

Real-time 6D Pose Tracking of Novel Objects Using 2D Gaussian Splatting

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What is 6D Pose tracking

To continuously know the position and orientation of an object in a world or base frame.

Motivation

Robotic manipulation: Enables real-time pick-and-place or manipulation of unfamiliar objects without CAD models in dynamic environments like warehouses or factories

Augmented Reality: Enables accurate anchoring of virtual content onto real-world objects

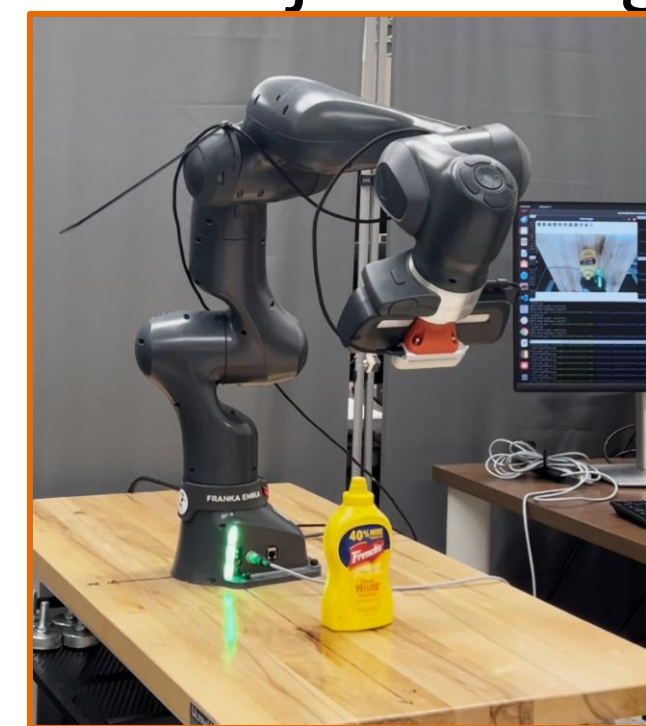
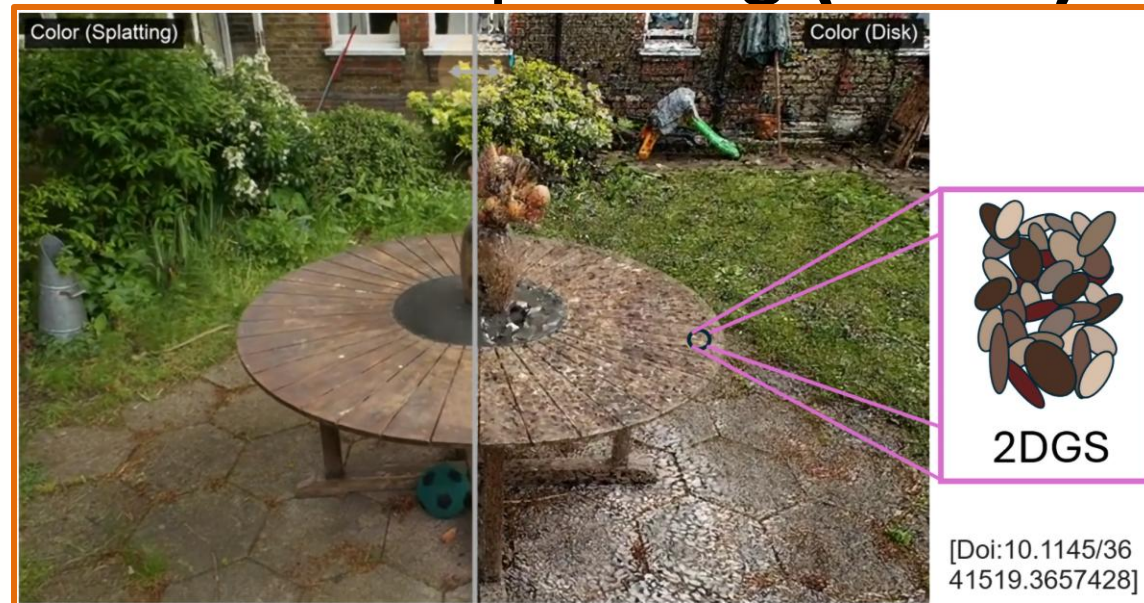
Service robots: Enables object tracking and manipulation in home and healthcare

Research Objective

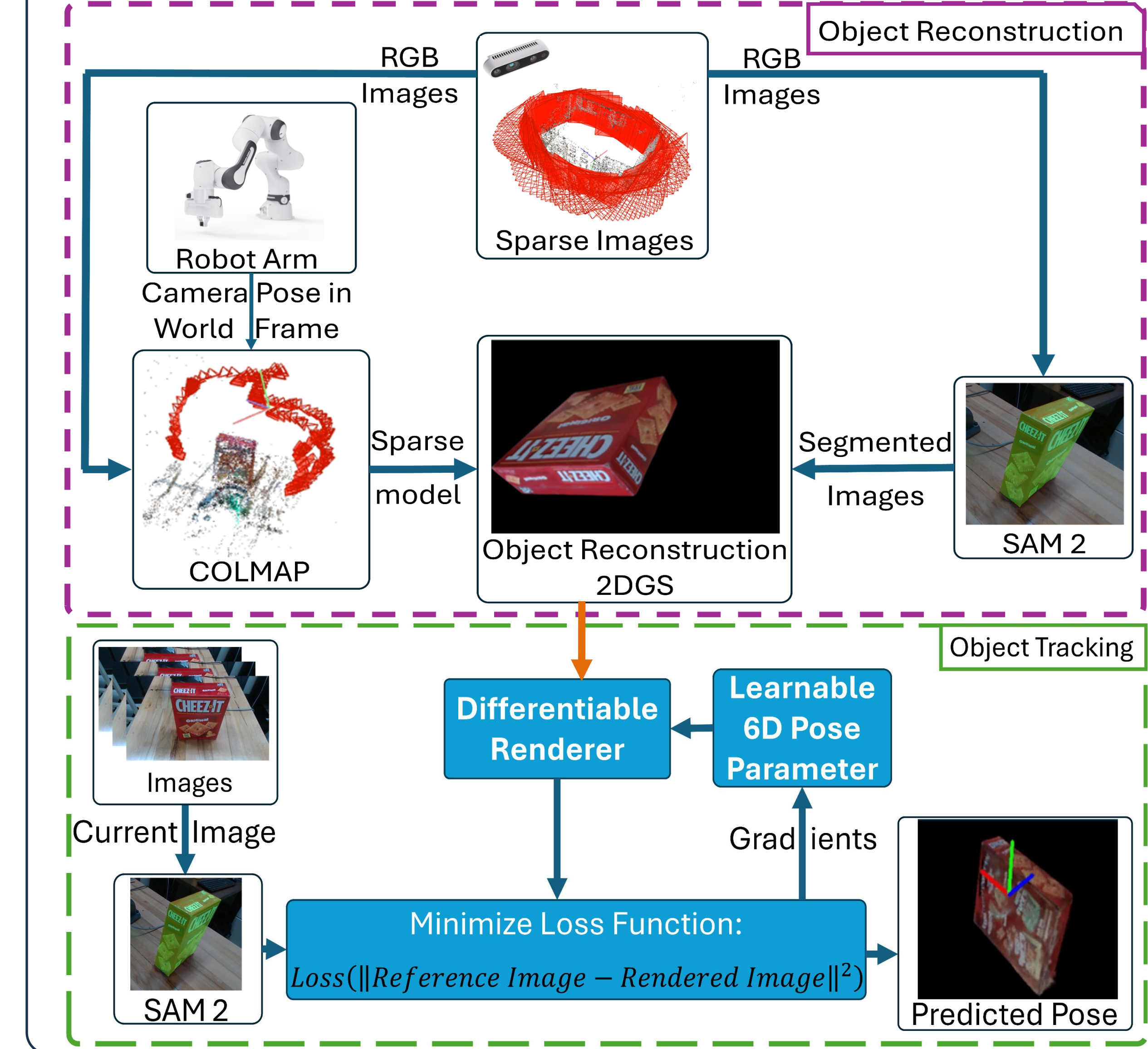
- Needed faster 6D Pose tracking rates (~25Hz) for real-time manipulation
- Should apply to a novel object
- No training should be required for tracking
- Eliminate intermediate representation

Object Reconstruction

To get the reconstruction of a novel object using 2D Gaussian Splatting (2DGS).



Methodology



Tracking Formulation

$$\min_p \|I_t^{\text{Ref}} - I_t^{\text{Ren}}(T_{2\text{DGS}}^W)\|^2$$

$T_{2\text{DGS}}^W$: 2DGS in frame
 I_t^{Ref} : Reference image at time t
 I_t^{Ren} : Rendered at time t

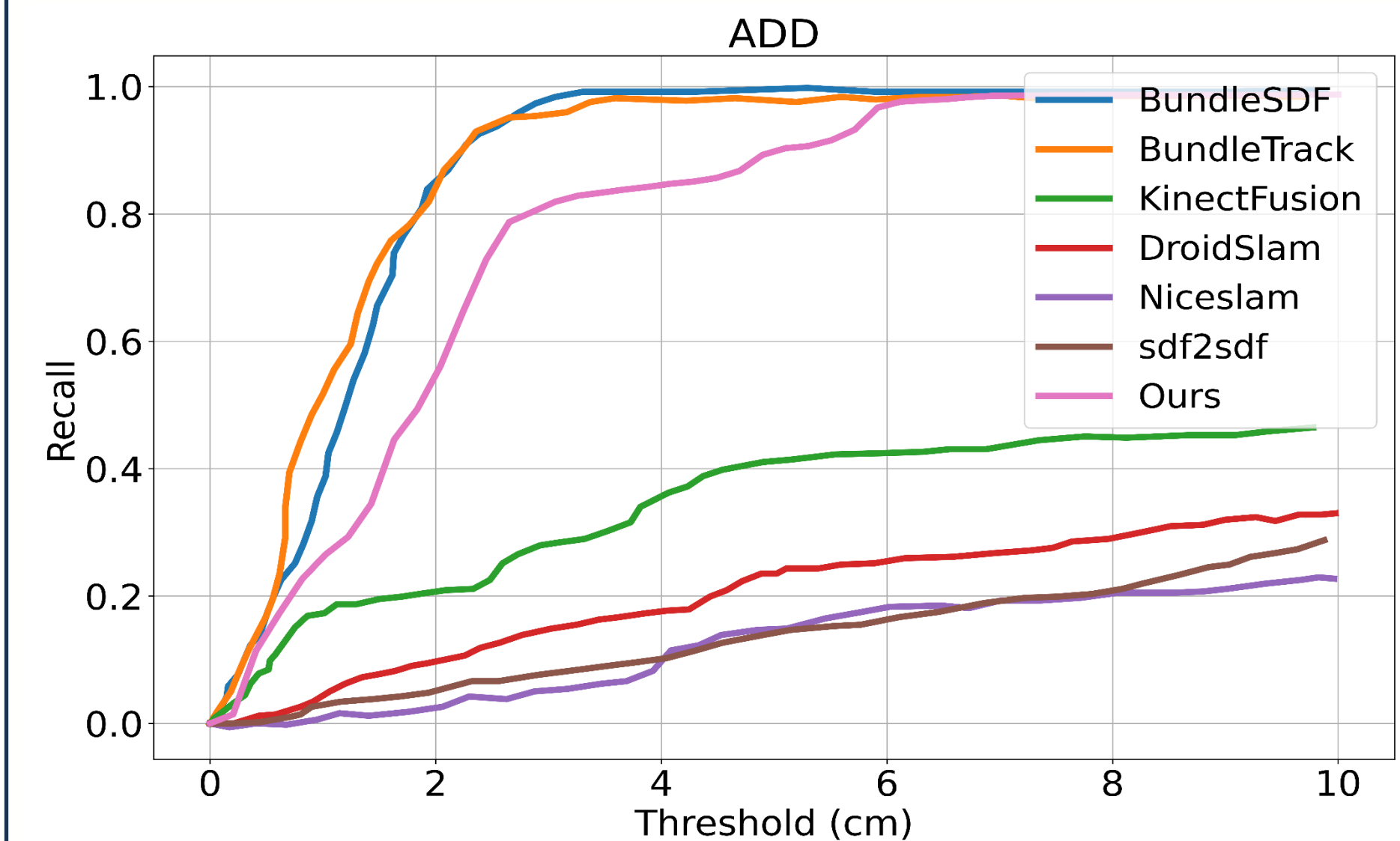
$$\text{where } T_{2\text{DGS}}^W = T_1^W \cdot T_{2\text{DGS}}^1$$

T_1^W : Transformation of local frame in world frame

$T_{2\text{DGS}}^1$: Transformation of Gaussian splats in the local frame.

Results

- Achieved ~34 Hz tracking rate on RTX 2000
- Metrics: ADD & ADD-S for accuracy, AUC (Area Under Curve) used as overall measure
- ADD: Average error distance of point cloud between predicted and ground truth pose
- ADD-S is like ADD but error: nearest points
- Pipeline execution time: avg 6 mins 10 sec
- Performance closely matches BundleTrack



Method	Tracks Novel Objects	Tracking Rate
RGF	✗	30 Hz
Bundle-Track	✗	~10 Hz
SDF-2-SDF	✓	~17 Hz
FoundationPose	✓	32 Hz
Ours	✓	~34 Hz

Acknowledgment

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