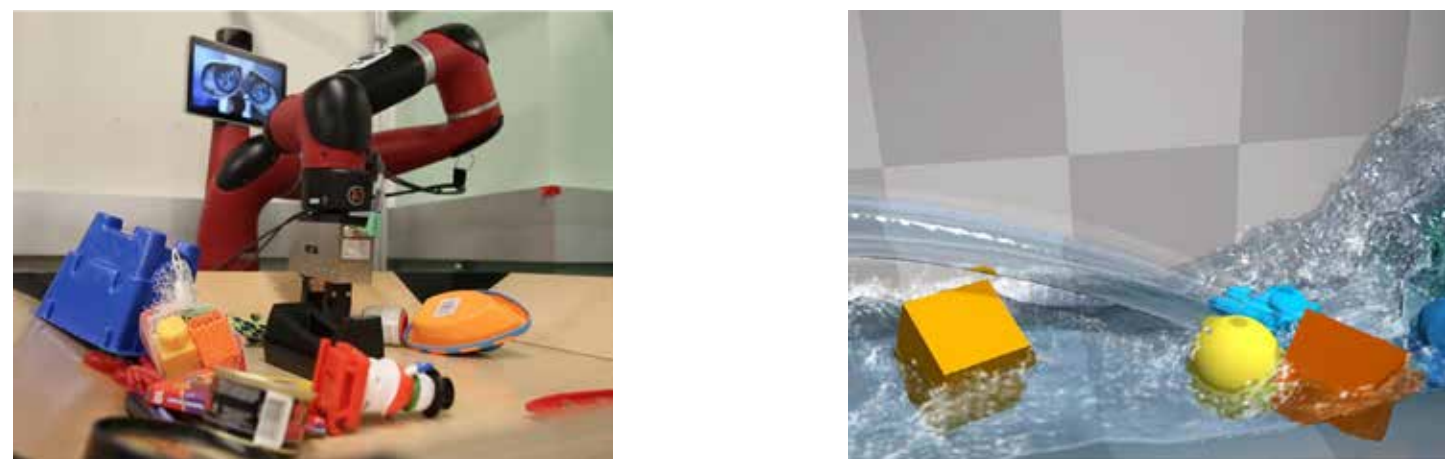




## Physics prediction abilities

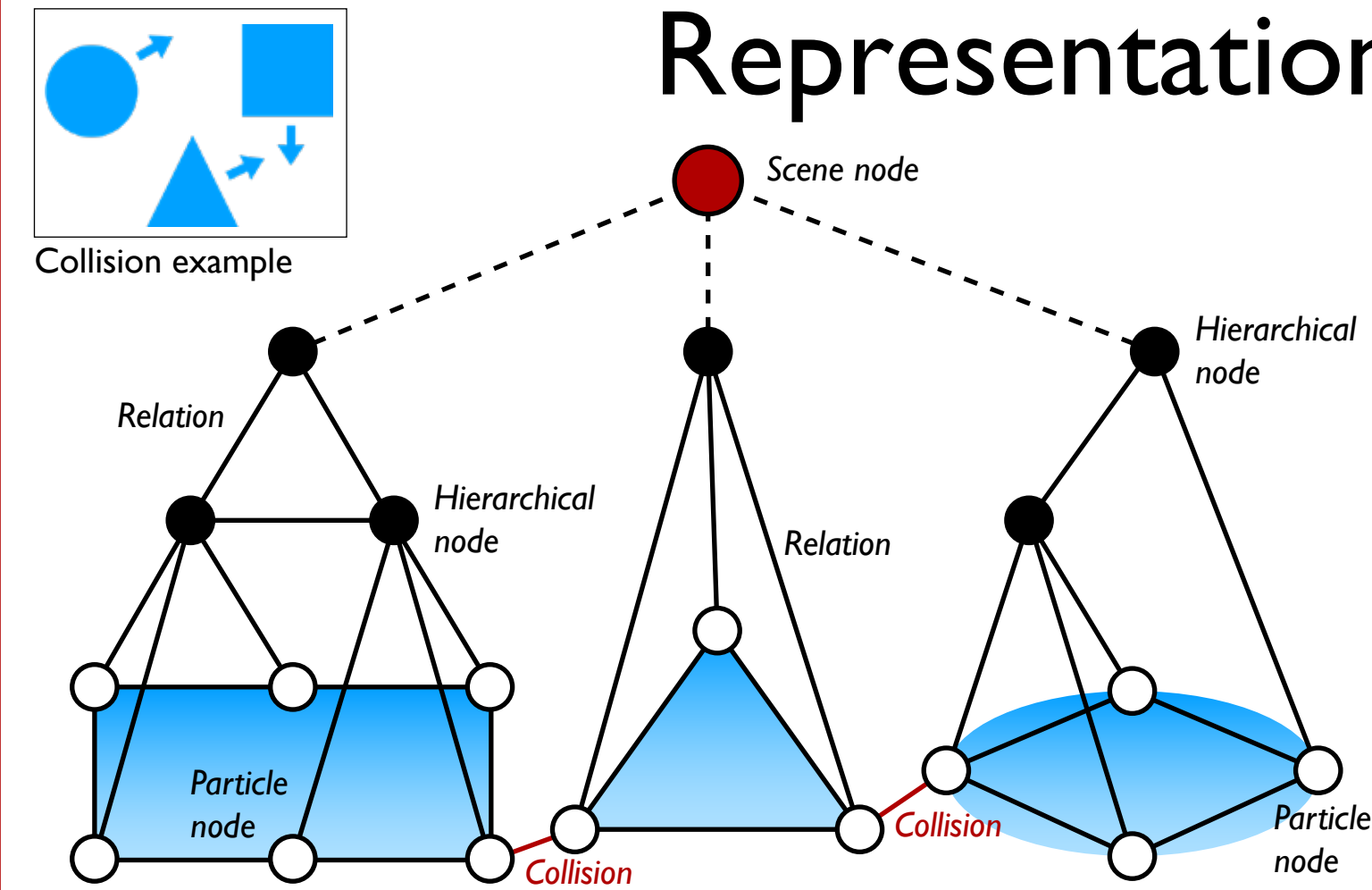


Intuitive Physics. Humans can predict physical trajectories and deformations of objects in an instant.



Physics applications. From robotic, to vision and graphics, physics prediction abilities are needed everywhere.

## Hierarchical Particle Relation Graph Representation



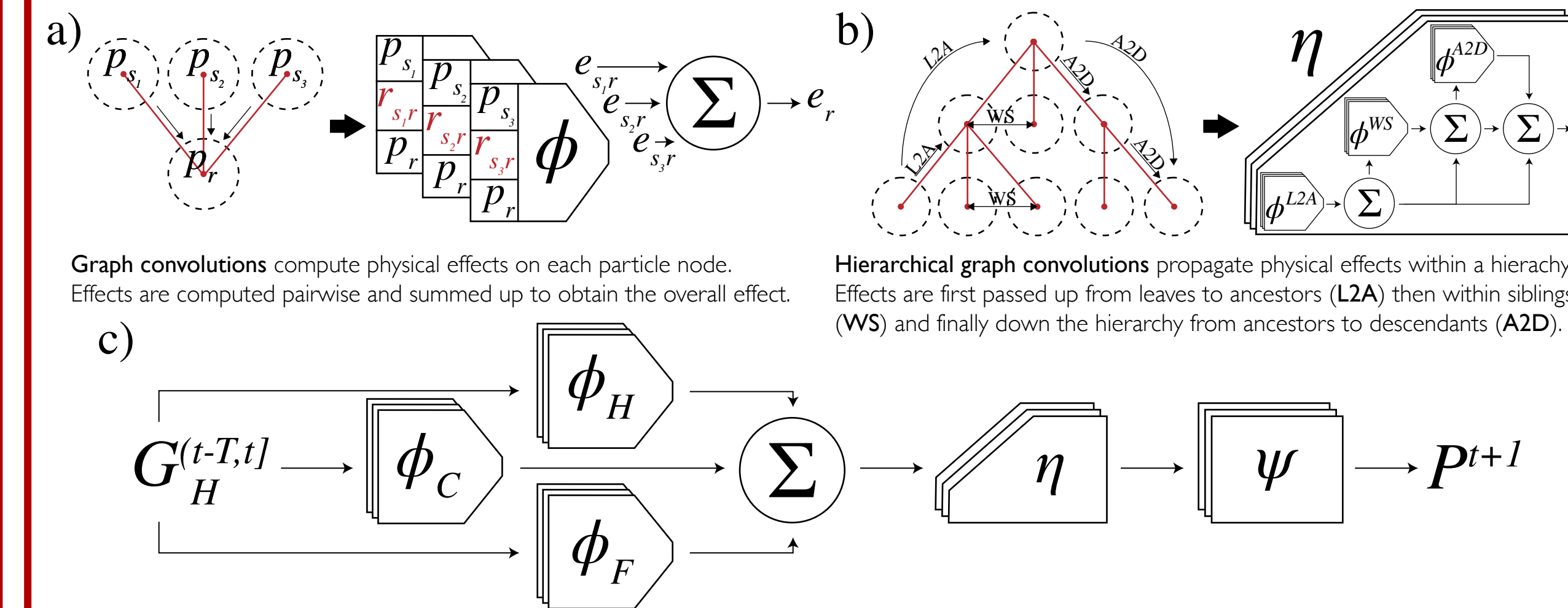
$$G_H \equiv \langle P, R \rangle$$

$$P_o \equiv \{p_i | i \in o\}$$

$$R \equiv \{r_{ij} \in \mathbb{R}^K\}$$

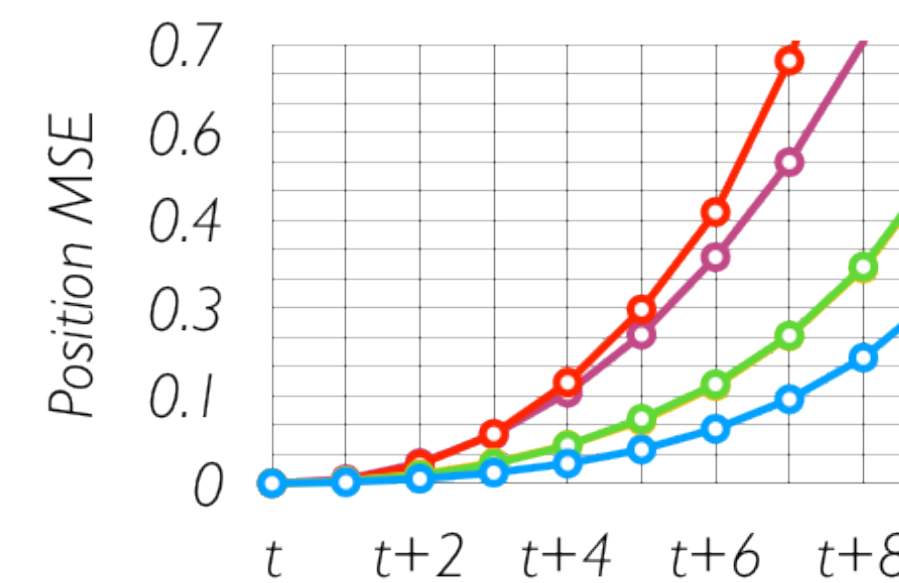
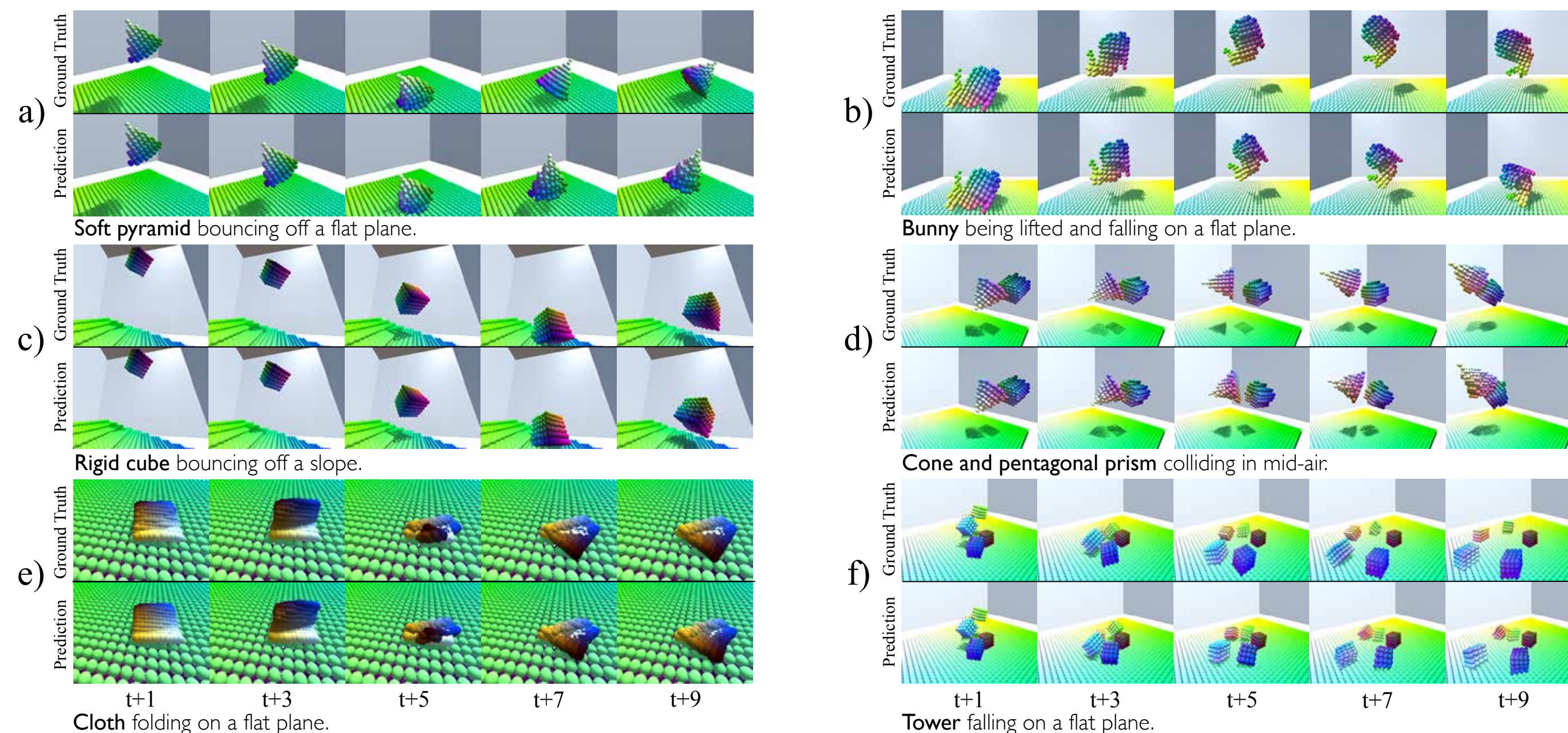
Hierarchical Particle Relation Graph. Particle nodes are connected by relation edges.

## Hierarchical Relation Network



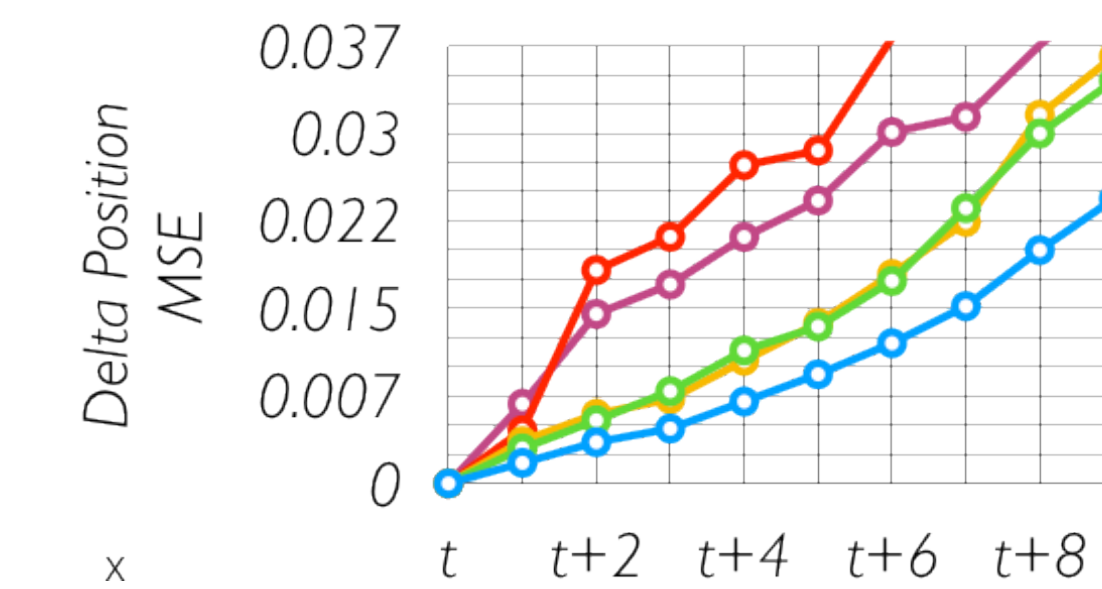
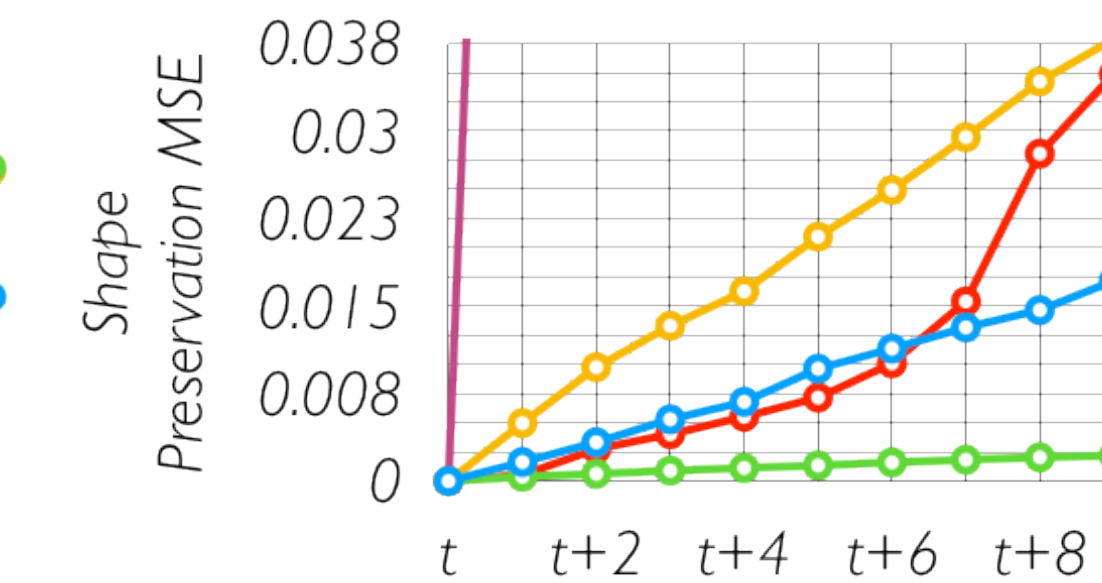
Hierarchical Relation Network (HRN) takes the past particle graphs  $G_H$  as input and outputs the next particle states  $P^{t+1}$ .  $\Phi_C$  processes collision effects,  $\Phi_F$  external force effects, and  $\Phi_H$  past history effects, which are then propagated within each object with  $\eta$ . The MLP  $\Psi$  computes the next states  $P^{t+1}$ .

## Results



- HRN (Full model)
- No global loss
- No preservation loss
- IN (Fully-connected graph)
- MLP

Qualitative Results. Cumulative mean-squared errors (MSE) for (delta) position and shape preservation. HRN performs best overall.



## Future Work



- Derive graph representation from images
- Stabilize long time range predictions
- Support more materials
- Mobel-based reinforcement learning in robotics

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