MOSIV: Multi-Object System Identification from Videos

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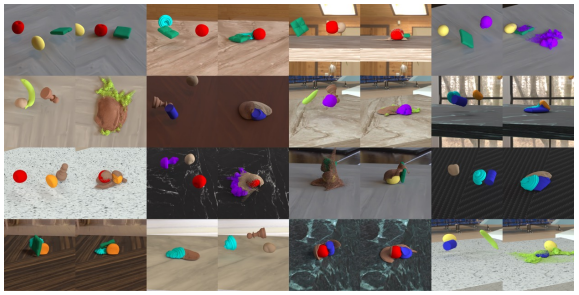


Highlights

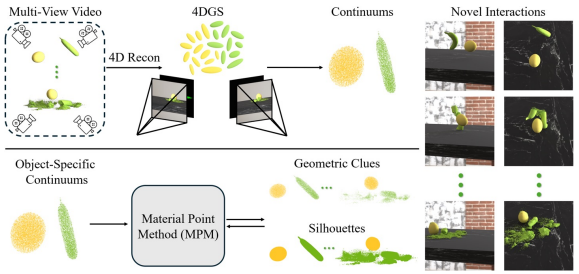
Multi-object system identification from videos: jointly recovering simulation-ready object continuums and object-specific physical parameters from videos, such that a simulator can replay observed motions and predict future behaviors.

Motivation: Prior methods are largely designed for single-object settings, making them inadequate for contact-rich multi-object interactions and accurate physical calibration.

Solution: Object-aware dynamic reconstruction + Gaussian-to-continuum lifting + differentiable MPM with object-wise supervision

Result: MOSIV achieves strong performance in both observable-state reconstruction and long-horizon future-state simulation, while also supporting physically plausible novel interactions

Method

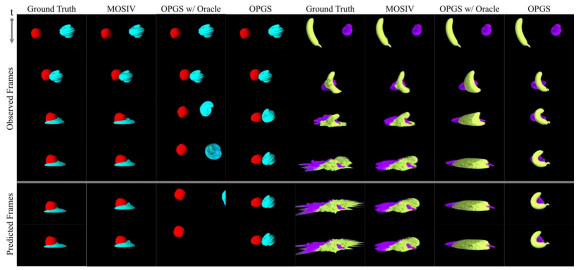


Object-aware dynamic reconstruction: Reconstruct 4D Gaussians from multi-view videos with object masks.

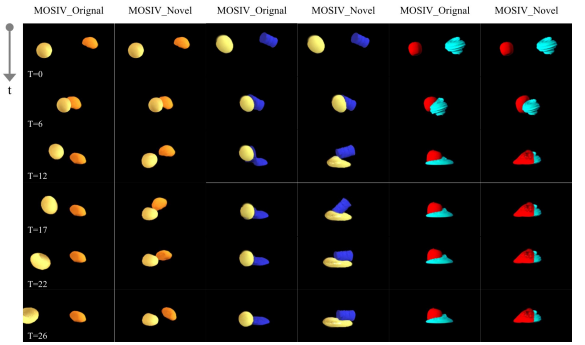
Gaussian-to-continuum lifting: reconstructed object is converted into a simulation-ready particle continuum

Phys Parameter Optimization: optimize per-object physical params. through differentiable MPM simulation.

Experiments



	Method	Inter-Material Interaction E–P	E–F	E–S	P–F	P–S	F–S	Intra-Material Interaction E–E	P–P	F–F	S–S	Average
PSNR ↑	OPGS (Lin et al., 2025)	27.63	27.01	24.46	26.24	26.80	24.89	26.84	29.79	23.59	24.72	25.93
	OPGS w/ Oracle (Lin et al., 2025)	25.37	24.62	23.26	23.81	25.98	23.36	25.06	25.86	22.53	24.52	24.39
	MOSIV (Ours)	**30.89**	**30.29**	**26.57**	**32.21**	**29.07**	**29.88**	**27.96**	**36.16**	**35.16**	**26.87**	**30.51**
SSIM ↑	OPGS (Lin et al., 2025)	0.968	0.966	0.892	0.971	0.945	0.951	0.951	0.980	0.953	0.931	0.945
	OPGS w/ Oracle (Lin et al., 2025)	0.952	0.941	0.877	0.949	0.938	0.933	0.948	0.955	0.936	0.931	0.930
	MOSIV (Ours)	**0.983**	**0.982**	**0.945**	**0.986**	**0.973**	**0.977**	**0.970**	**0.992**	**0.987**	**0.971**	**0.977**
CD ↓	OPGS (Lin et al., 2025)	11.10	3.931	27.97	2.692	10.16	8.165	23.82	1.030	7.281	13.85	11.79
	OPGS w/ Oracle (Lin et al., 2025)	33.24	81.98	46.09	91.28	17.33	43.18	10.35	77.54	43.82	3.01	43.50
	MOSIV (Ours)	**1.095**	**0.358**	**2.022**	**0.183**	**0.839**	**0.593**	**4.876**	**0.129**	**0.166**	**2.301**	**1.256**
EMD ↓	OPGS (Lin et al., 2025)	0.085	0.078	0.135	0.069	0.085	0.092	0.134	0.052	0.105	0.104	0.095
	OPGS w/ Oracle (Lin et al., 2025)	0.157	0.227	0.188	0.243	0.112	0.186	0.113	0.228	0.199	**0.063**	0.168
	MOSIV (Ours)	**0.043**	**0.041**	**0.069**	**0.028**	**0.047**	**0.052**	**0.064**	**0.012**	**0.033**	0.103	**0.049**



Summary

MOSIV achieves state-of-the-art observable and future-state simulation, with strong visual fidelity and physically plausible novel interactions