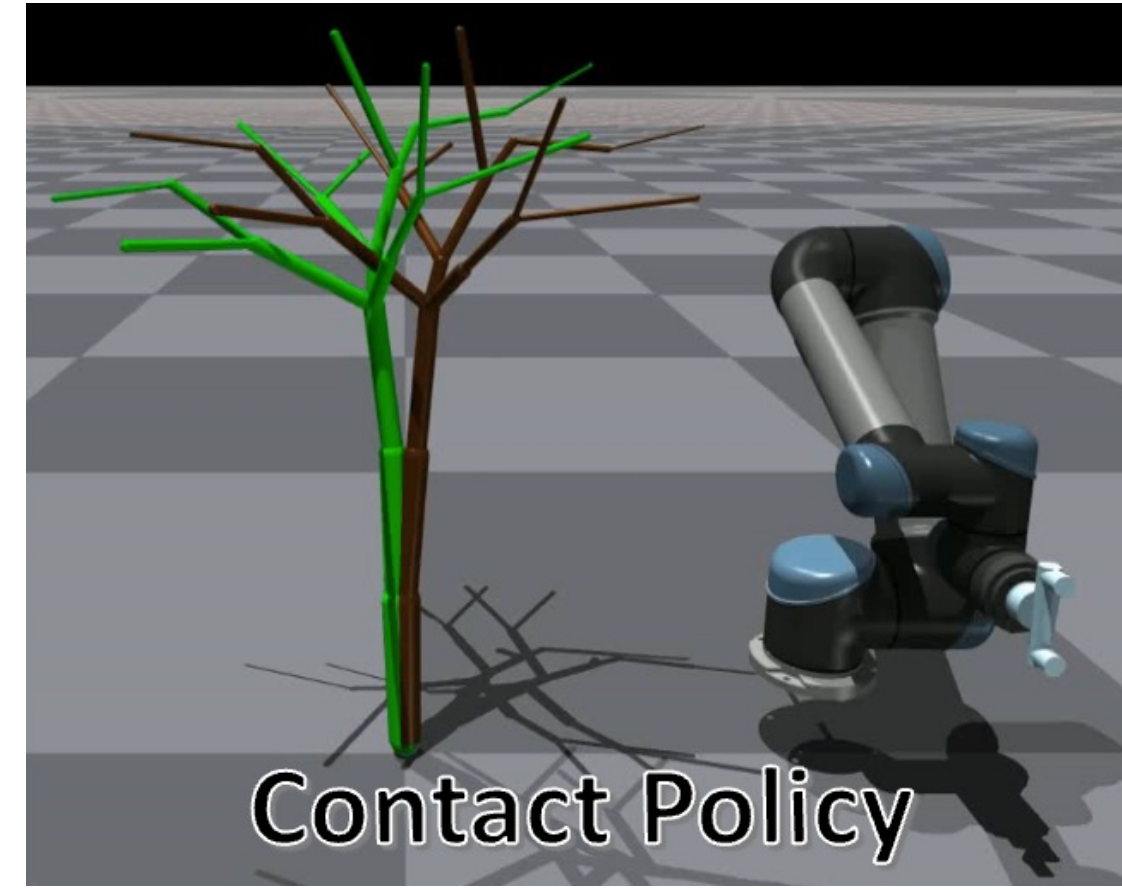
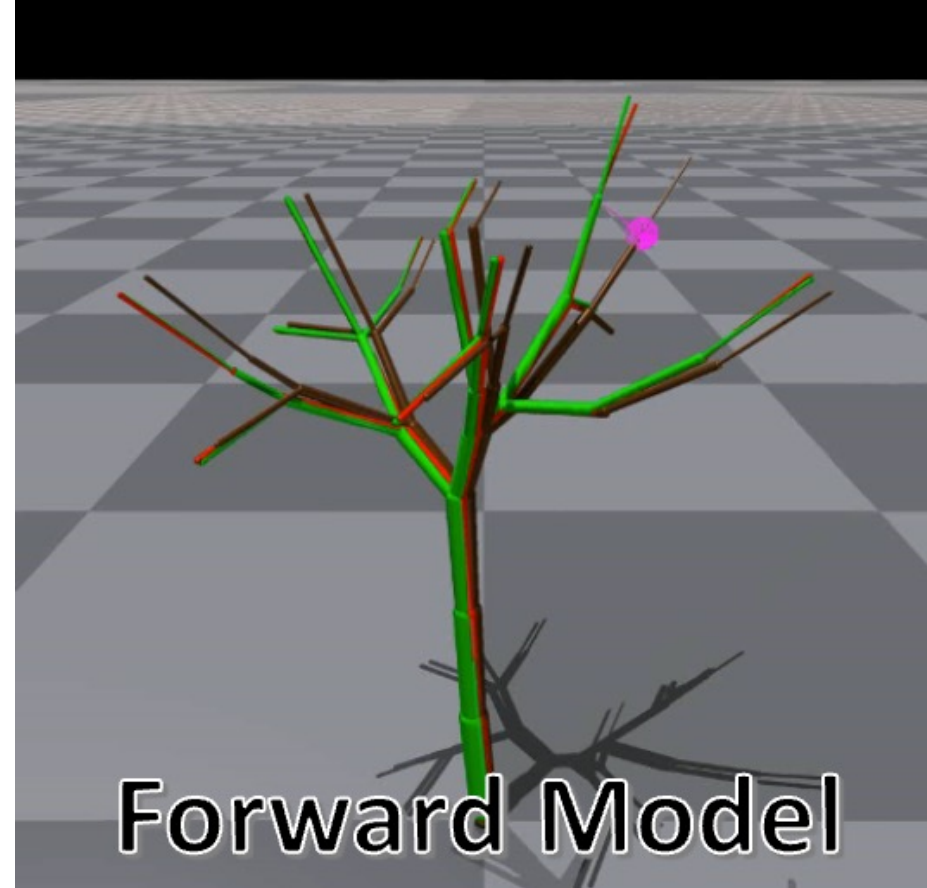


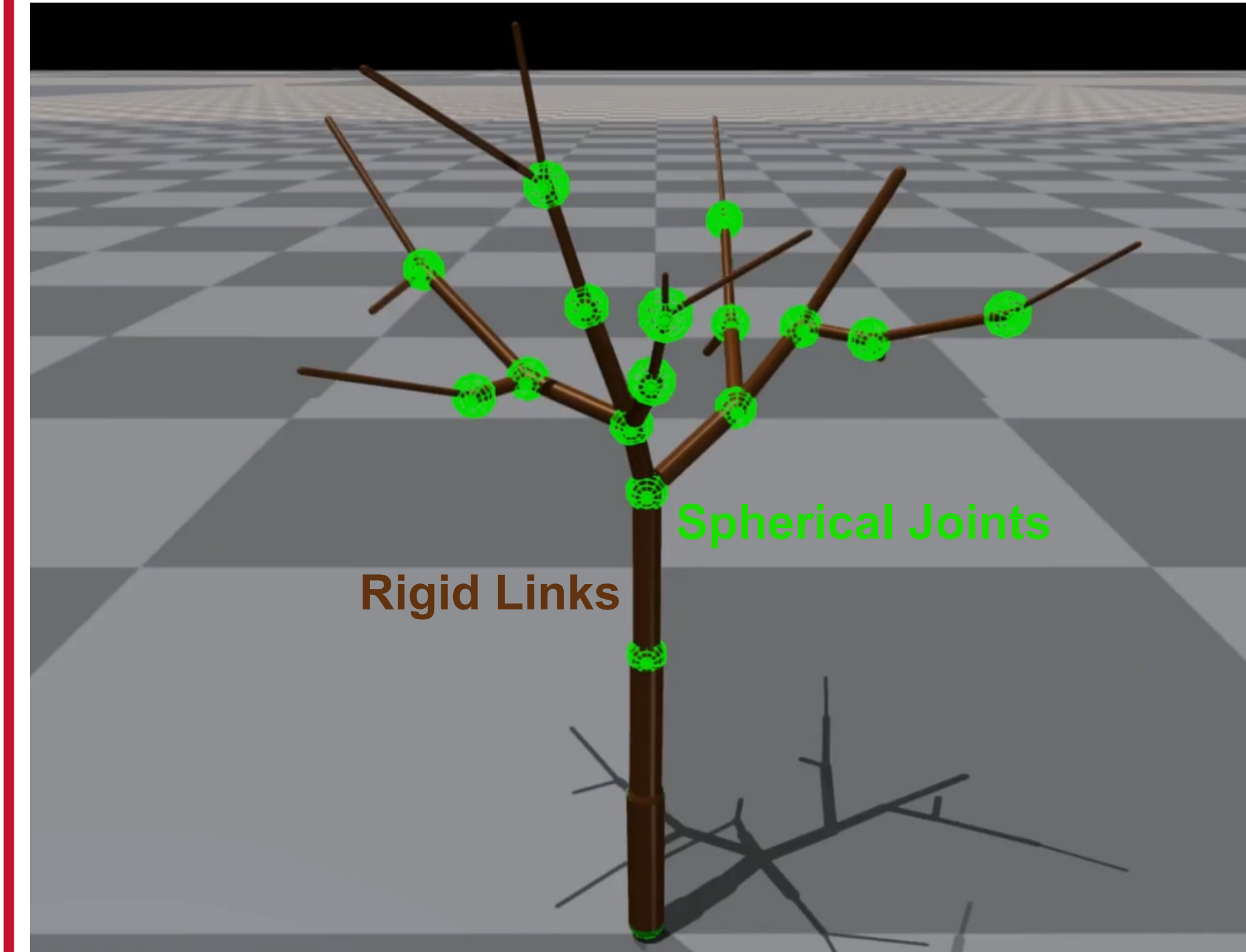
1. Motivation

A Framework for Tree Crop Manipulation

- Objective:** Enabling contact interaction/manipulation with branch structures
- Introduce a **graph-based representation** for tree crops.
- Show how this representation facilitates **learning of tree crop behavior** using simulated data from a basic tree model.



2. Mass-Spring-Damper Tree Model



Spring Damper Model:

$$\tau = K_s \theta_p + K_d \dot{\theta}_p$$

Torque Stiffness Damping

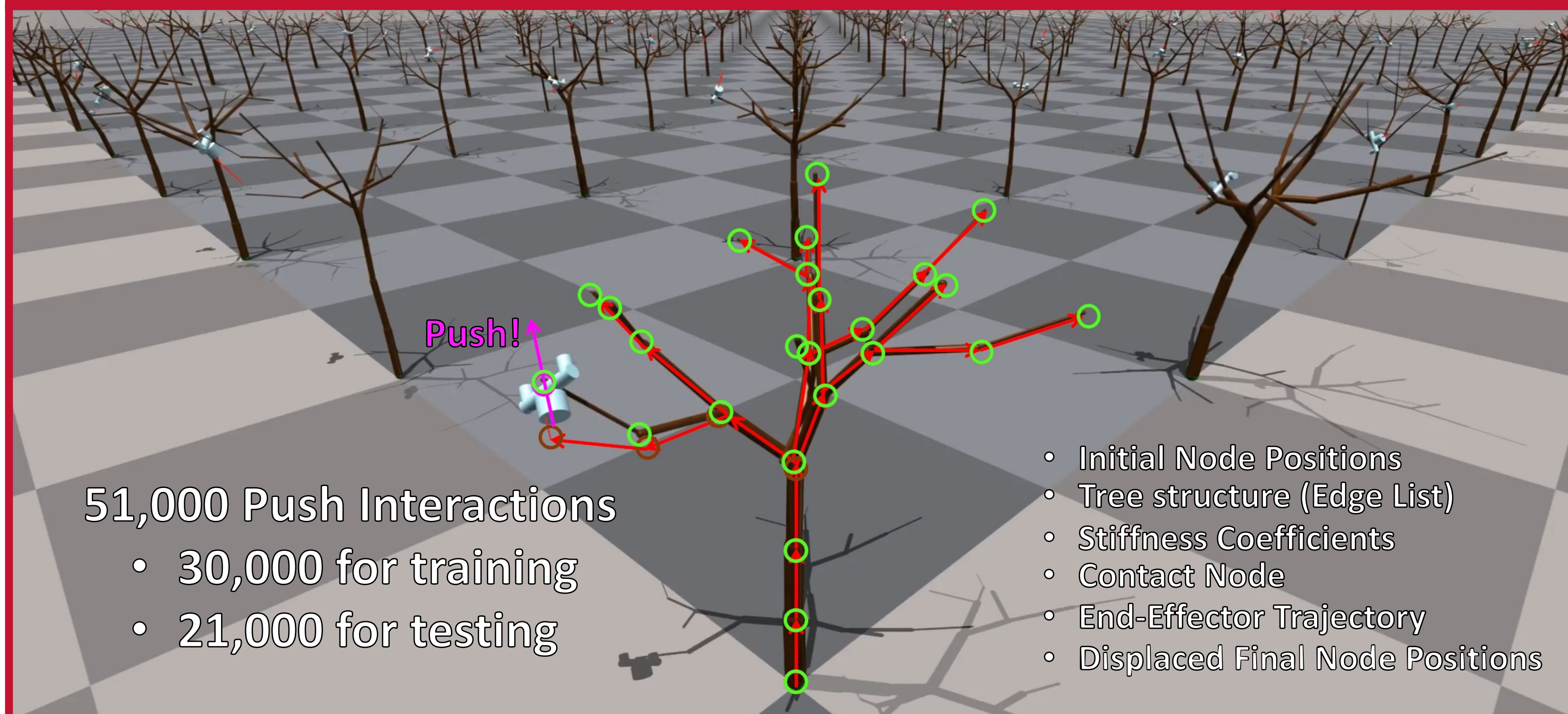
Beam Deflection Model:

$$\theta_p = \frac{PL^2}{2EI}$$

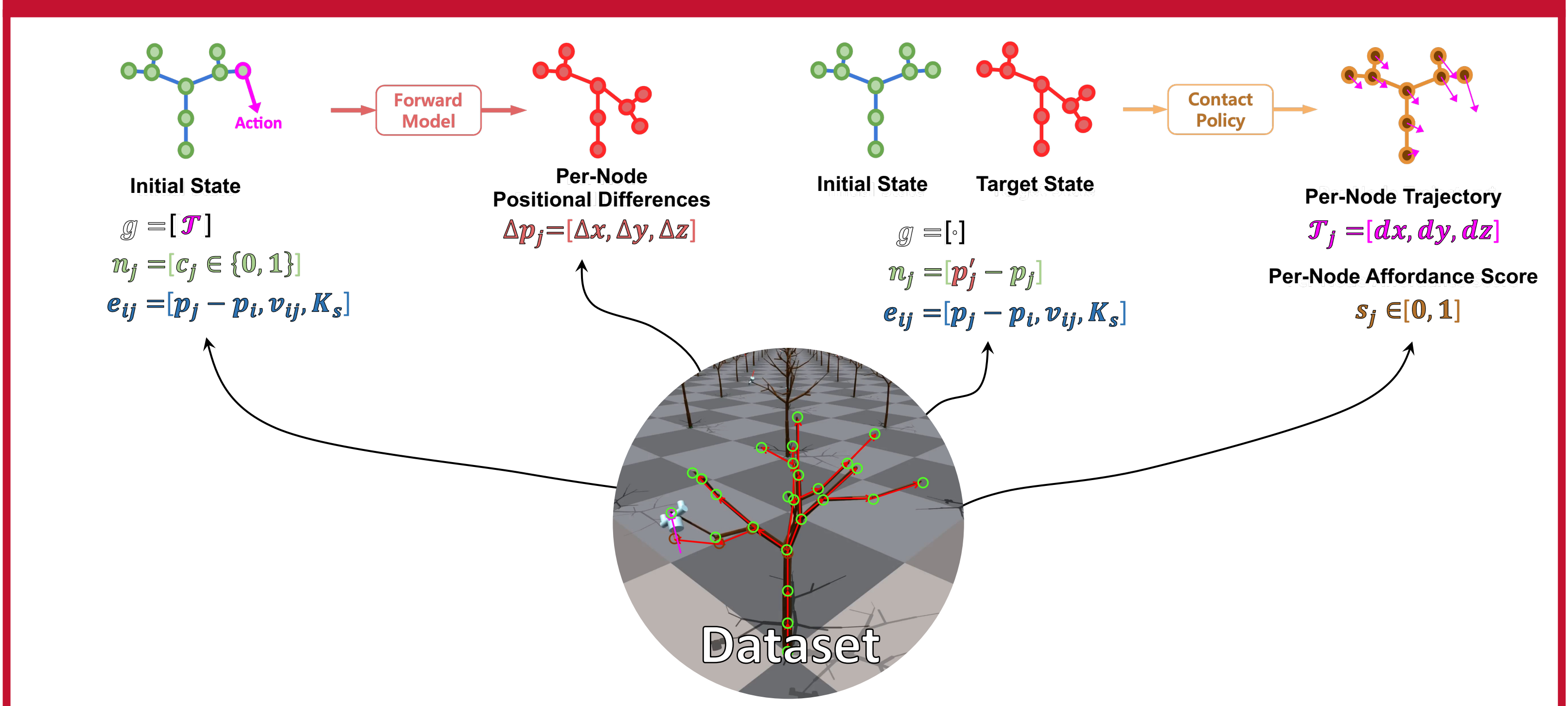
Applied Force Length Second Moment of Inertia Young's Modulus

$$K_s = \frac{E\pi r^4}{2L}$$

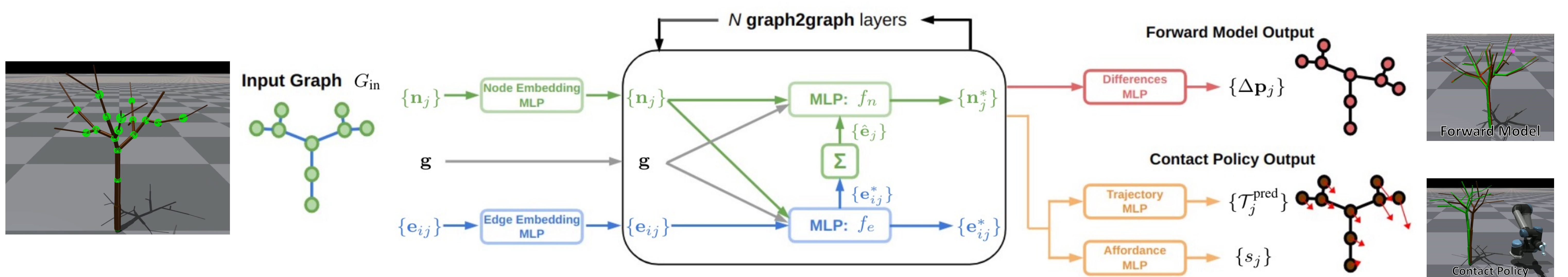
3. Data Collection



4. Supervised Learning

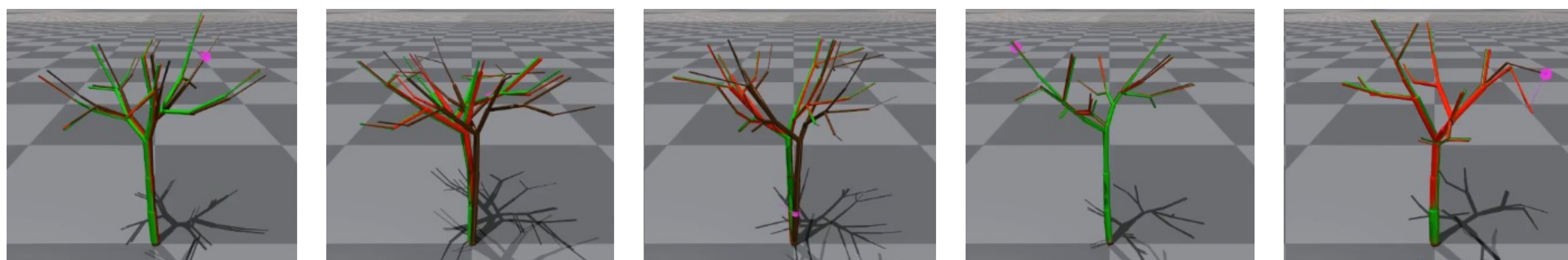


5. Leveraging Graph Representations

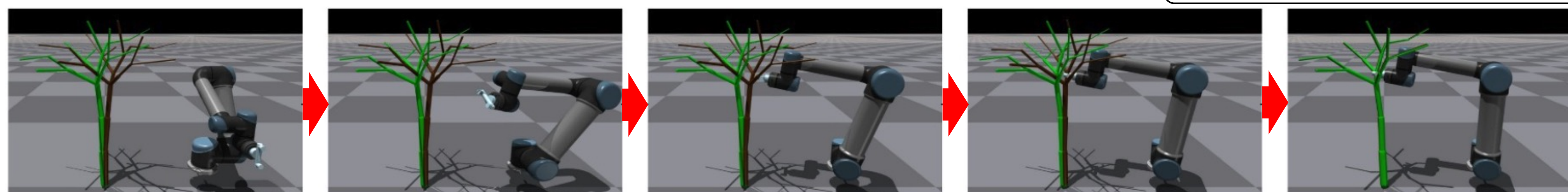


6. Results in Simulation

Forward Model Predictions



Contact Policy Inference



Method	Node Position Error	
	Forward Model	Contact Policy
PointNet	11 cm	4.2 cm
GNN (Ours)	2.2 cm	2.5 cm