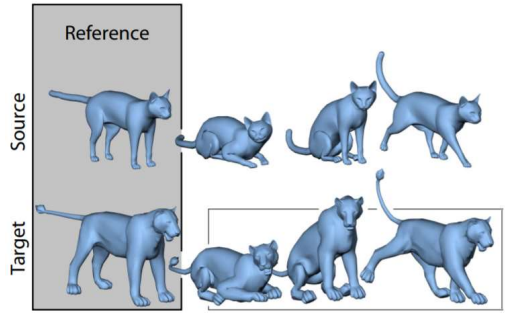
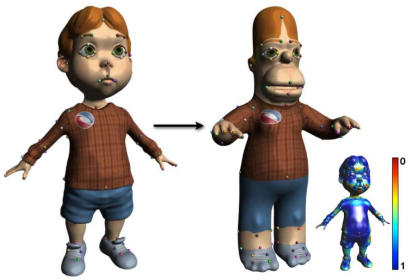
Our 3D Style Transfer



Prior Works



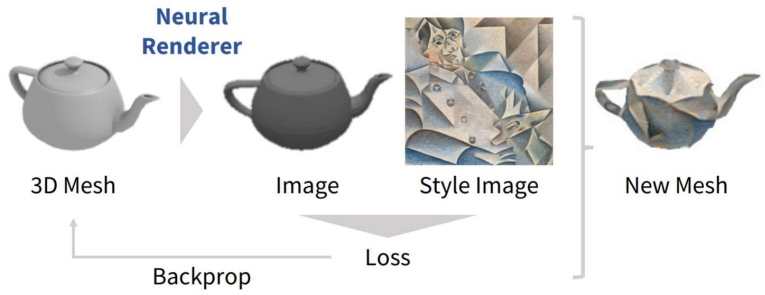
Sumner et al 2004
Deformation transfer



Panozzo et al 2013
Texture transfer

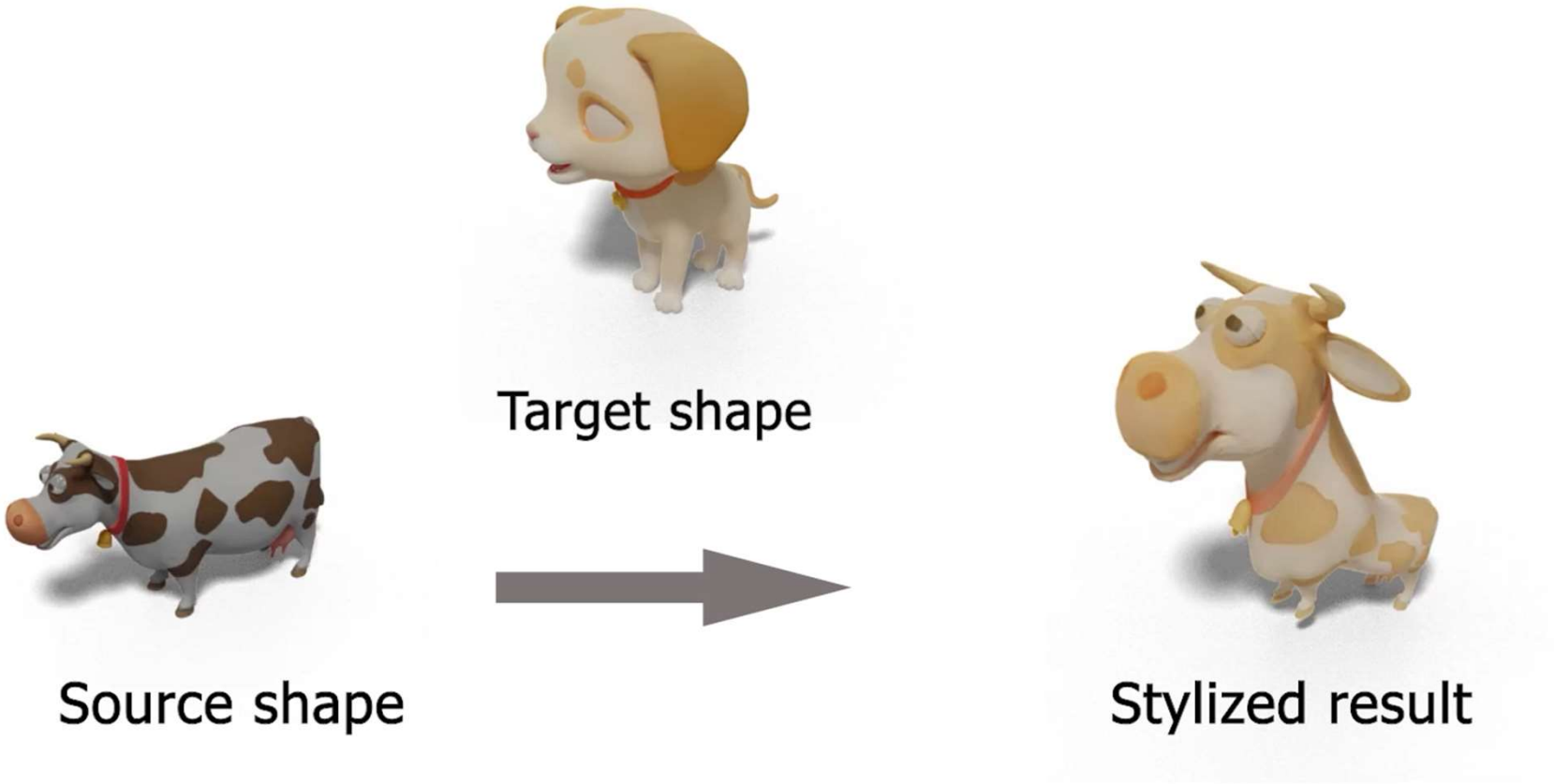
Liu et al 2019
Cubic stylization

Wang et al 2020
Neural Cage

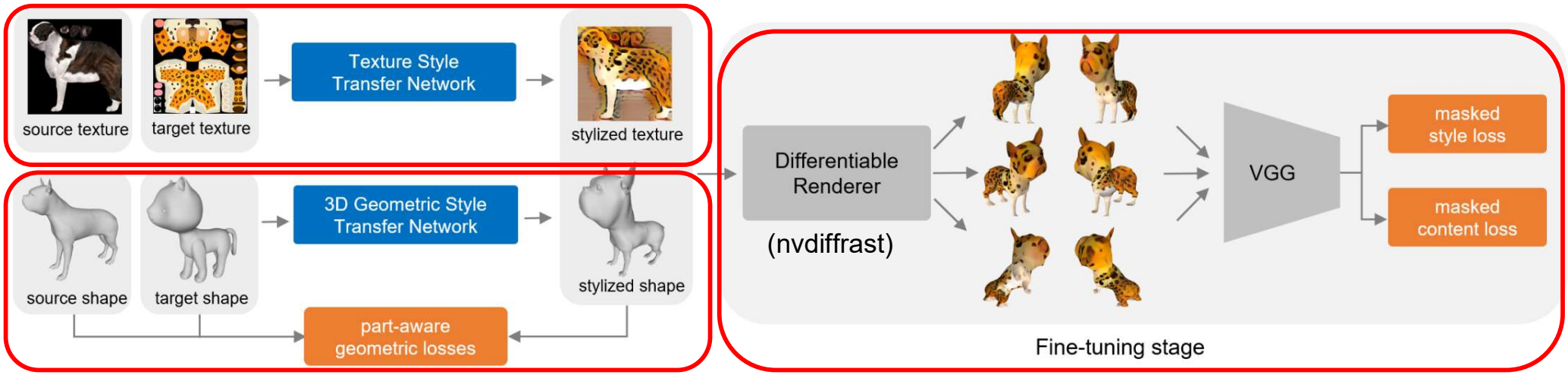


Kato et al 2017
Neural 3D Mesh Renderer

Our 3D Style Transfer



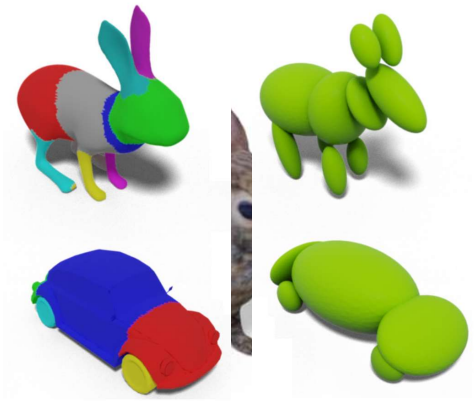
Our 3D Style Transfer

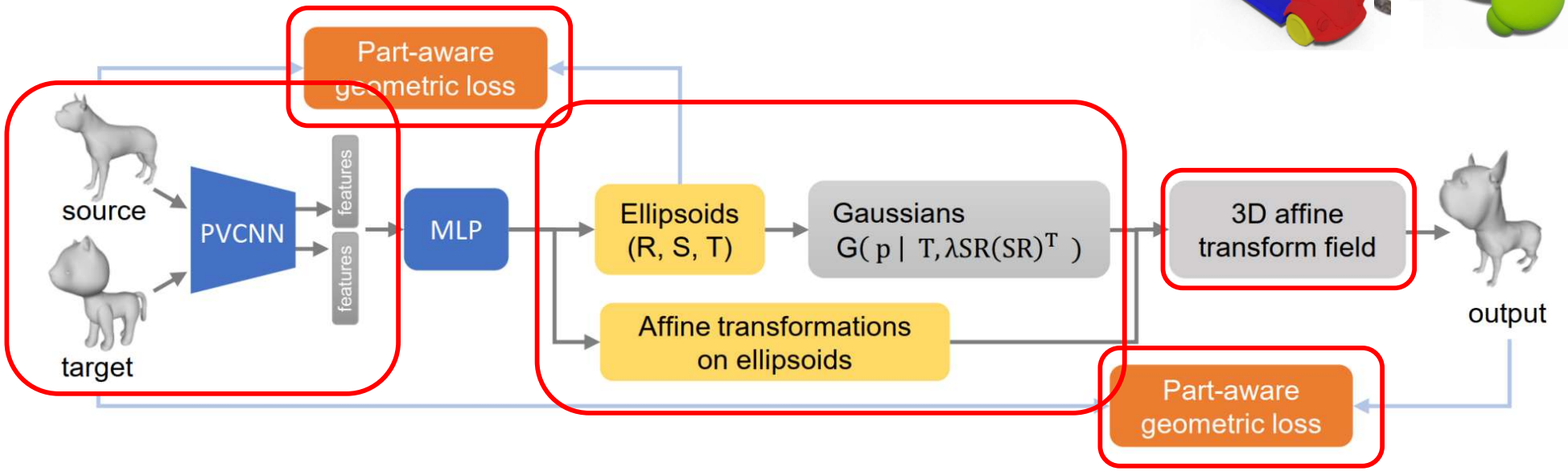


Stage 1

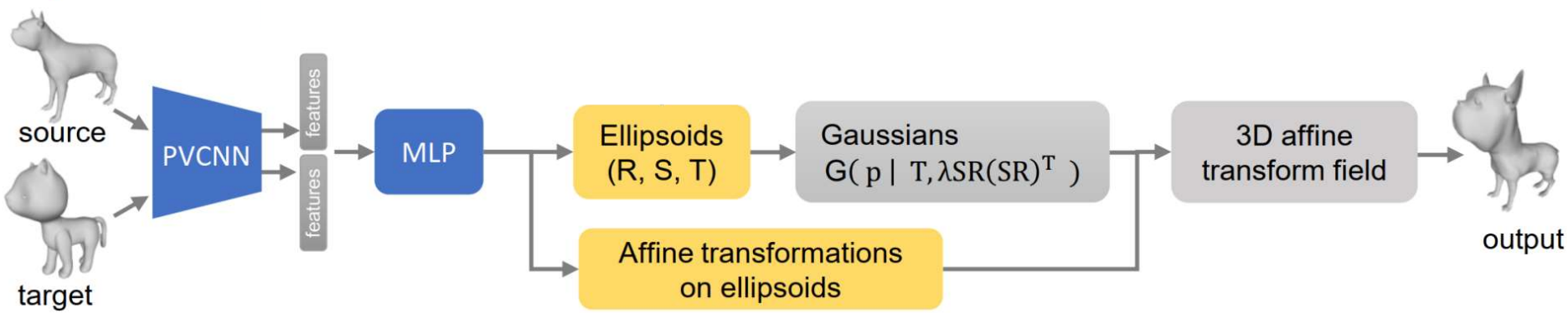
Stage 2

Geometric Style Transfer

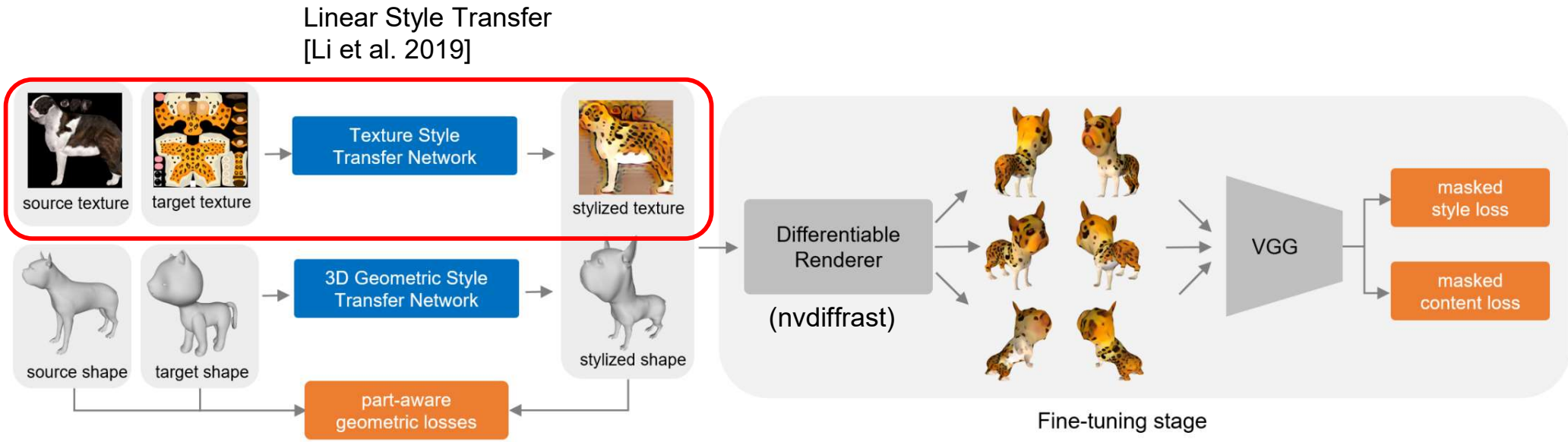




Geometric Style Transfer



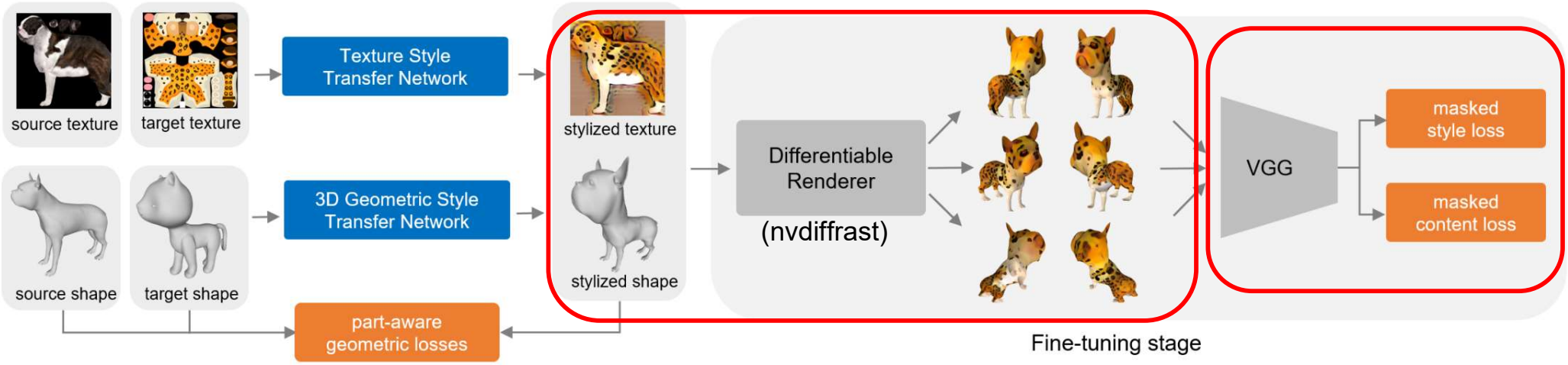
Texture Style Transfer



Stage 1

Stage 2

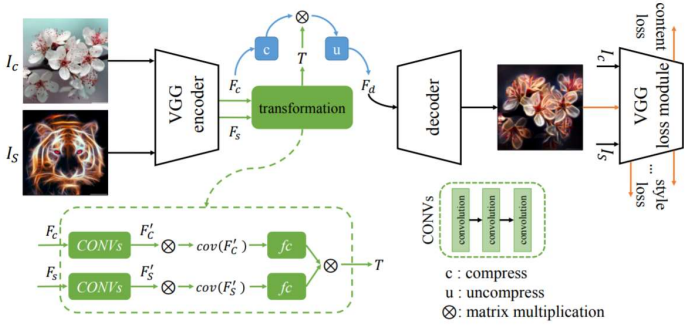
Joint Geometry and Texture Finetuning



- **20 steps**
- **10 seconds on RTX 2080Ti**

Baseline

NeuralCage [Wang et al. 2020]

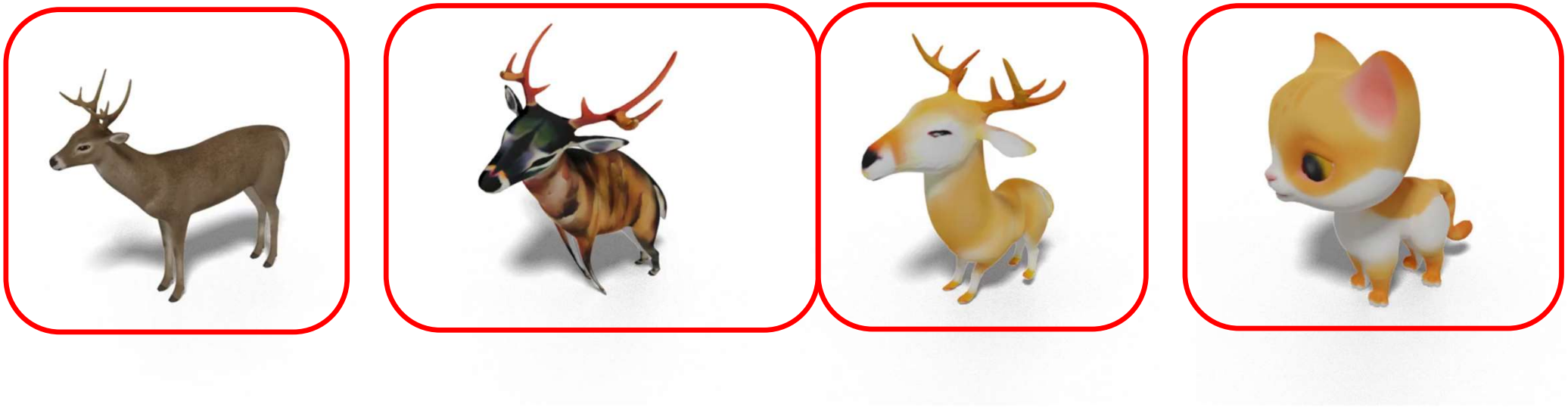


Linear Image Style Transfer [Li et al 2019]

Geometry

Texture image

Qualitative Results and Comparison



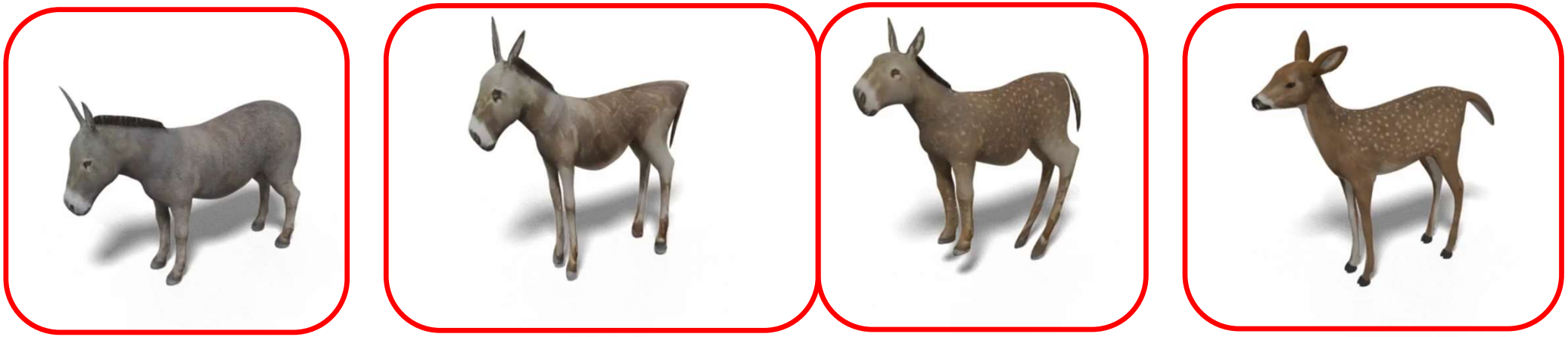
Source shape

NeuralCage [Wang et al. 2020] +
Linear Style Transfer[Li et al 2019]

Our result

Target shape

Qualitative Results and Comparison



Source shape

NeuralCage [Wang et al. 2020] +
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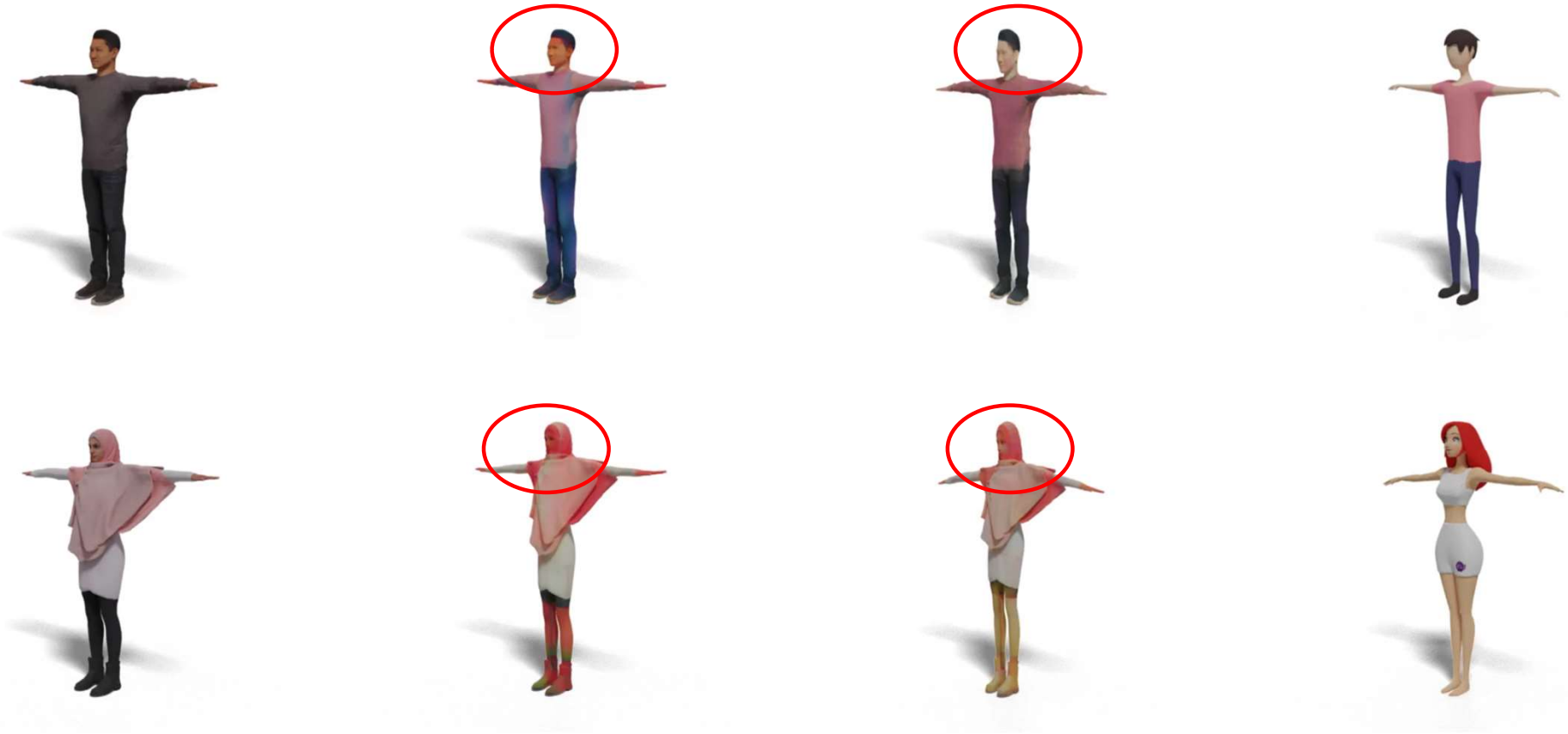
Our result

Target shape

Qualitative Results and Comparison



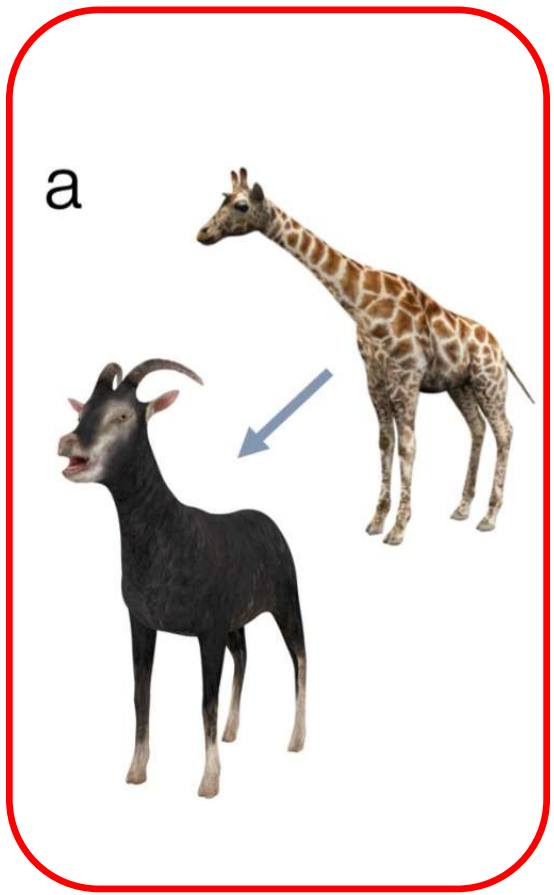
Source shape

NeuralCage [Wang et al. 2020] + Linear Style Transfer[Li et al 2019]

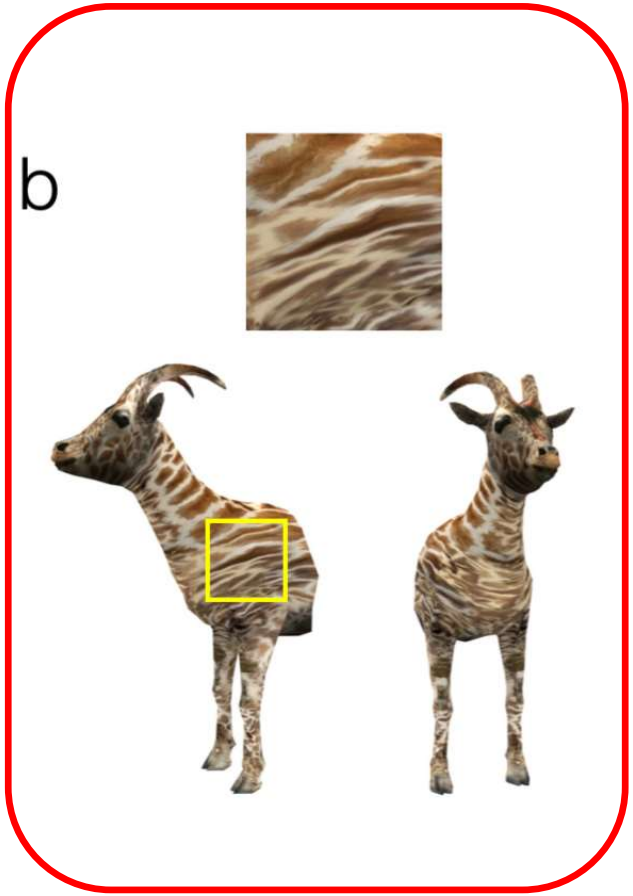
Our result

Target shape

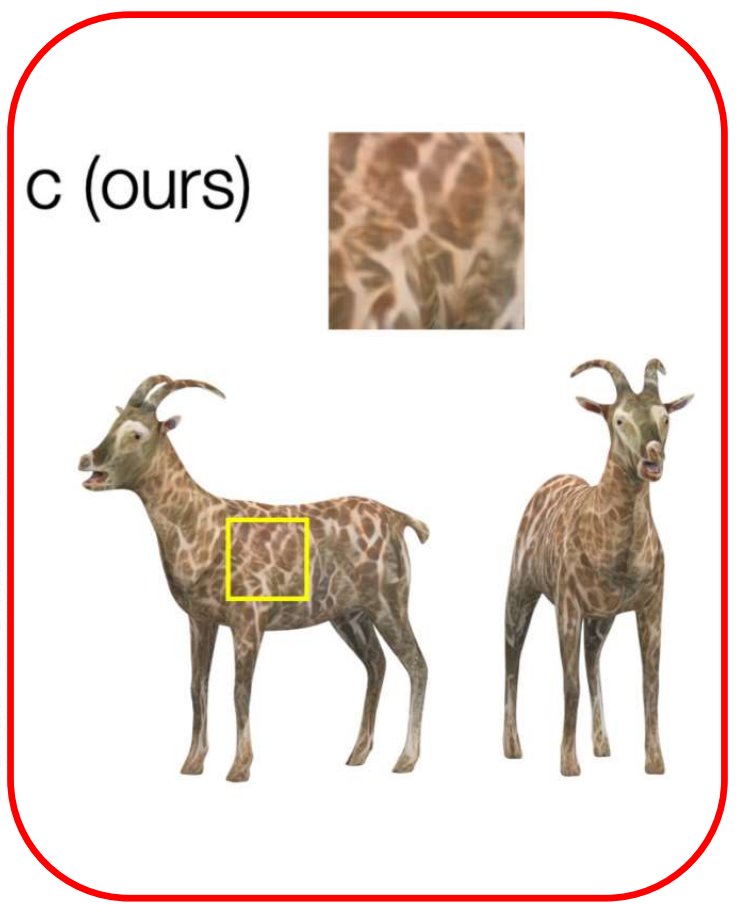
Texture Transfer for Mesh



Input

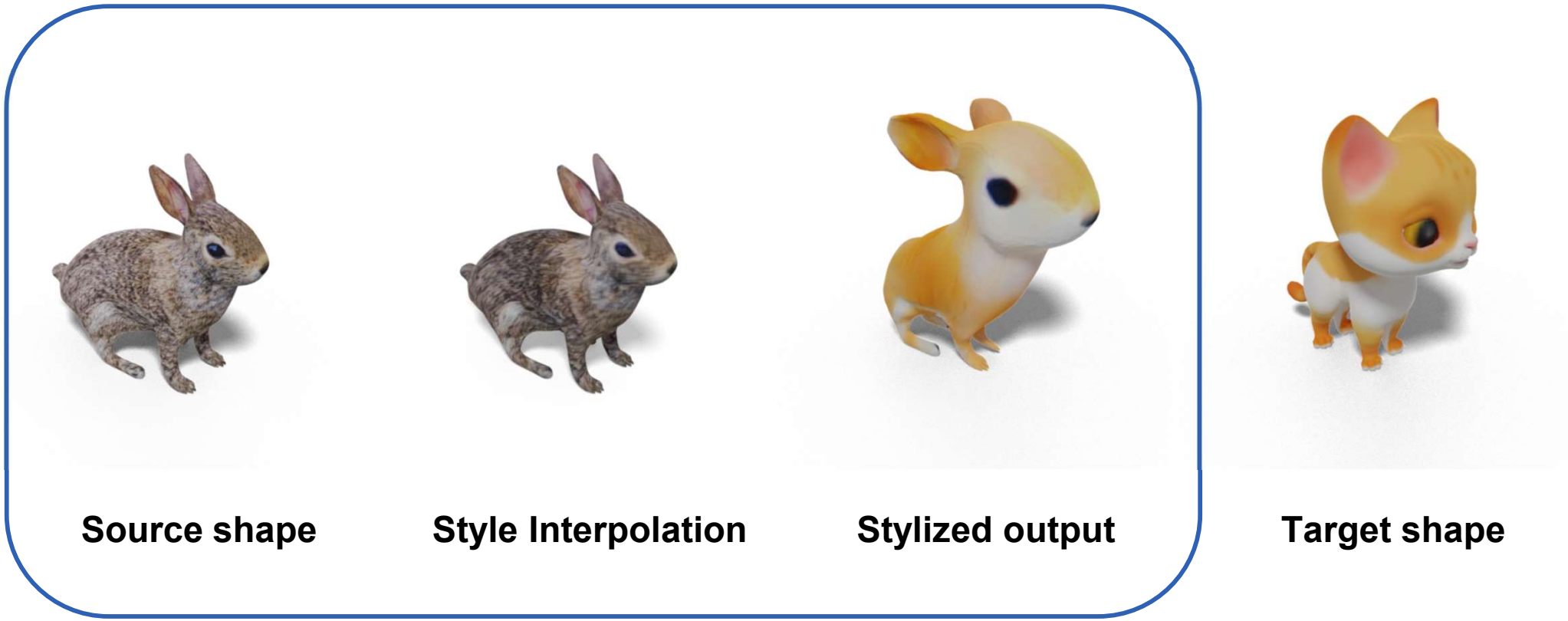


Result of
[Schmidt et al. 2019]



Our result

Linear Style Interpolation in Real-time



Source shape | Style Interpolation | Stylized output | Target shape

Linear Style Interpolation in Real-time

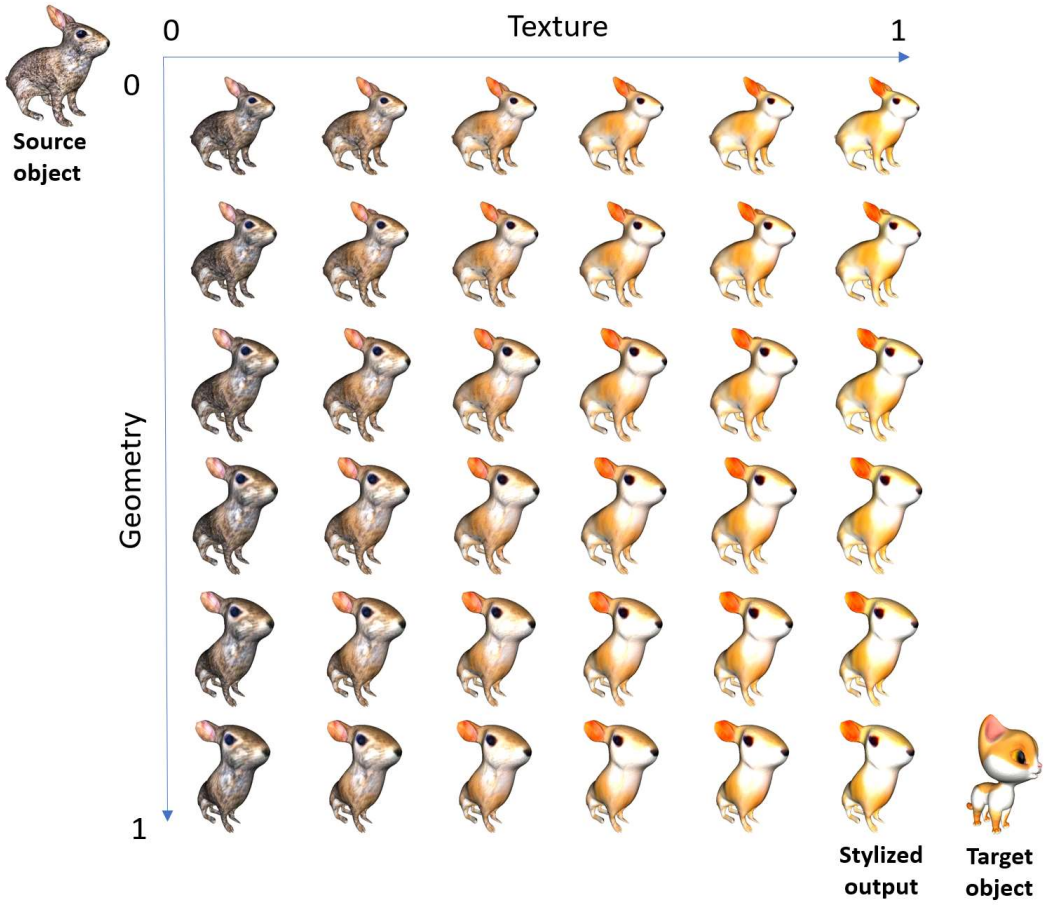
Source shape

Style Interpolation

Stylized output

Target shape

Linear Style Interpolation in Real-time



Thank you!

https://nv-tlabs.github.io/3DStyleNet/

https://nv-tlabs.github.io/DMTet/