NeRF for Robotics

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Contents

NeRF

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Task: 3D Reconstruction from 2D Images

Method: Optimize 3D(MLP) with Ground Truth 2D Images

3D Representation(MLP) → 2D Image → Loss(rendered_img, GT)

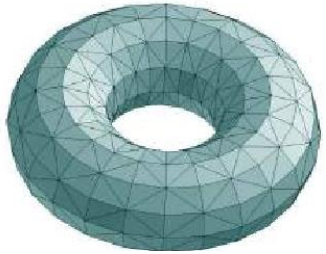
NeRF

Donut

NeRF

Donut

Explicit



Mesh:

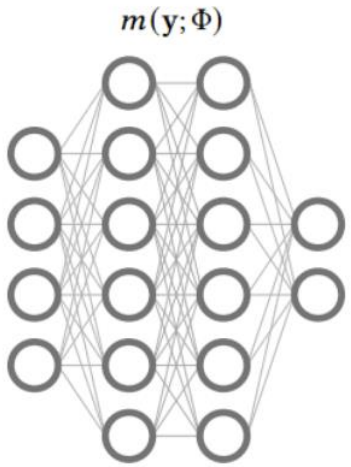
Points of triangles

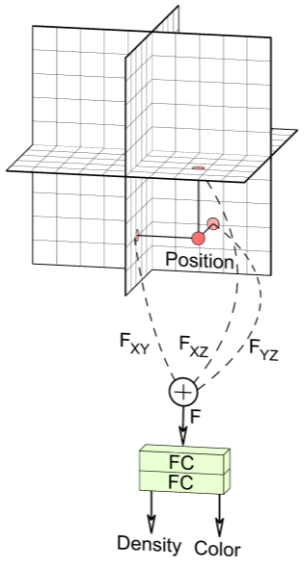
Implicit

$$(R - \sqrt{x^2 + y^2})^2 + z^2 = r^2$$

NeRF

3D Representation

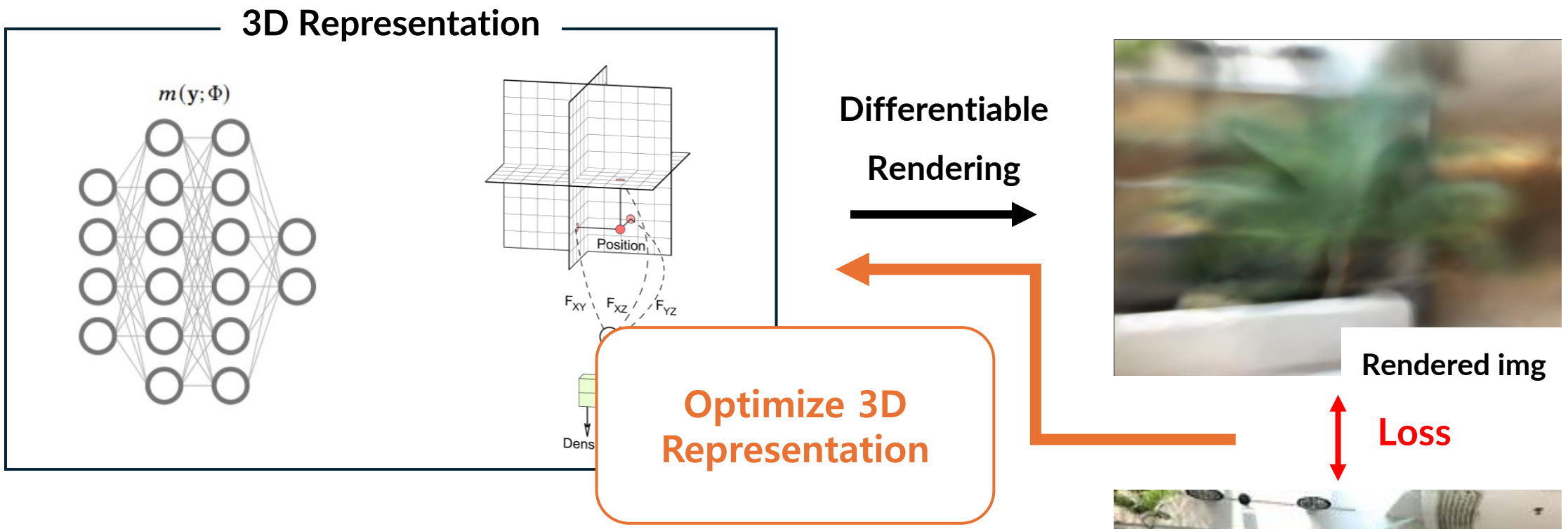




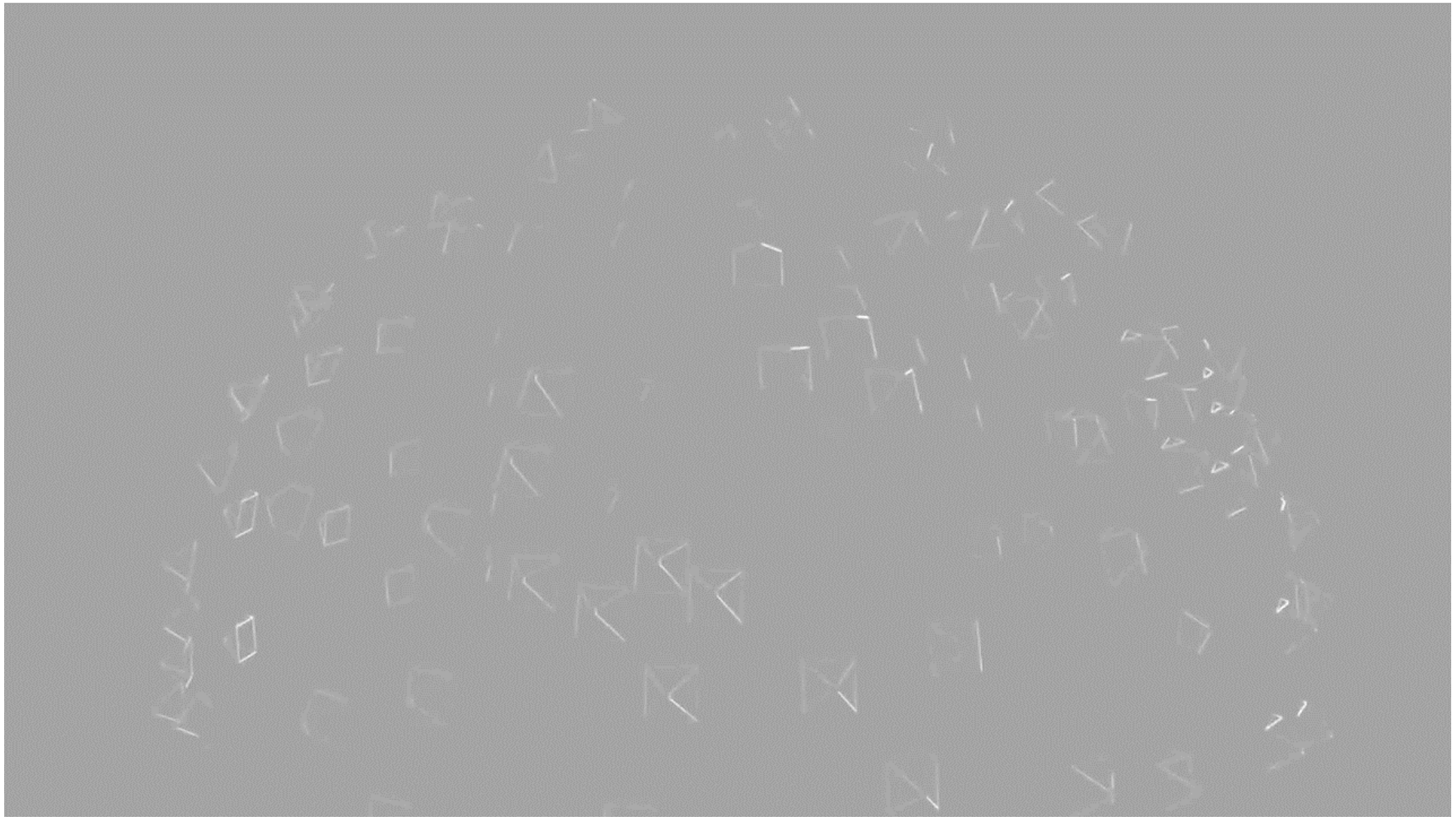
Differentiable Rendering

Rendered img

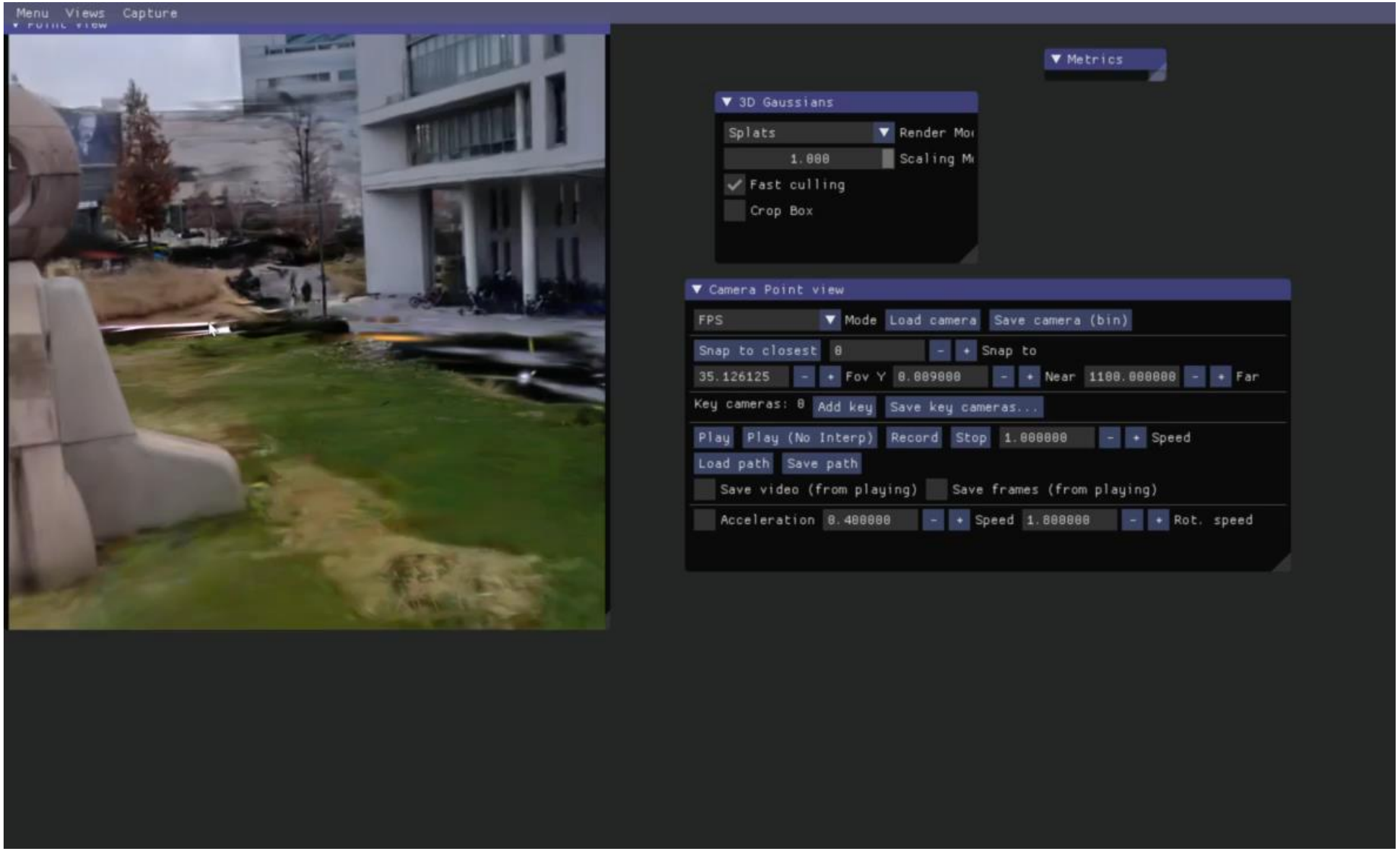
NeRF


3D Representation
$m(\mathbf{y};\Phi)$
Position
F_{XY}
F_{XZ}
F_{YZ}
Dens
Differentiable
Rendering
Optimize 3D
Representation
Rendered img
Loss
Ground truth

NeRF

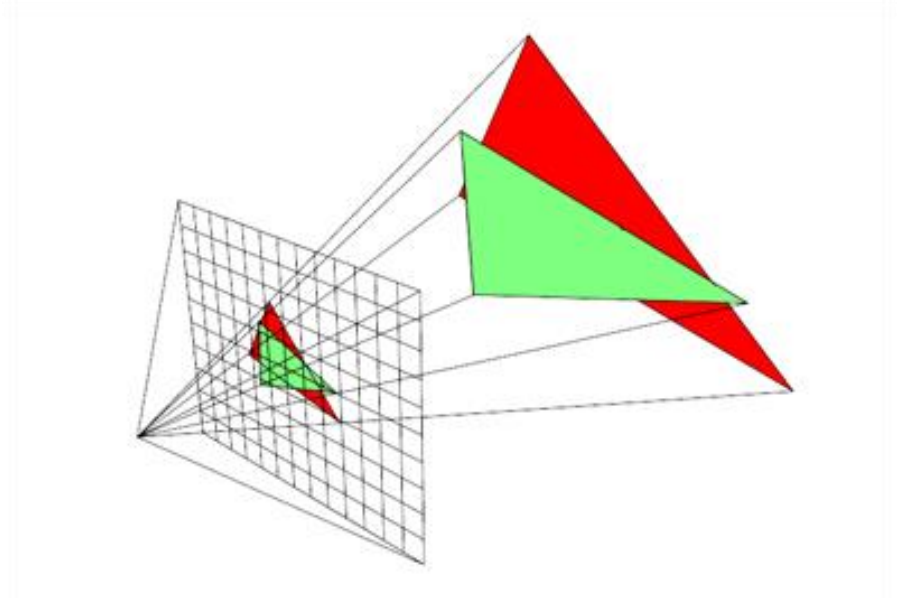


3D Gaussian Splatting



3D Gaussian Splatting

- No Neural Network, Only Point Clouds
- No Ray, Rasterization-based



Advantages

- **Fast Rendering (Real-time Rendering)**
- Fast Training
- High Quality (not best)
- Easier Code

Limitations

- Large Memory
- Splotchy Artifacts

What is this ‘NeRF’ for?

Obviously…

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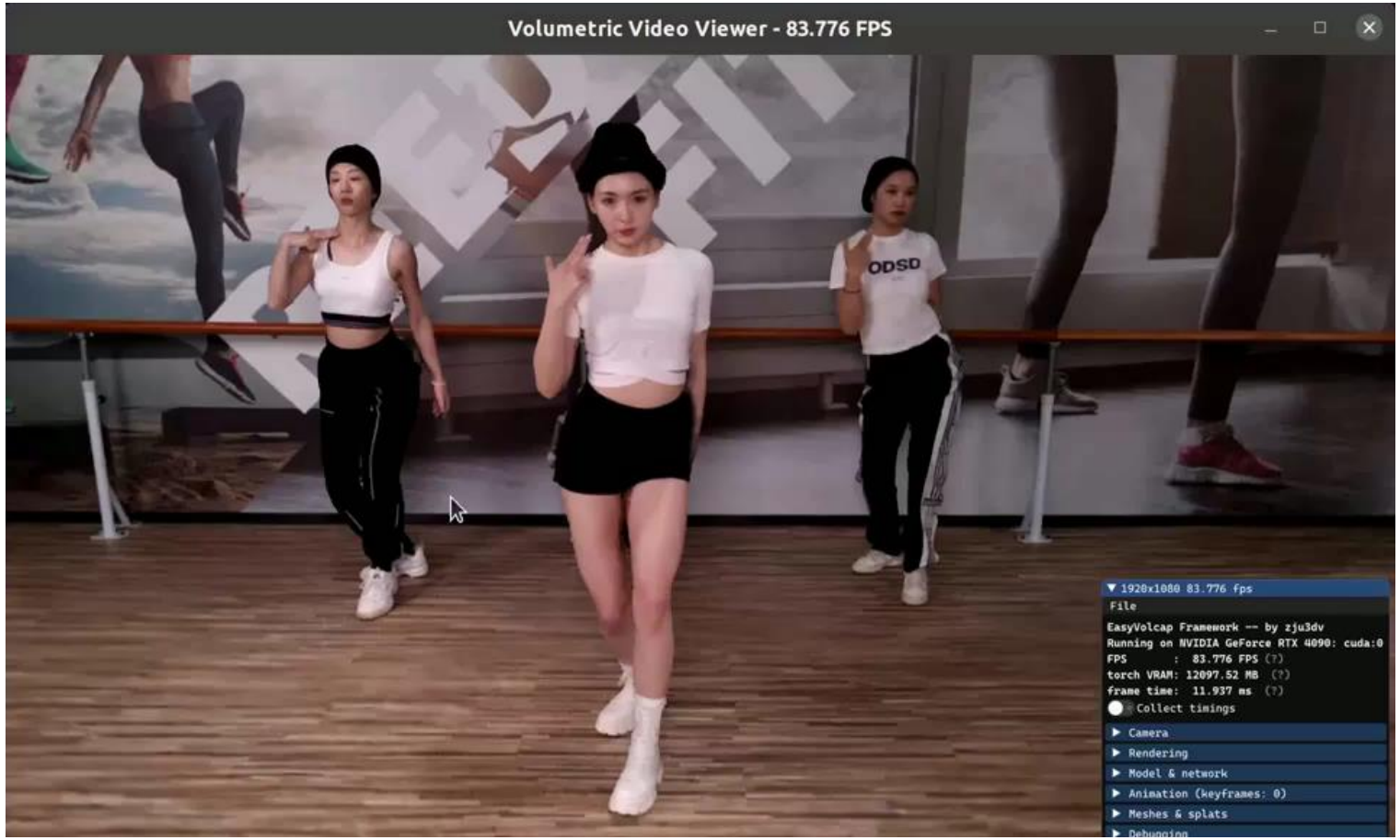
Obviously… Entertainment! VR/AR! Metaverse!



4K4D: Real-Time 4D View Synthesis at 4K Resolution

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https://radiancefields.com/gmix-ai-dynamic-gaussian-splatting/

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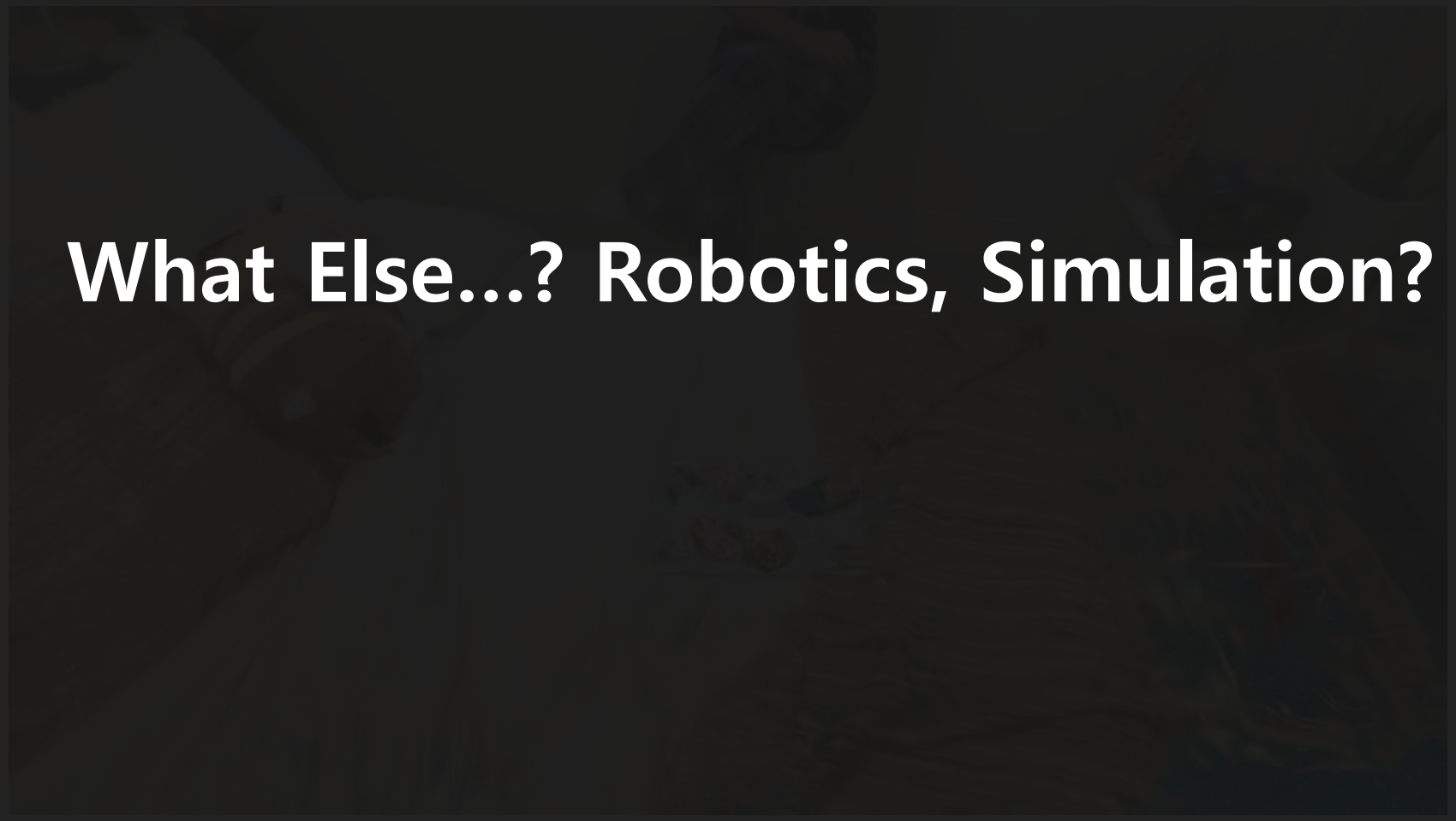
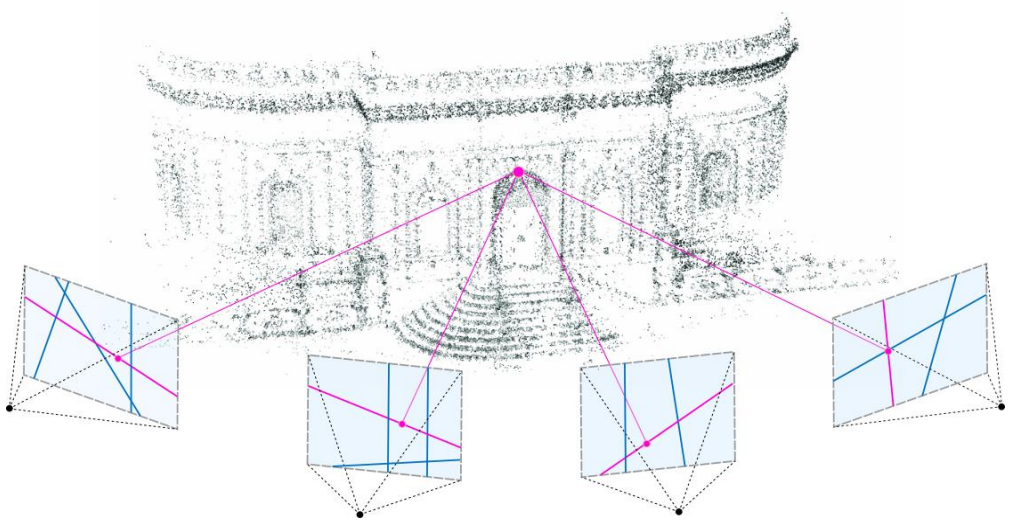


https://radiancefields.com/gmix-ai-dynamic-gaussian-splatting/

What is NeRF Doing?

3D Reconstruction = ‘Understanding 3D Space/Object’

What’s different from conventional 3D Reconstruction? ➔ Photo-Realism..!



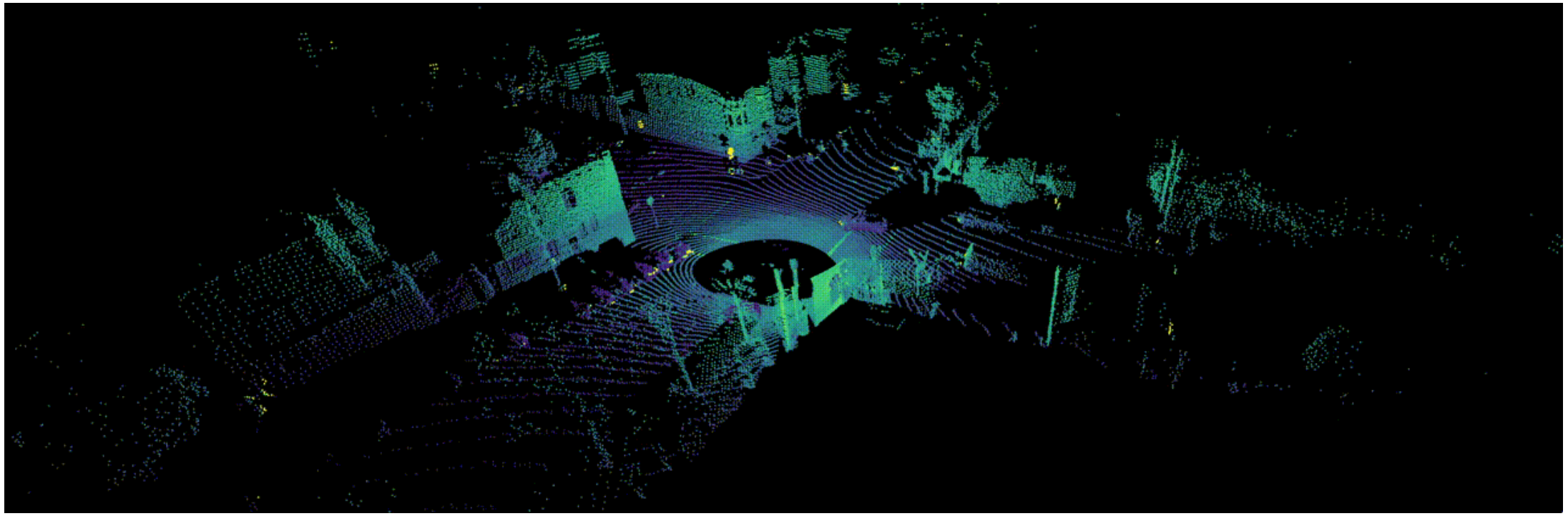
Structure-from-Motion

VS

NeRF

What is NeRF Doing?

Conventional 3D Recon → Focused on Geometry…! (Different Purpose)

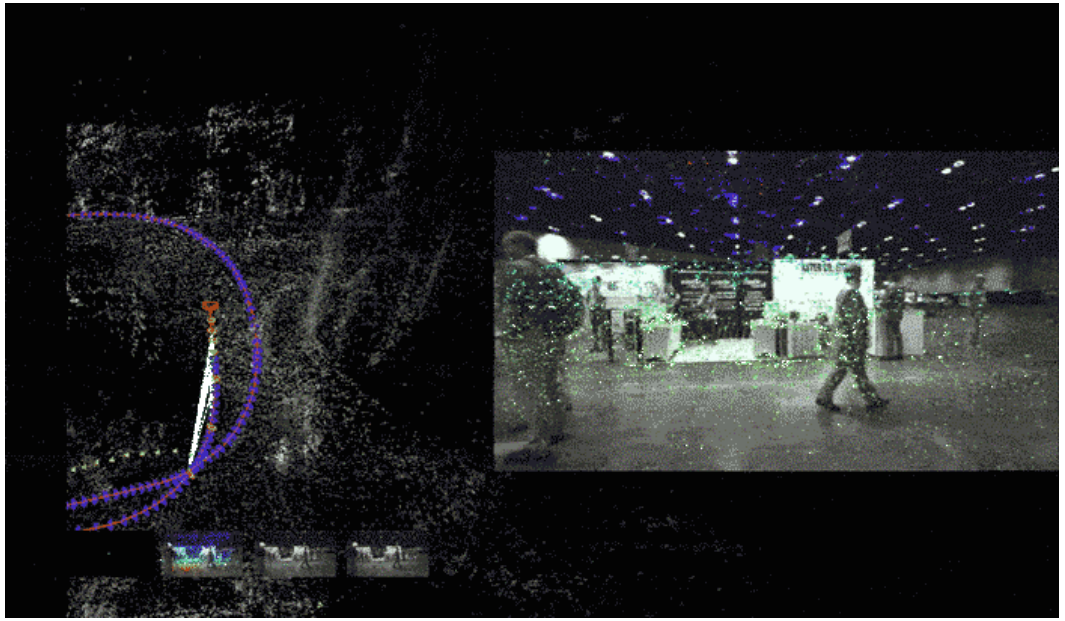


SLAM

What is NeRF Doing?

Conventional 3D Recon → Focused on Geometry…!

While NeRF task aims Complete Reconstruction (both Photo-realism & Geometry)



SLAM

NeRF Task

NeRF for Robotics

Is NeRF ‘too much’ for Robotics?

=

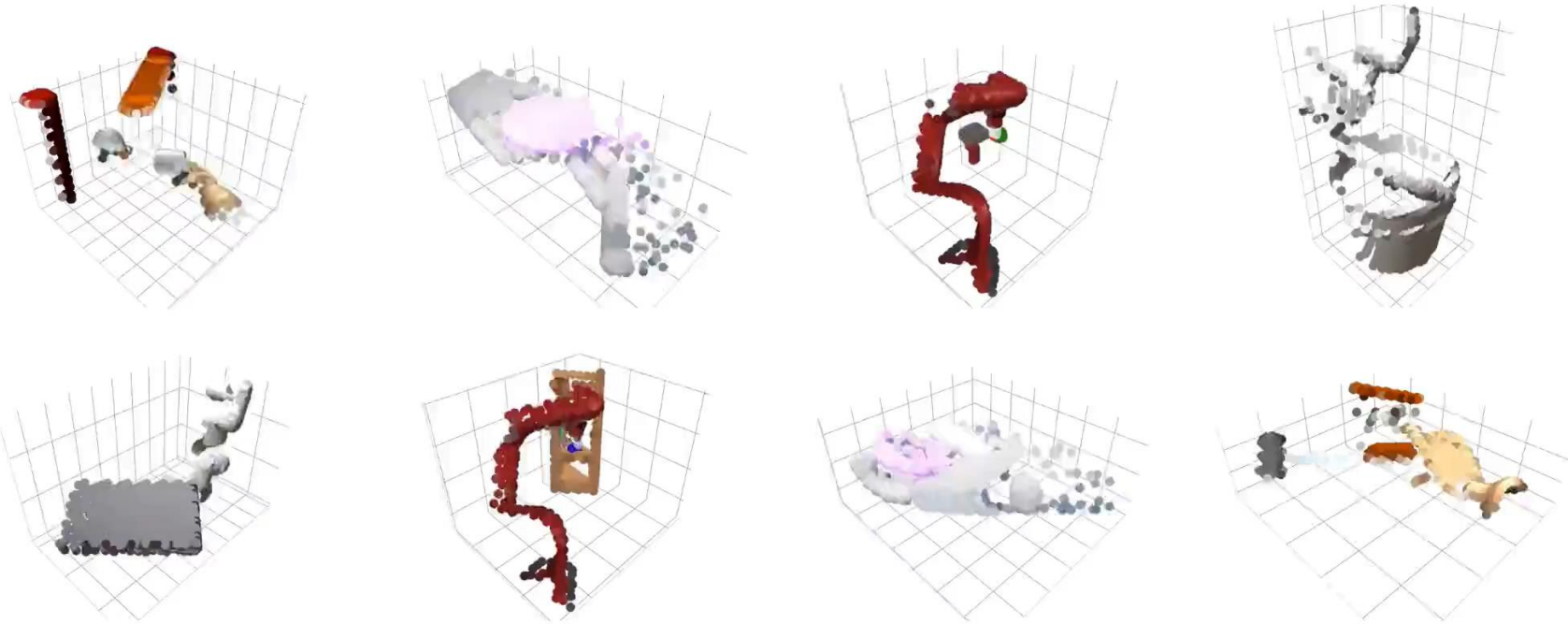
Full-3D is Expensive, Is it worth it?

NeRF for Robotics

1. Coarse 3D Information

- Robotic Tasks might not require photorealistic 3D information
- 3D Diffusion Policy (24 arxiv)

  - Abstract Point Cloud Conditioned Diffusion



NeRF for Robotics

2. Abstarct NeRF

- More fine-grained information
- GNFactor (CoRL 23 Oral)
  - NeRF Generation from Single Image (Fast)

NeRF for Robotics

3. Complete NeRF

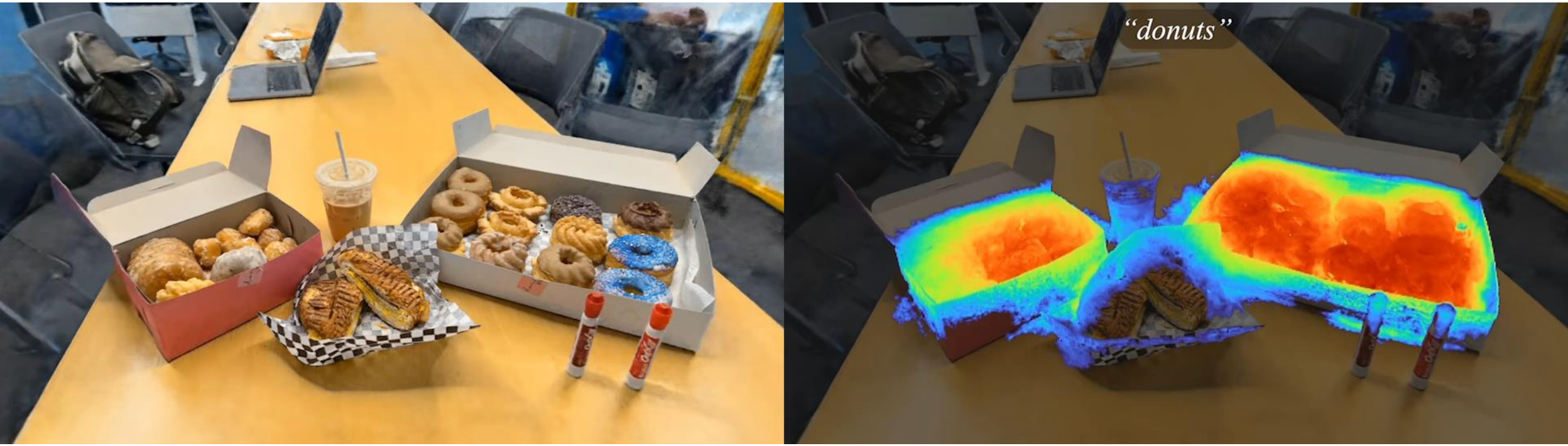
- Photo-realism enables High-level Perception
- LeRF-TOGO (CoRL 23 Best Paper)

Photorealistic Recon ➔ Semantic Embedding ➔ Robot Manipulation

NeRF for Robotics

3. Complete NeRF

- LeRF(ICCV 23 Oral): NeRF + CLIP Language Embedding



NeRF for Robotics

3. Complete NeRF

- LeRF(ICCV 23 Oral): NeRF + CLIP Language Embedding

NeRF for Robotics

3. Complete NeRF

- LeRF-TOGO (CoRL 23 Best Paper) - Zero-shot Text2Grasp

NeRF for Robotics

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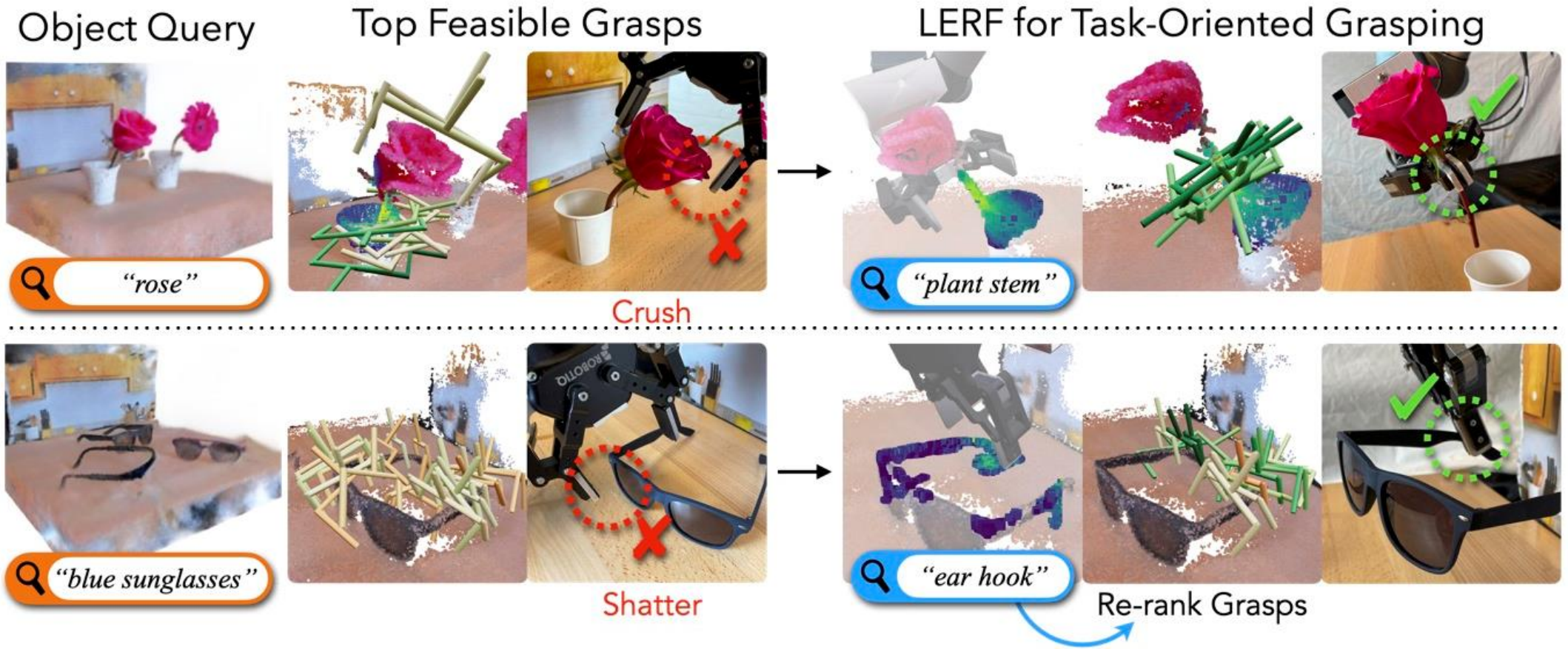
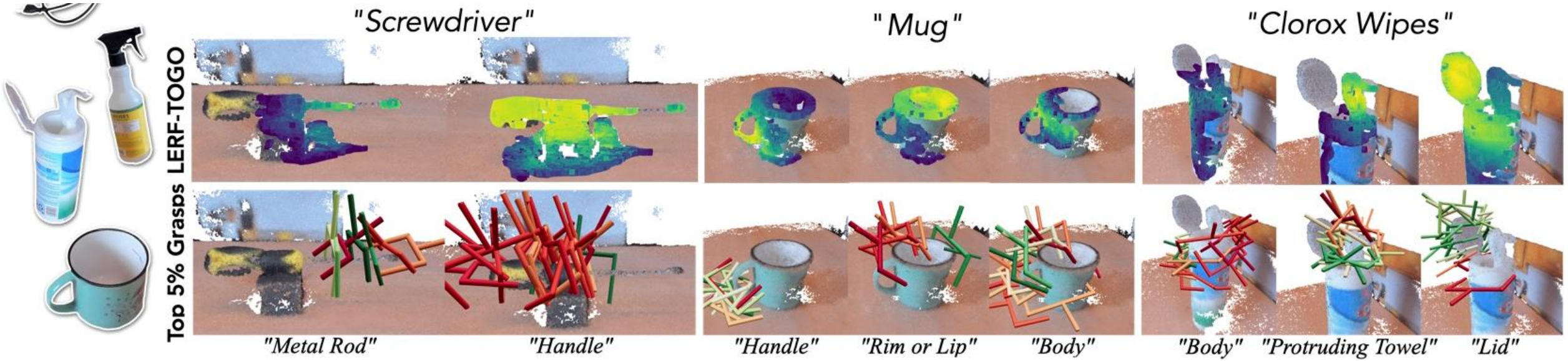


NeRF for Robotics

3. Complete NeRF

- LeRF-TOGO (CoRL 23 Best Paper) - Zero-shot Text2Grasp



NeRF for Robotics

3. Complete NeRF

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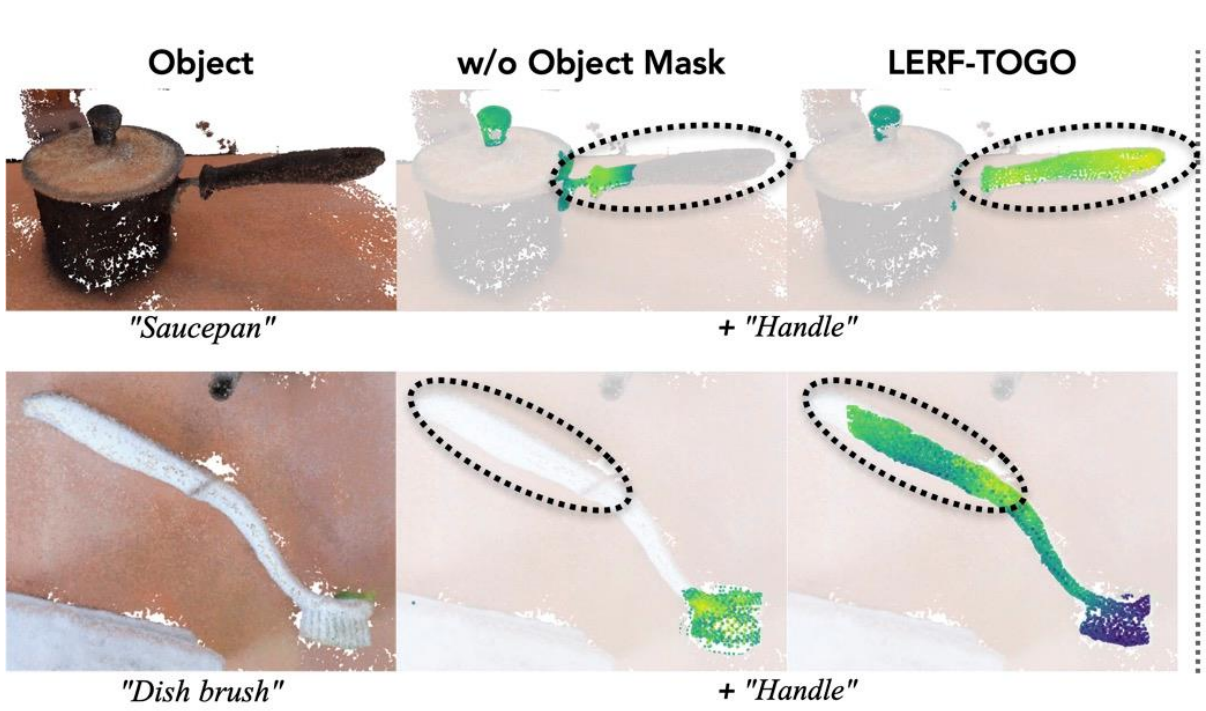
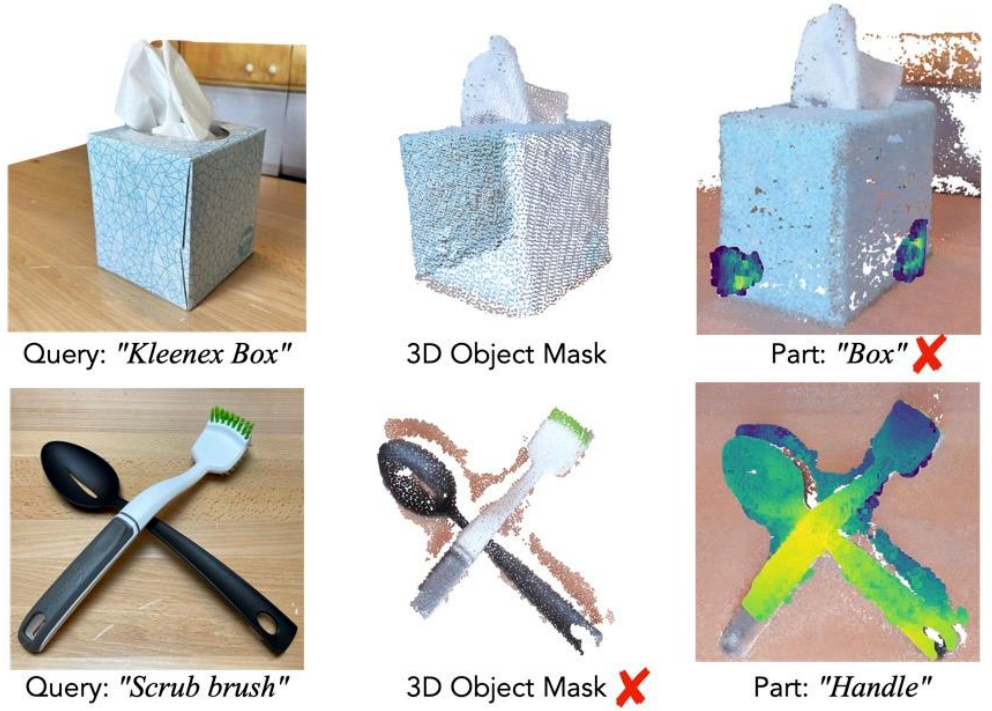
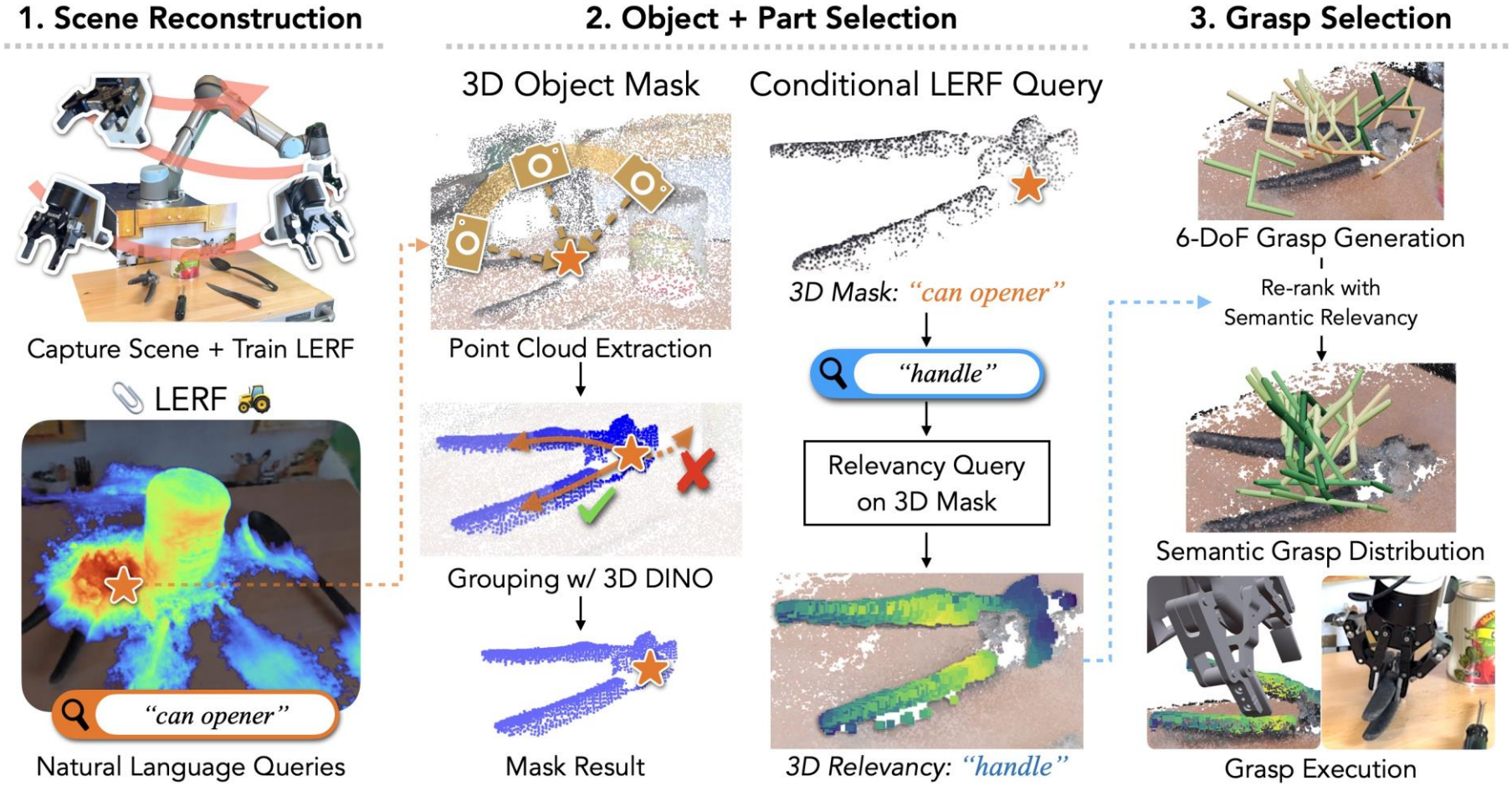




NeRF for Robotics

3. Complete NeRF

- LeRF-TOGO (CoRL 23 Best Paper) - Method



Discussion

Using NeRF for Robotics?

➔

Managing Trade-off between Cost and Perception

Thank You!