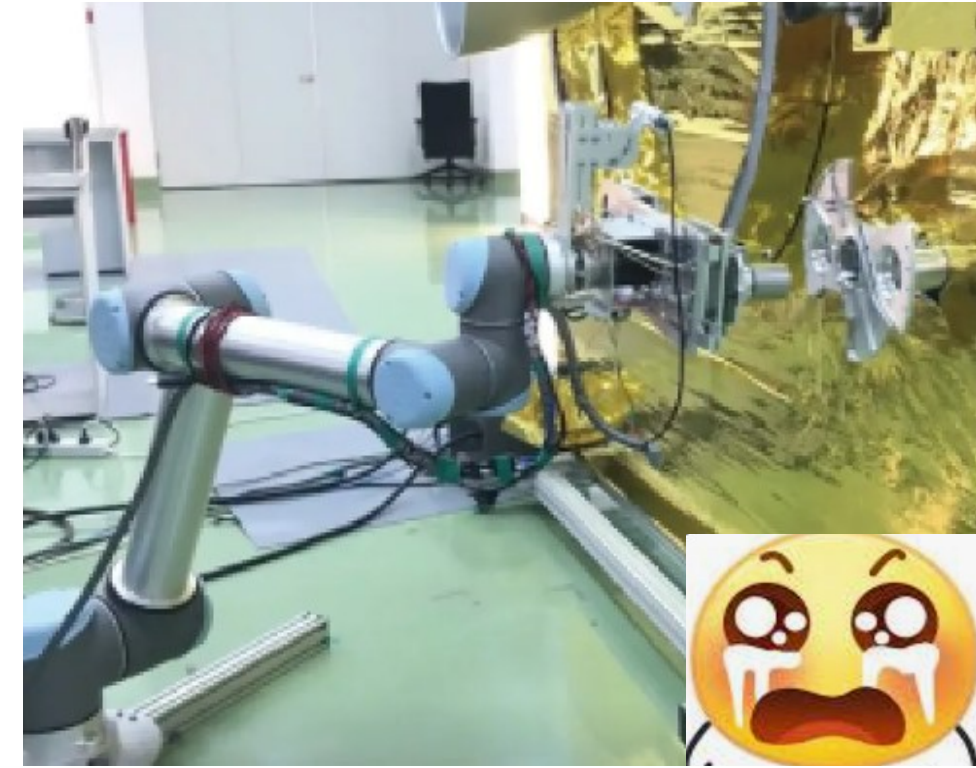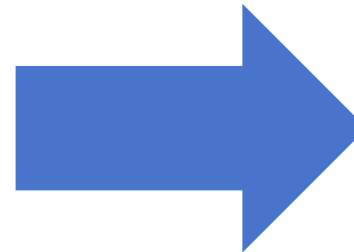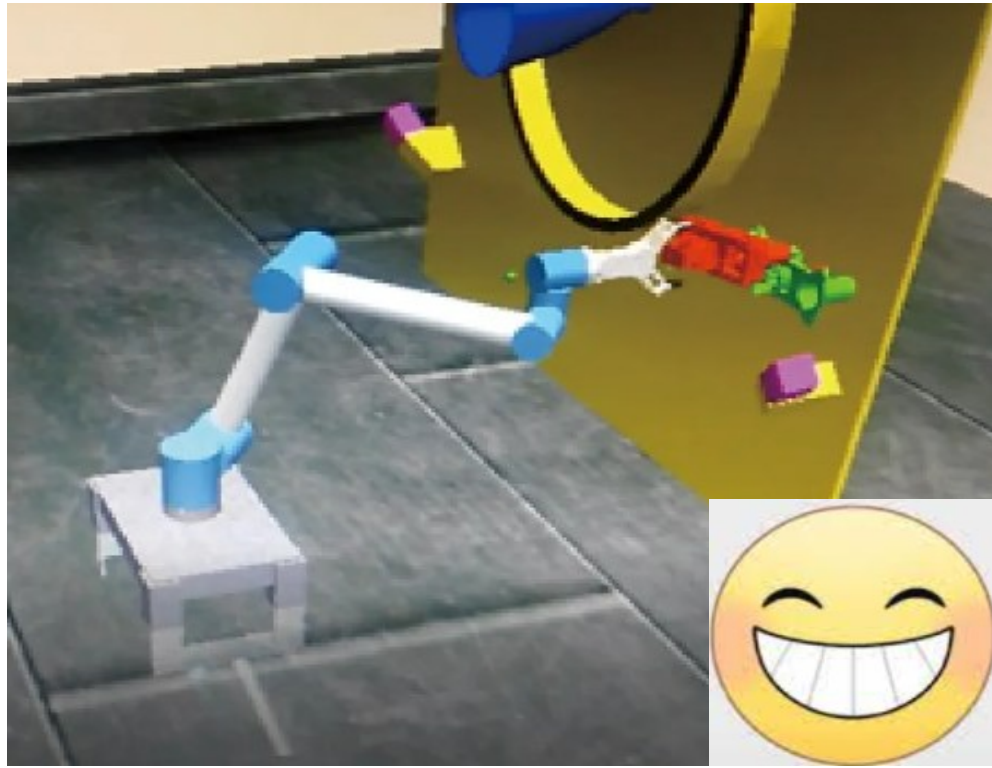# RL-GSBridge: 3D Gaussian Splatting Based Real2Sim2Real Method for Robotic Manipulation Learning

Guangming Wang

Postdoctoral Research Associate

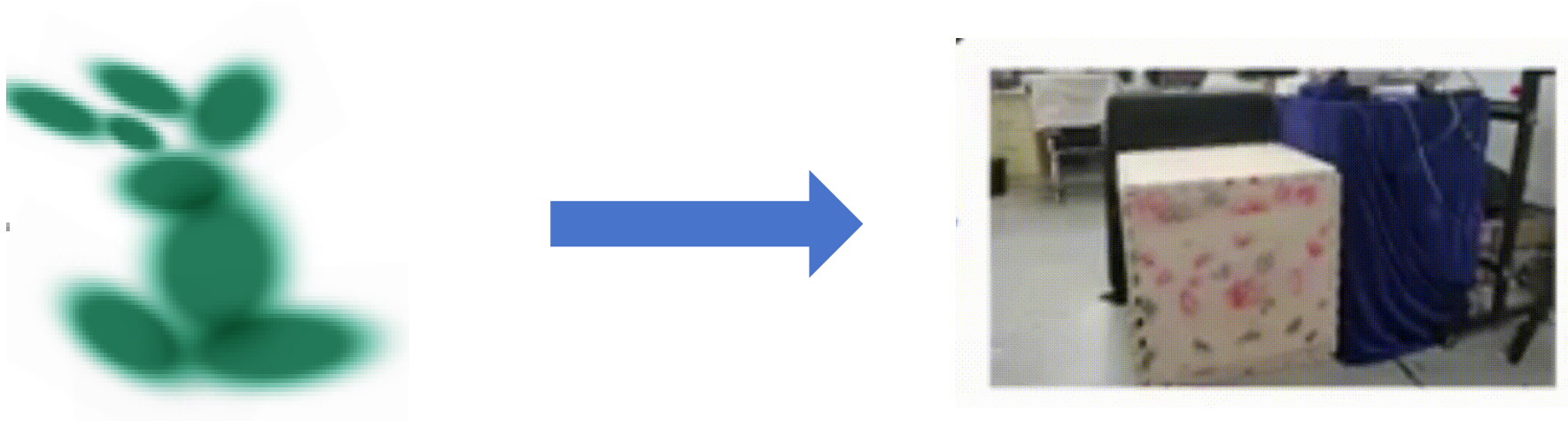Department of Engineering, University of Cambridge

Challenges in Sim2Real

Gap between Simulation and Real.

Motivation

3D Gaussian Splatting:
- high quality real-world reconstruction
- novel view synthesis

Kerbl B, Kopanas G, Leimkühler T, et al. 3d gaussian splatting for real-time radiance field rendering[J]. ACM Trans. Graph., 2023, 42(4): 139:1-139:14.

Motivation

Original 3D Gaussian Splatting:

Kerbl B, Kopanas G, Leimkühler T, et al. 3d gaussian splatting for real-time radiance field rendering[J]. ACM Trans. Graph., 2023, 42(4): 139:1-139:14.

Framework and Main Contributions

1. **Real2Sim** by **Soft Mesh Binding GS**

Simulation

Dynamics-based GS Editing

Render img

Real-world

Grasp

Pick & place

RL-GS Bridge

2. **Learn Policy at Simulator with Physic Dynamics-based GS renderer**
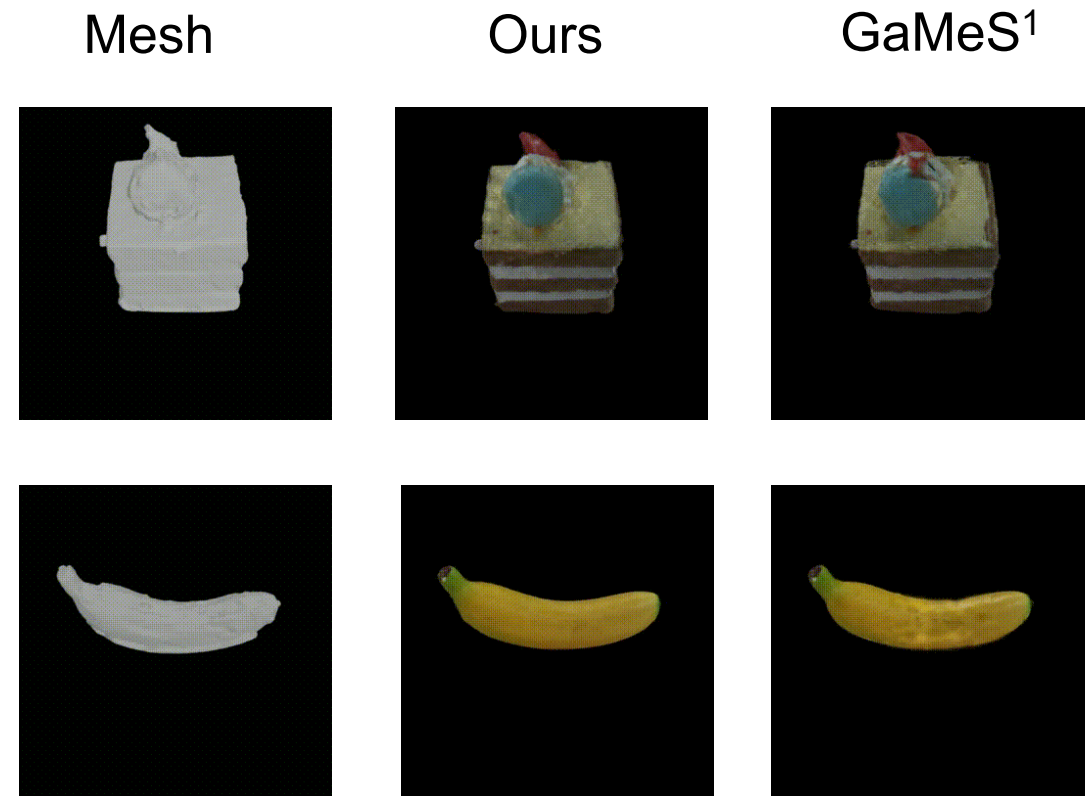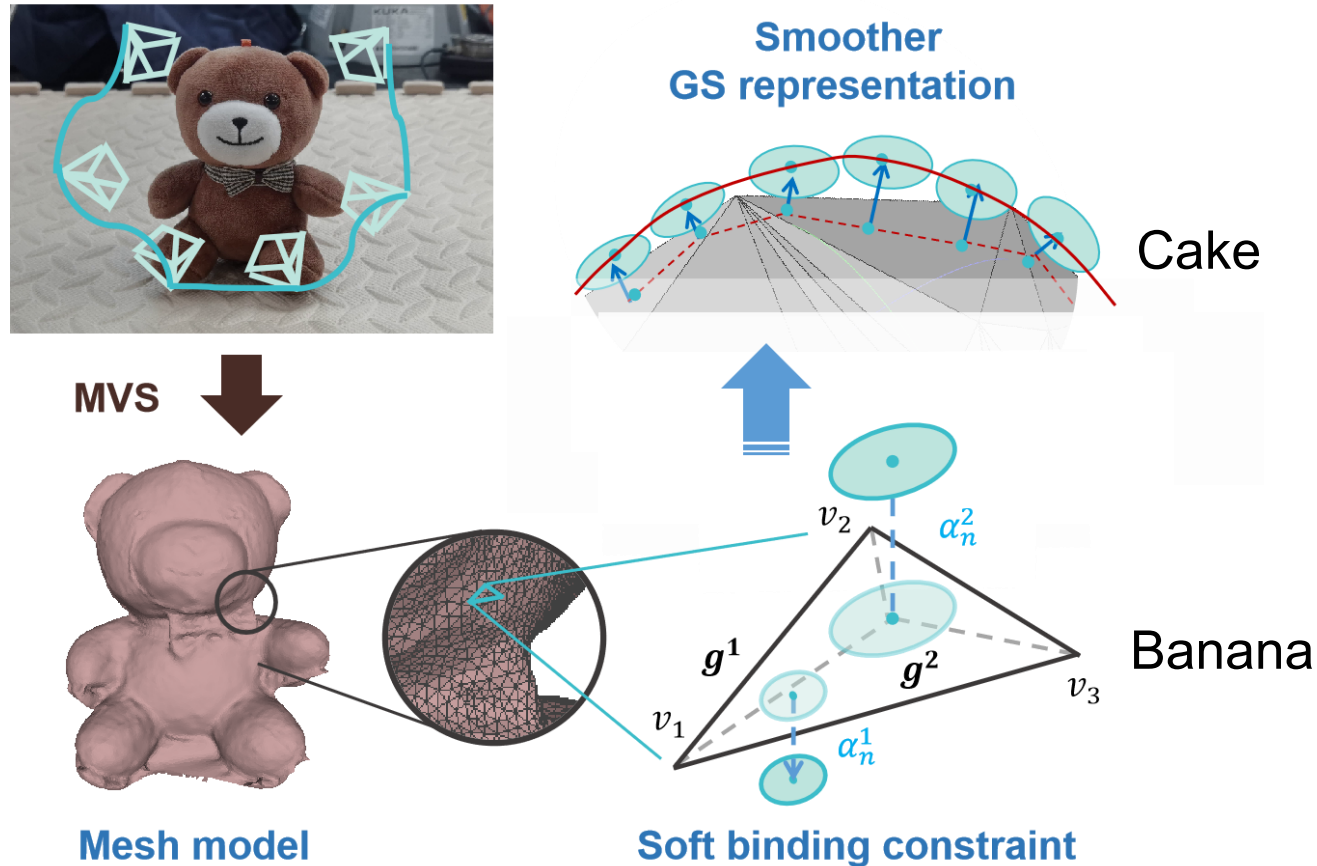
3. **Zero-shot Real-world Robot Manipulation on Various Tasks**
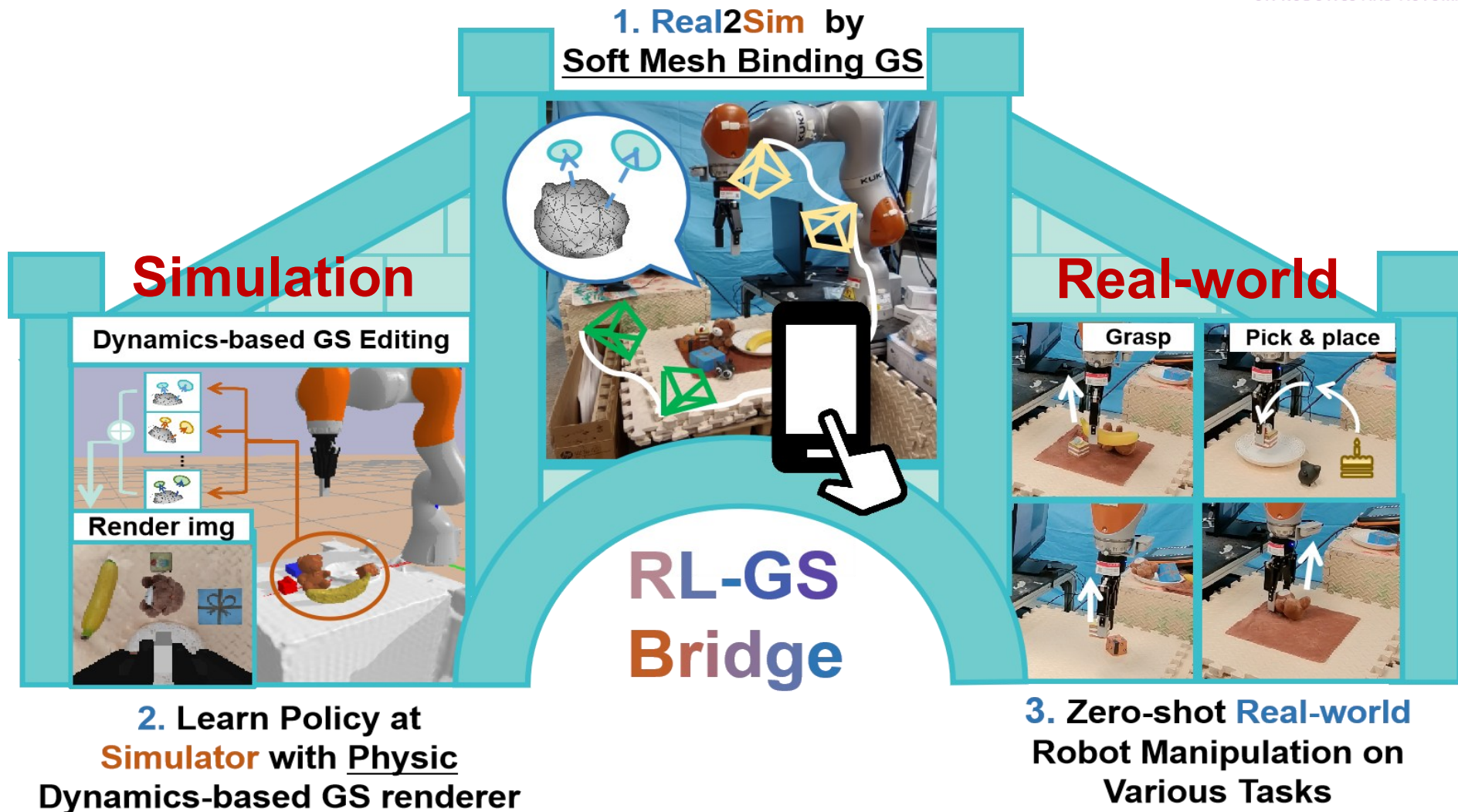
- A Real2Sim2Real framework (RL-GS Bridge) for Zero-shot sim-to-real transfer
- A Soft Mesh Binding GS Modelling Method
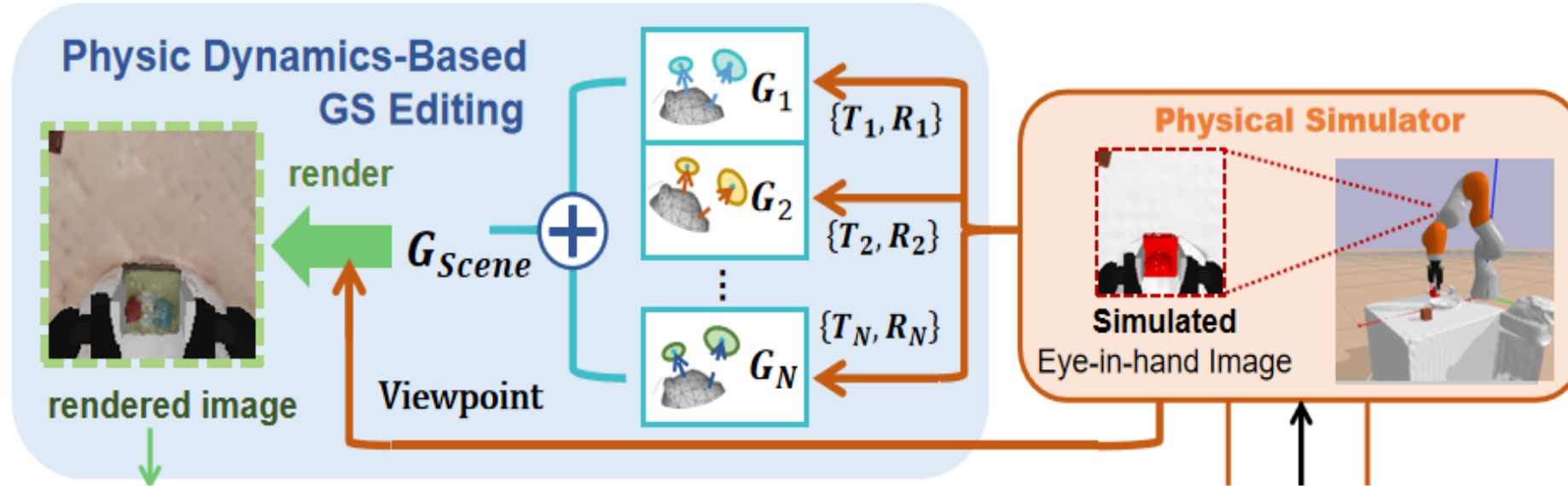- Physical Dynamics-Based GS Editing

Soft Mesh Binding GS Modeling

a soft mesh binding strategy to replace the hard mesh binding baseline[1]
better flexibility and quality of rendered images

Smoother GS representation

Cake

Banana

Mesh model

Soft binding constraint

Mesh Ours GaMeS[1]

[1] Waczyńska, Joanna, et al. "Games: Mesh-based adapting and modification of gaussian splatting." arxiv preprint arxiv:2402.01459 (2024).
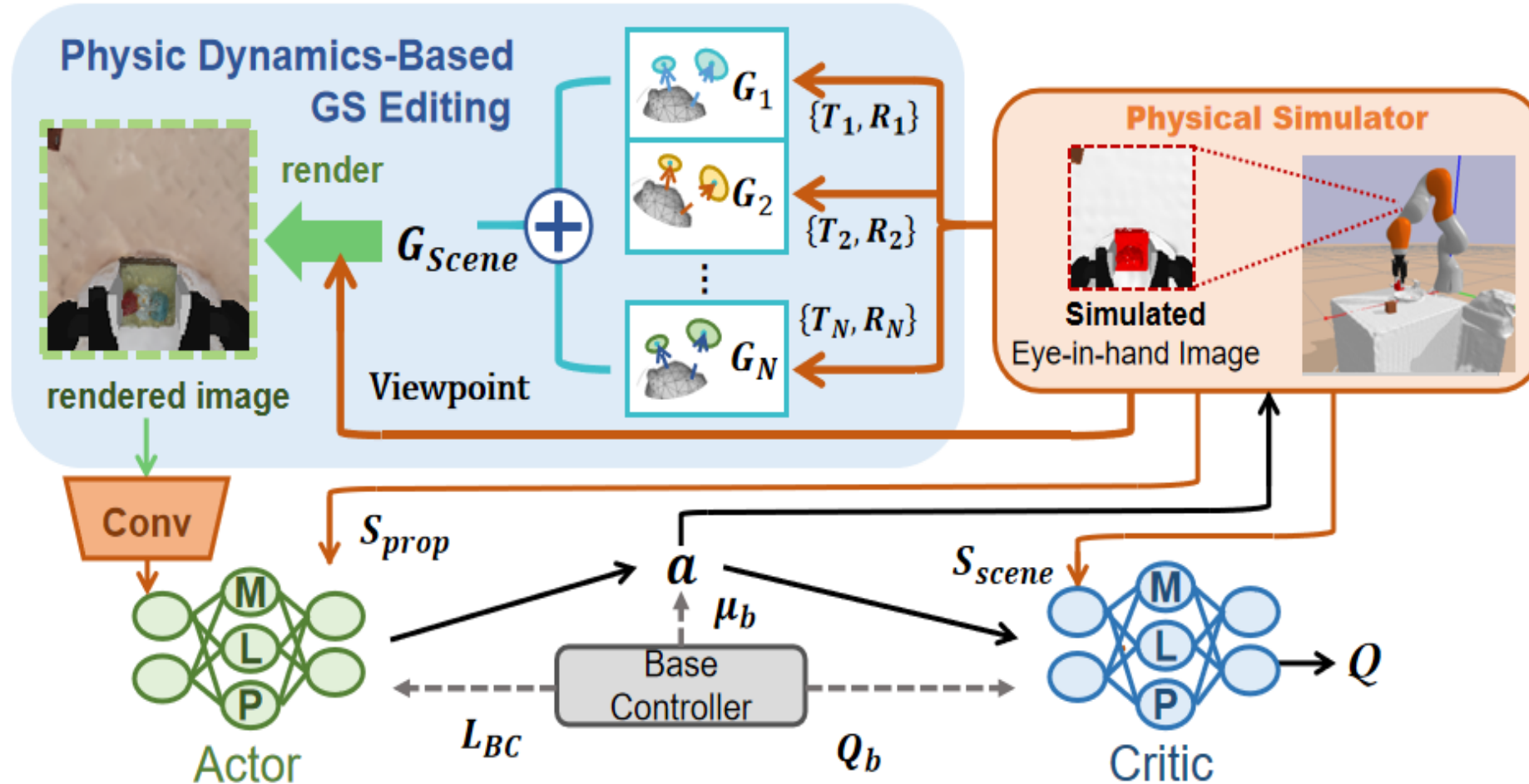
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Physical Dynamics-Based GS Editing

integrate dynamics signals from the simulator to edit 3D GS models, reflecting realistic robot interactions
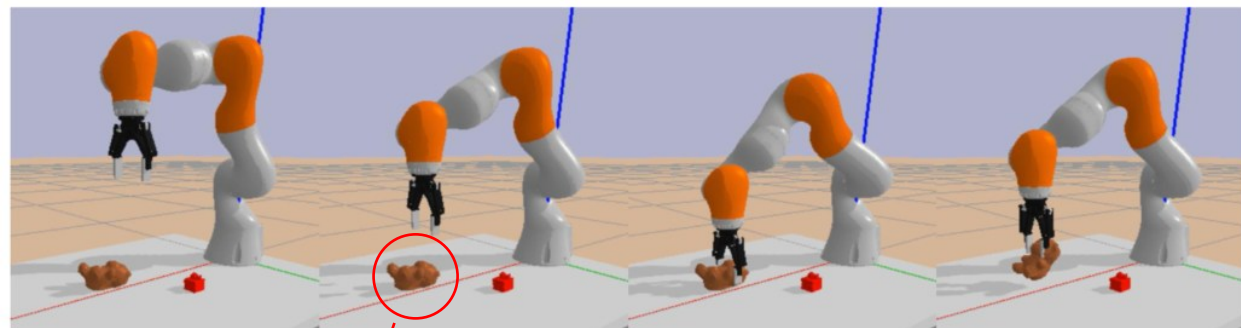
Physical Dynamics-Based GS Editing

integrate dynamics signals from the simulator to edit 3D GS models, reflecting realistic robot interactions

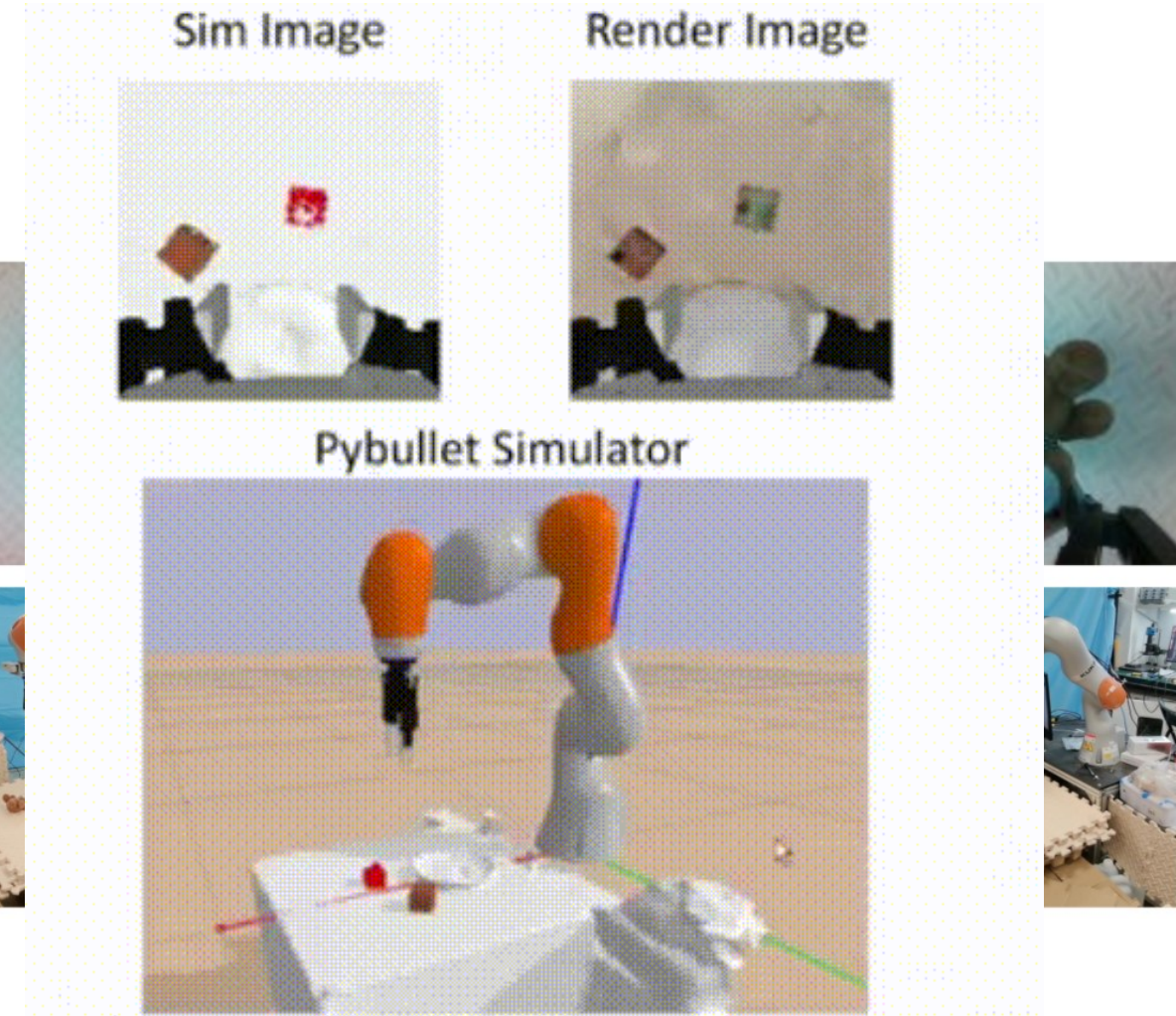Wang, Guangming, et al. "Learning of long-horizon sparse-reward robotic manipulator tasks with base controllers." IEEE Transactions on Neural Networks and Learning Systems (2022): 4072-4081.

Visualization

Simulation

Rendered from 3D GS

Mesh

Real-Word Experiments

Video: Experiment Results

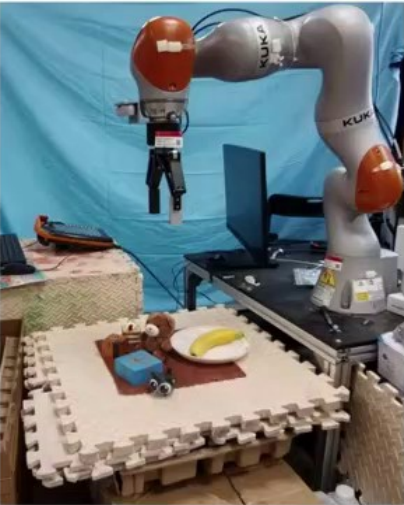**Table I .** Comparision between RL-GSBridge and pure simulation method.

Object	Small-cube		Bear	
Test scene	Sim	Real	Sim	Real
RL-sim	**96.88**	12.50 (↓87%)	**93.75**	25.00 (↓73%)
RL-GSBridge	**96.88**	**96.88**	87.50	**100.00** (↑14%)

Real-Word Experiment Setup

- **Hardware:** KUKA iiwa with Robotiq 2F-140 and Intel Realsense D435i camera
- **Task:**
  - grasp (different obj and bg)
  - pick and place
- **Objects:** small cube, cake, banana, toy bear
- **Background:** foam pad, foam with tablecloth

Table II. RL-GSBridge's performance in all scenarios.

Object (Background)	Cake (Foam pad)		Banana (Foam pad)		Small-cube (Tablecloth)		Cake (Tablecloth)		Banana (Tablecloth)		Bear (Tablecloth)	
Test scene	Sim	Real	Sim	Real	Sim	Real	Sim	Real	Sim	Real	Sim	Real
Success rate (%)	**100.00**	**100.00**	**100.00**	93.75 (↓6%)	**96.88**	87.50 (↓10%)	**100.00**	93.75 (↓6%)	**100.00**	96.88 (↓3%)	**87.50**	75.00 (↓14%)

RL-GS Bridge

Code Page

Thanks!
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