UC San Diego

Dynamic Gaussians Mesh:

Consistent Mesh Reconstruction from Dynamic Scenes

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ICLR

Project Website

Background

Images to Static 3D Mesh

Convert 2D images into 3D mesh for ***novel view synthesis*** and ***geometric processing***.

Articulated Objects Mesh

Physical Simulation (SAPIEN)

Videos to Dynamic Mesh

Recover a dynamic mesh sequence from video input, enabling (re-)animation.

Sora Generated Video

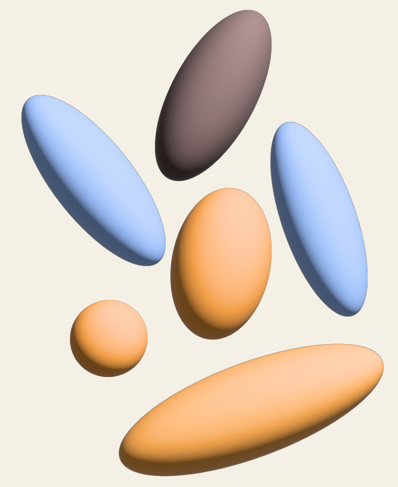
Re-Animation

(Virtual Pets: Animatable Animal Generation in 3D Scenes, 2023)

Method

Deformable 3D Gaussian Splatting

Canonical 3D Gaussians $G(x; \mu, r, s, \alpha)$: position (μ), scale (s), rotation (r), opacity (α)



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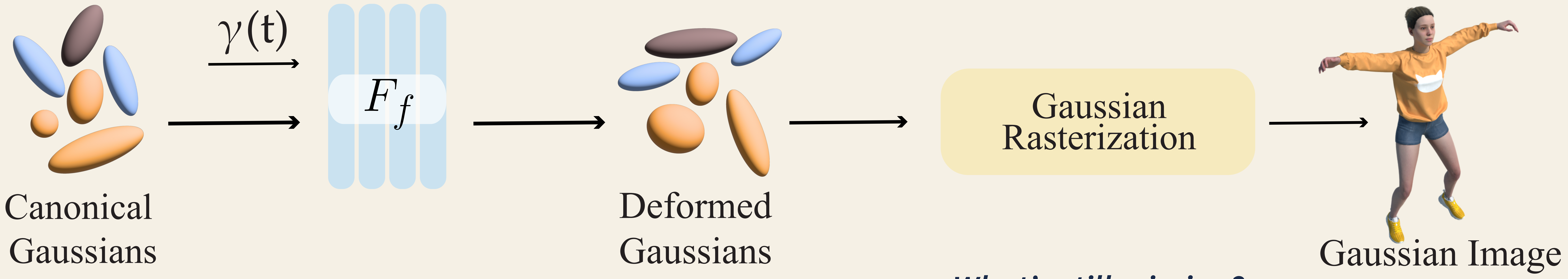
Deformable 3D Gaussian Splatting

Canonical 3D Gaussians $G(x; \mu, r, s, \alpha)$: position (μ), scale (s), rotation (r), opacity (α)

Deformation $\mathscr{F}(\gamma(x), \gamma(t)) = (\delta x, \delta r, \delta s, \delta \alpha)$

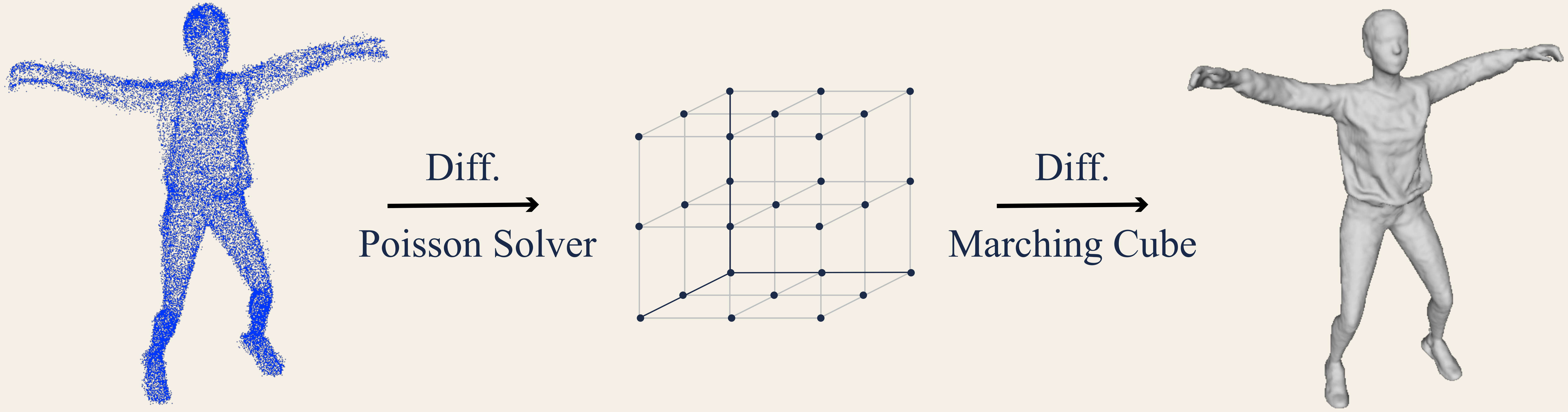


What's still missing?

Surface!

Point to Surface

Recover topology from oriented Gaussian points in differentiable manner.



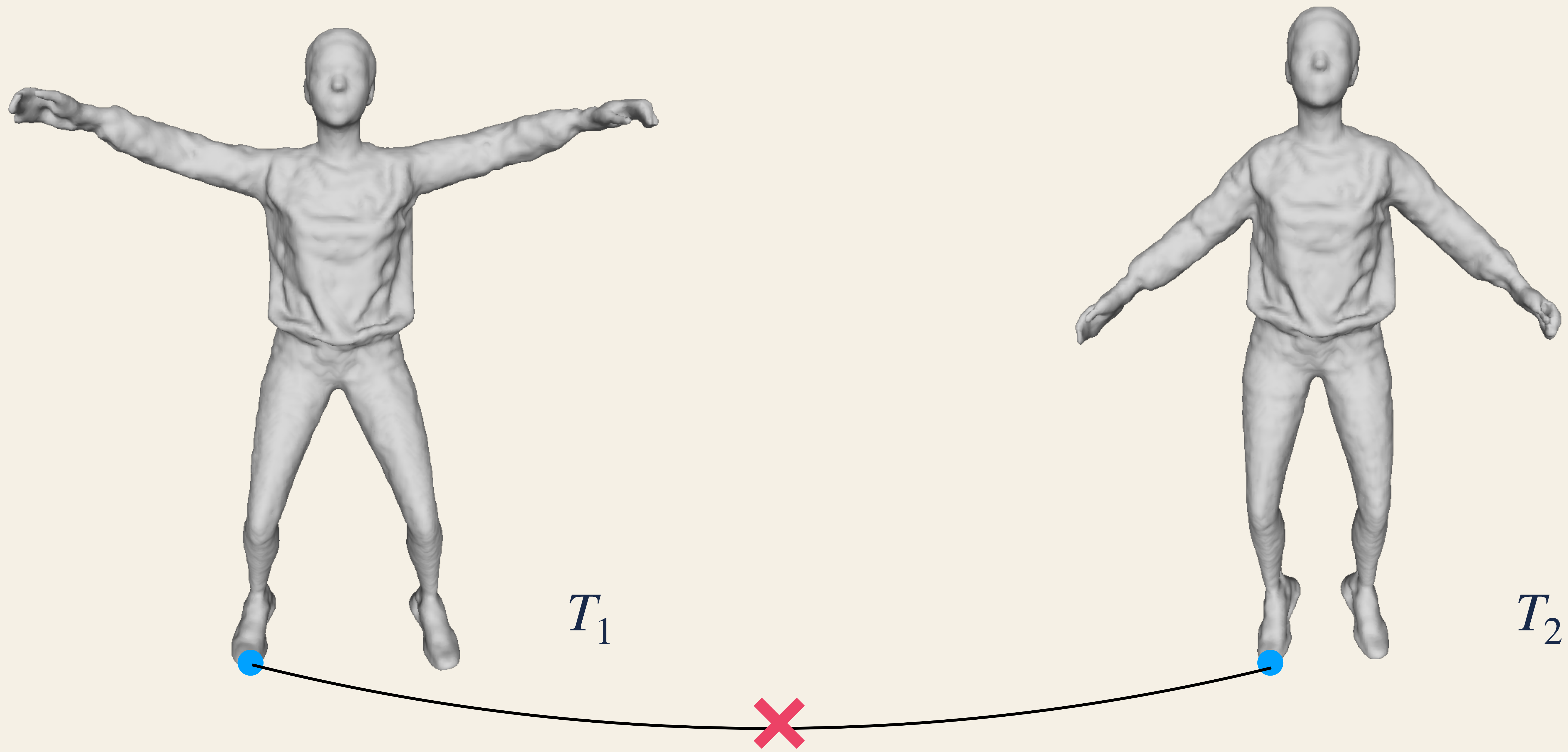
Deformed Gaussian Centers

What's still missing? Mesh

Building Correspondence

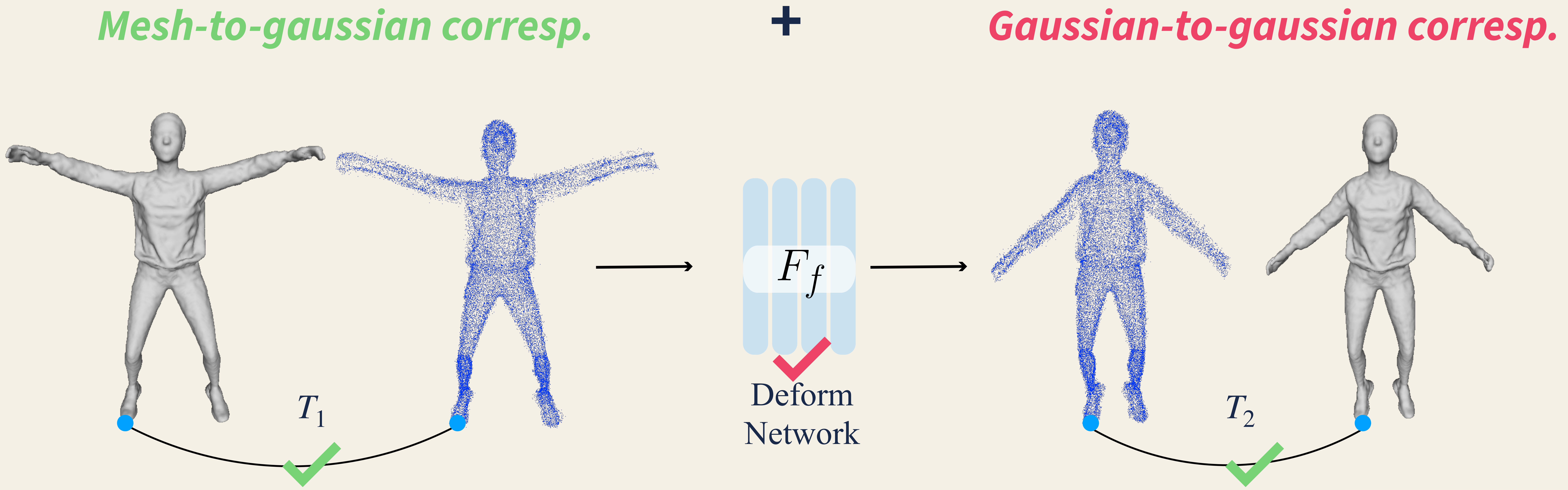
Temporal meshes are recovered independently.

How to obtain the ***mesh-to-mesh correspondence***?



Building Correspondence

Decompose the ***mesh-to-mesh correspondence*** into:



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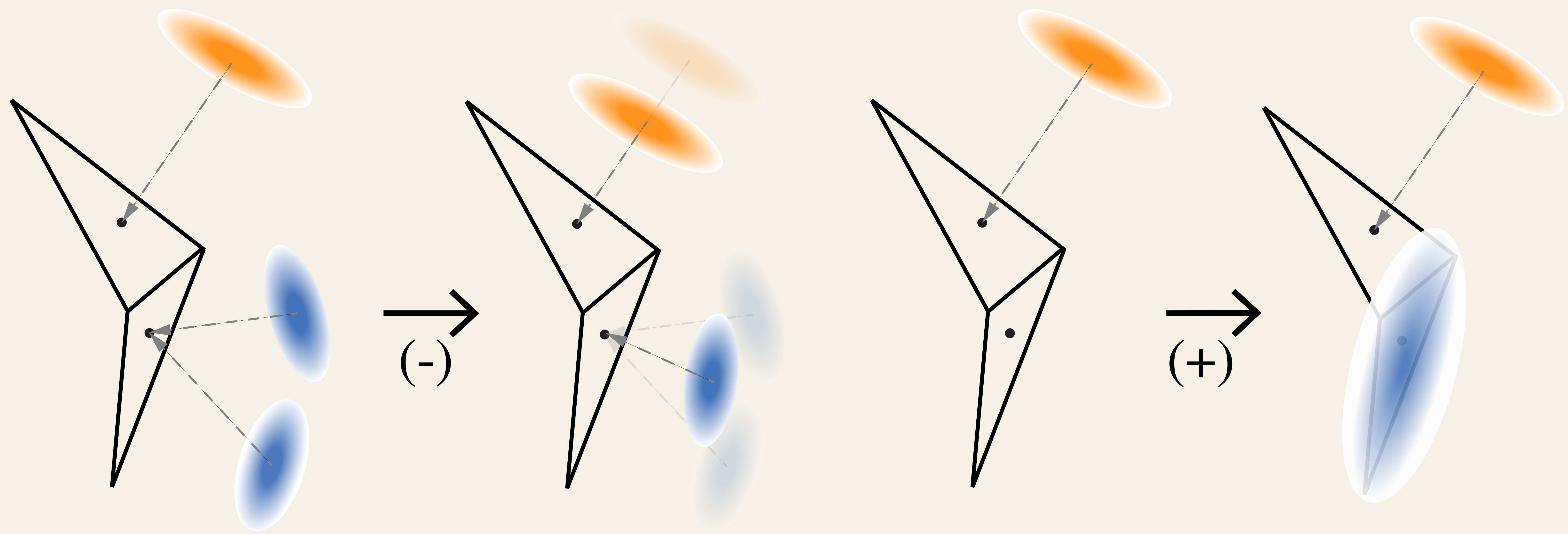
Gaussian-Mesh Anchoring

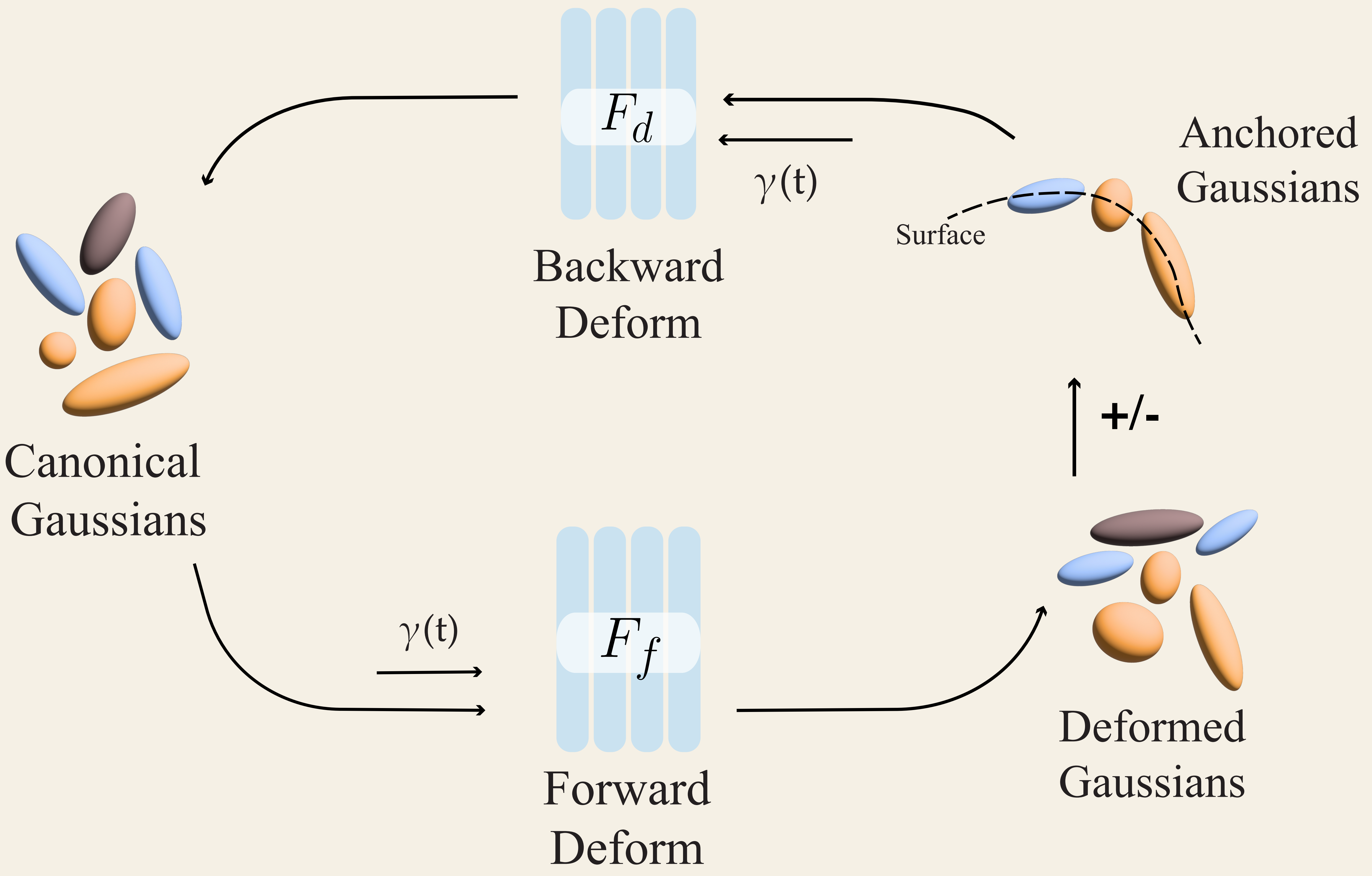
Encourage the ***one-to-one correspondence*** between mesh and Gaussian points.

Align the deformed Gaussians to the mesh faces.

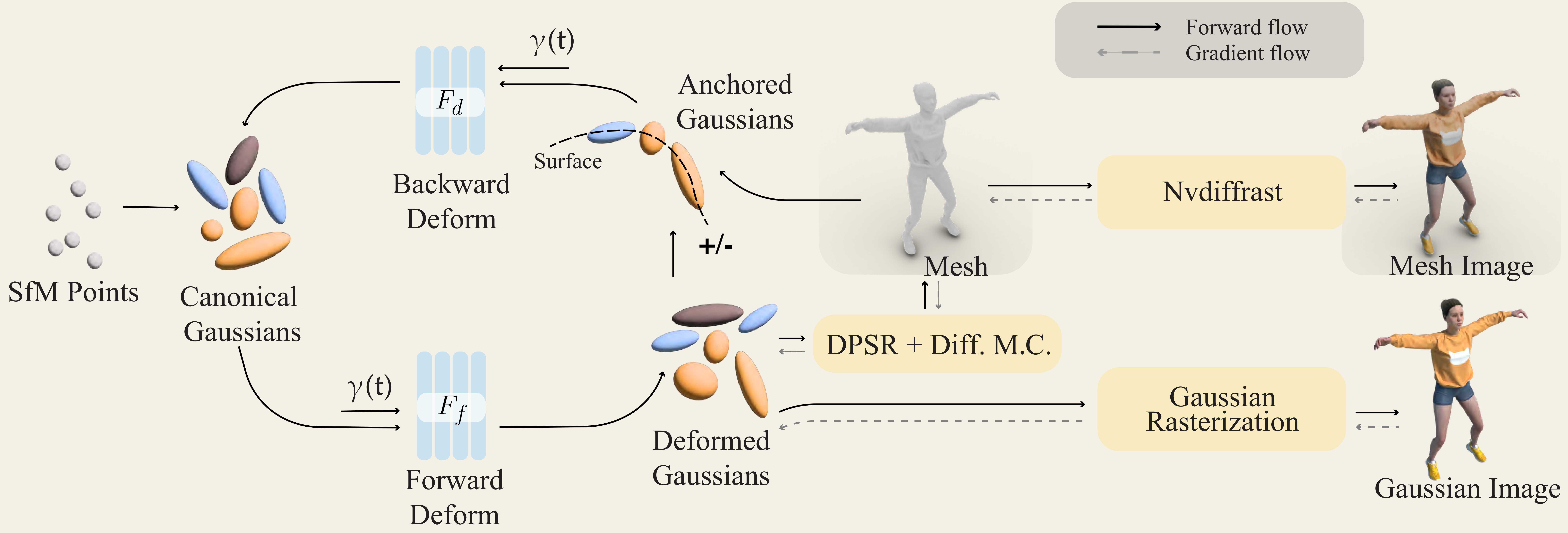


Cycle-Consistent Deformation

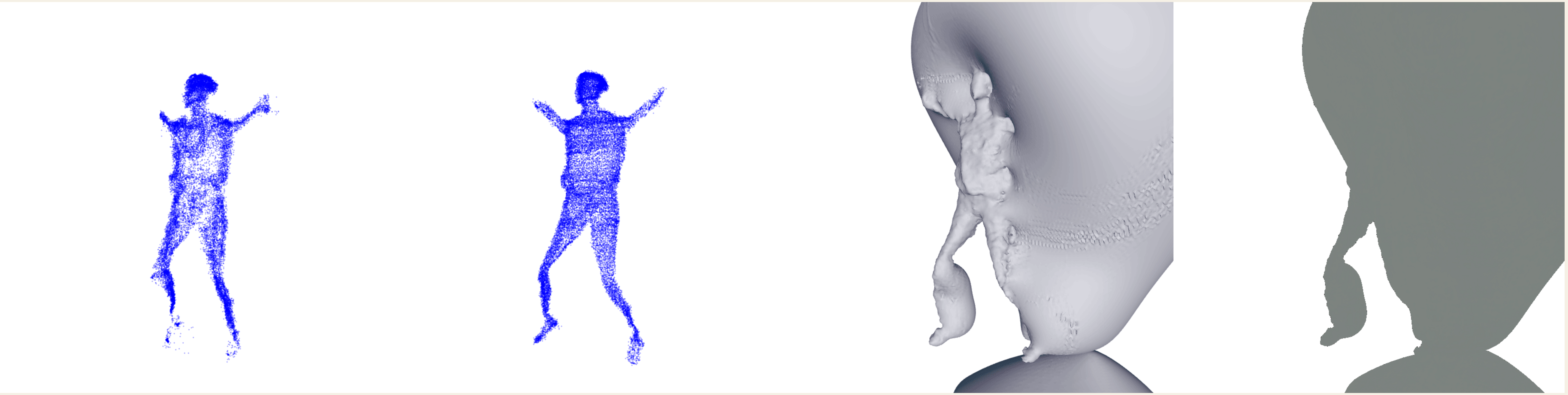
Update the ***canonical Gaussians*** to accommodate the ***anchored Gaussians***.



Overall Pipeline



Training Process Visualization



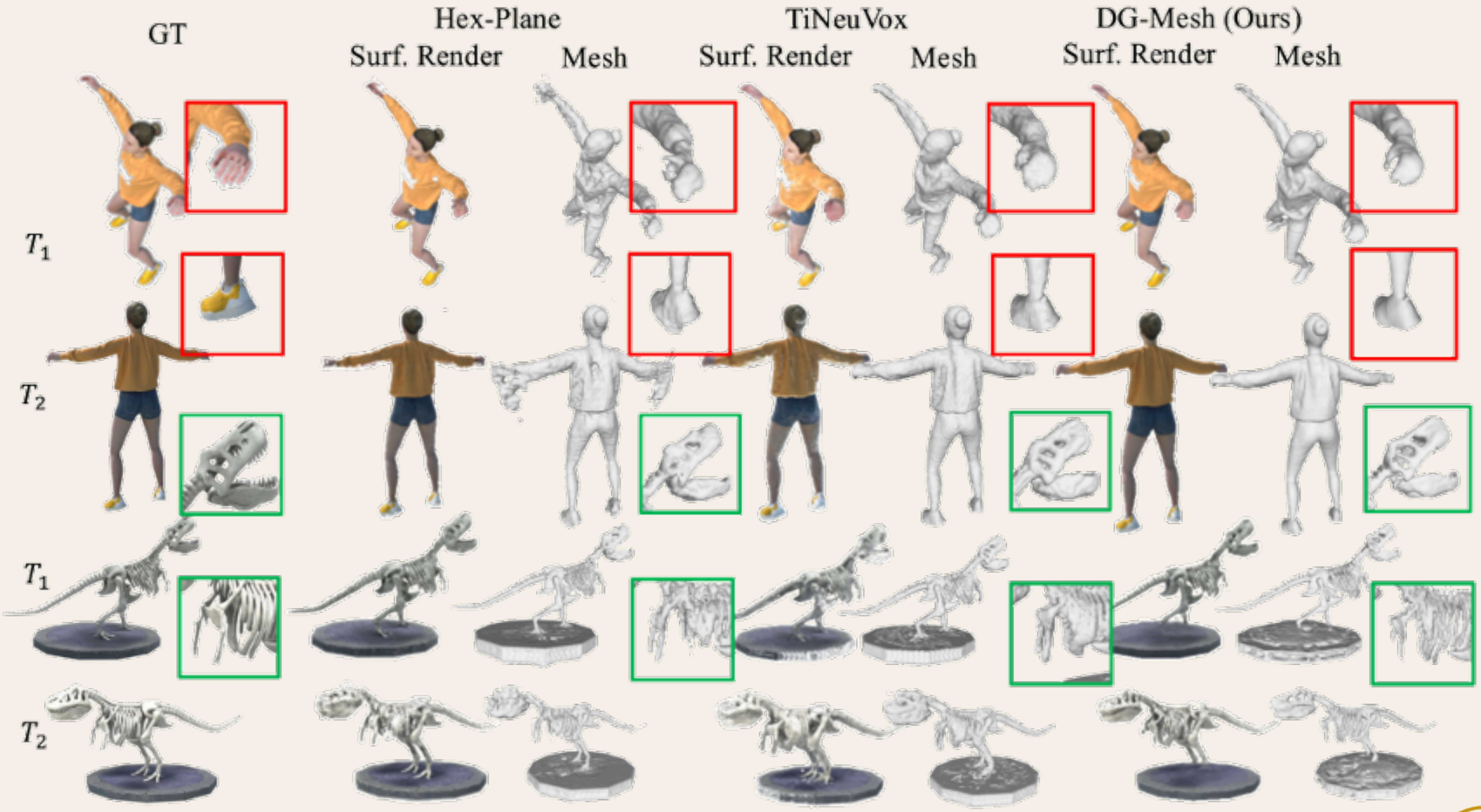
4D GS Center | Anchored GS Center | Mesh | Mesh Rendering

Results

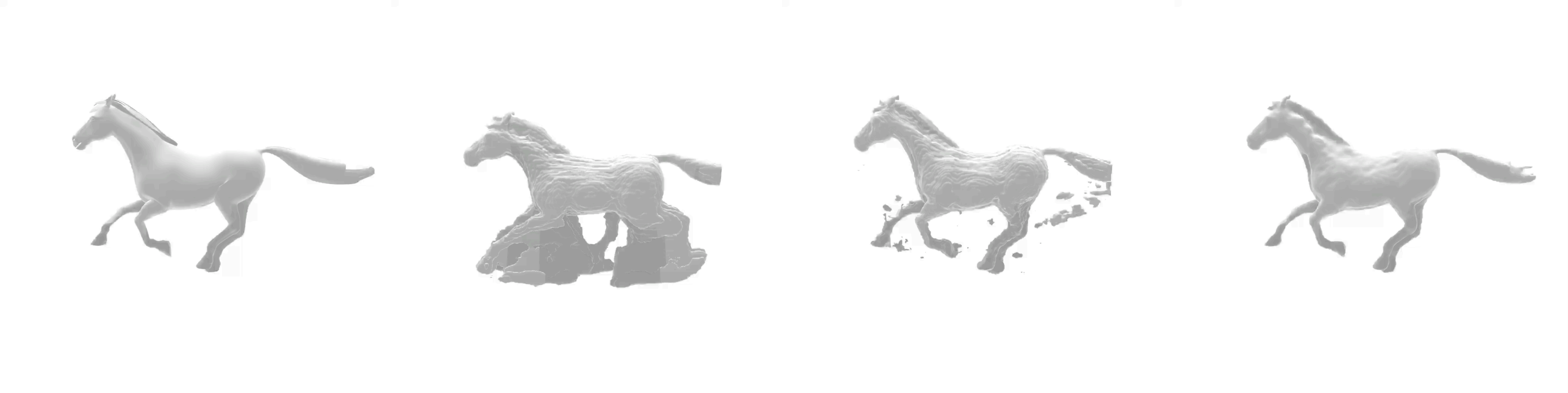
Qualitative Results on D-NeRF Dataset

Mesh Rendering | Mesh | Anchored Gaussians | Mesh Rendering | Mesh | Anchored Gaussians

Qualitative Results on D-NeRF Dataset

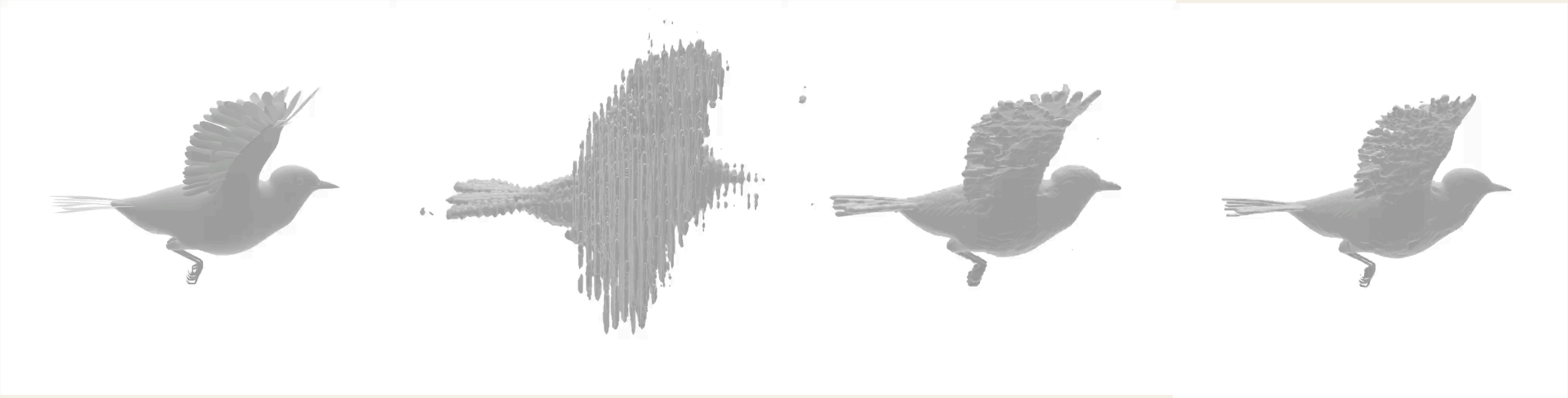


Qualitative Results on DG-Mesh Dataset



GT D-NeRF TiNeuVox **DG-Mesh (Ours)**

Qualitative Results on DG-Mesh Dataset



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D-NeRF

TiNeuVox

DG-Mesh (Ours)

Quantitative Results on DG-Mesh Dataset

Method	Corresp.	Duck				Horse				Bird			
		CD ↓	EMD ↓	PSNR ↑	PSNR_m ↑	CD ↓	EMD ↓	PSNR ↑	PSNR_m ↑	CD ↓	EMD ↓	PSNR ↑	PSNR_m ↑
D-NeRF	✗	0.934	0.073	29.785	23.019	1.685	0.280	25.474	17.381	1.532	0.163	23.848	19.573
K-Plane	✗	1.085	0.055	33.360	20.372	1.480	0.239	28.111	21.629	0.742	0.131	23.722	19.559
HexPlane	✗	2.161	0.090	32.108	27.945	1.750	0.199	26.779	22.395	4.158	0.178	22.189	20.595
TiNeuVox-B	✗	0.969	0.059	34.326	22.073	1.918	0.246	28.161	18.156	8.264	0.215	25.546	19.844
4DGS	✗	1.134	0.111	37.127	-	1.500	0.272	29.185	-	2.311	0.187	23.834	-
Deformable-GS	✗	2.366	0.115	34.187	-	1.510	0.217	30.280	-	1.358	0.141	25.095	-
DG-Mesh	✓	0.790	0.047	-	32.890	0.299	0.168	-	27.098	0.557	0.128	-	22.977

Method	Corresp.	Beagle				Torus2sphere				Girlwalk			
		CD ↓	EMD ↓	PSNR ↑	PSNR_m ↑	CD ↓	EMD ↓	PSNR ↑	PSNR_m ↑	CD ↓	EMD ↓	PSNR ↑	PSNR_m ↑
D-NeRF	✗	1.001	0.149	34.470	24.446	1.760	0.250	24.227	13.562	0.601	0.190	28.632	21.146
K-Plane	✗	0.810	0.122	38.329	24.613	1.793	0.161	31.215	15.706	0.495	0.173	32.116	23.008
HexPlane	✗	0.870	0.115	38.034	29.970	2.190	0.190	29.714	22.350	0.597	0.155	31.771	24.214
TiNeuVox-B	✗	0.874	0.129	38.972	25.773	2.115	0.203	28.756	14.985	0.568	0.184	32.806	20.207
4DGS	✗	0.644	0.106	42.995	-	2.188	0.261	28.329	-	0.596	0.315	33.430	-
Deformable-GS	✗	1.154	0.161	42.530	-	2.210	0.248	28.274	-	1.103	0.183	34.157	-
DG-Mesh	✓	0.639	0.117	-	34.518	1.607	0.172	-	26.605	0.726	0.136	-	28.643

Quantitative Results on D-NeRF Dataset

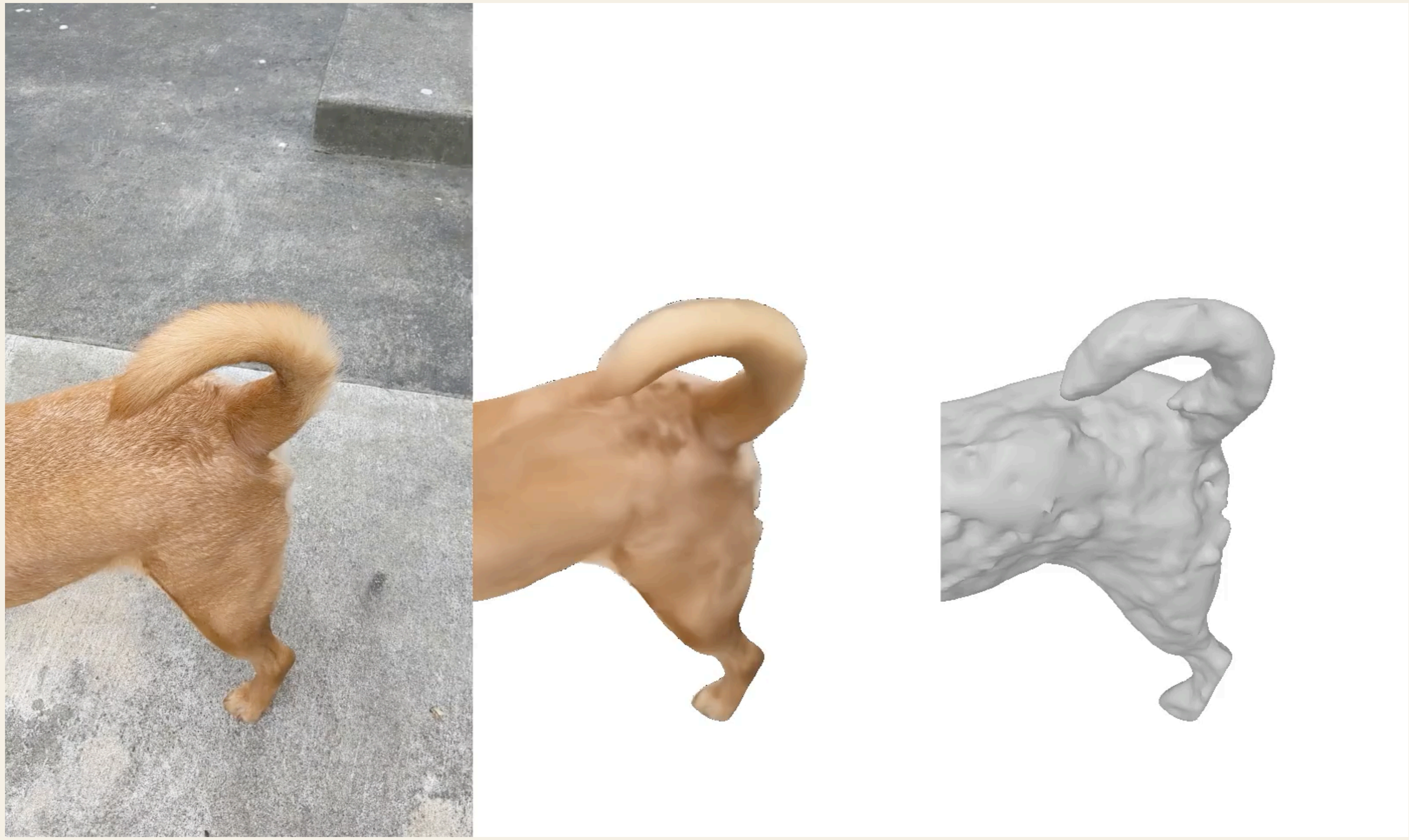
Method	Lego			Bouncingballs			Jumpingjacks			Hook		
	$PSNR_m \uparrow$	SSIM $\uparrow$	LPIPS $\downarrow$	$PSNR_m \uparrow$	SSIM $\uparrow$	LPIPS $\downarrow$	$PSNR_m \uparrow$	SSIM $\uparrow$	LPIPS $\downarrow$	$PSNR_m \uparrow$	SSIM $\uparrow$	LPIPS $\downarrow$
D-NeRF	20.384	0.818	0.137	23.398	0.899	0.157	22.255	0.914	0.103	20.300	0.889	0.108
K-Plane	19.523	0.828	0.127	23.307	0.935	0.109	25.240	0.937	0.068	22.503	0.900	0.094
HexPlane	22.872	0.904	0.072	25.389	0.957	0.069	27.078	0.954	0.052	24.513	0.929	0.070
TiNeuVox-B	21.927	0.843	0.126	24.819	0.947	0.101	23.621	0.932	0.075	21.429	0.908	0.085
DG-Mesh	21.289	0.838	0.159	29.145	0.969	0.099	31.769	0.977	0.045	27.884	0.954	0.074

Method	Mutant			Standup			Trex			Hellwarrior		
	$PSNR_m \uparrow$	SSIM $\uparrow$	LPIPS $\downarrow$	$PSNR_m \uparrow$	SSIM $\uparrow$	LPIPS $\downarrow$	$PSNR_m \uparrow$	SSIM $\uparrow$	LPIPS $\downarrow$	$PSNR_m \uparrow$	SSIM $\uparrow$	LPIPS $\downarrow$
D-NeRF	21.070	0.906	0.077	23.380	0.925	0.069	22.594	0.908	0.085	18.907	0.877	0.129
K-Plane	23.226	0.923	0.064	25.778	0.946	0.048	23.093	0.921	0.075	18.073	0.881	0.123
HexPlane	26.811	0.953	0.045	27.931	0.965	0.035	26.629	0.953	0.046	21.250	0.917	0.094
TiNeuVox-B	22.967	0.925	0.064	24.263	0.941	0.051	24.219	0.927	0.070	18.657	0.883	0.118
DG-Mesh	30.400	0.968	0.055	30.208	0.974	0.051	28.951	0.959	0.065	25.460	0.959	0.084

Qualitative Results on Nerfies Dataset

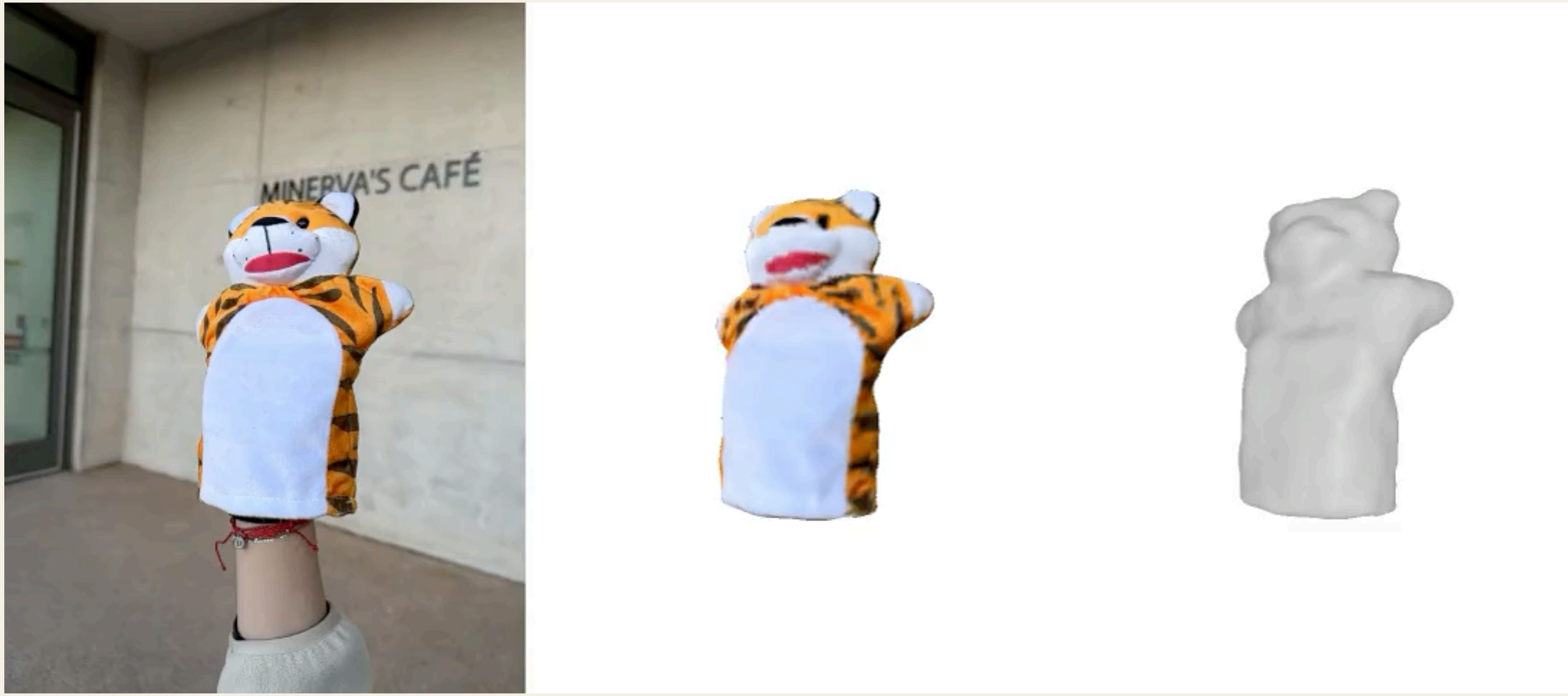
GT Mesh Rendering Mesh

Qualitative Results on Nerfies Dataset



GT Mesh Rendering Mesh

Qualitative Results on Monocular Videos



GT　　Mesh Rendering　　Mesh

Qualitative Results on Monocular Videos

GT Mesh Rendering Mesh

Applications

Conclusions

Conclusions

- DG-Mesh propose high-fidelity mesh reconstruction and motion tracking from monocular dynamic inputs.
- Decompose mesh tracking into Gaussian-Mesh and Gaussian-Gaussian links.
- Build Gaussian-Mesh correspondence through ***Gaussian-Mesh Anchoring***.
- Build Gaussian-Gaussian correspondence through ***Cycle-Consistent Deformation***.
- Supports various applications like dynamic content editing.

Thanks