

Composable Causality in Semantic Robot Programming

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The Challenges of Assembly Tasks

Initial Scene



Goal Scene



Executing Multi-Objective Actions



Causal Control Basis

- Control basis: behaviors to execute

$$\Phi$$

- Temporal graphs: decompose symbolic action to controllers

$$G_T$$

- Causal graphs: behaviors involved in multi-objective action

$$G_C$$

- **Causal control basis:**

$$\Phi = (\Phi, G_T, G_C)$$

Causal Control Basis

- Control basis:

$$\Phi$$

- Temporal graphs:

$$G_T$$

- Causal graphs:

$$G_C$$

- Causal control basis:

$$\Phi = (\Phi, G_T, G_C)$$

- Use causal control basis to estimate the **transition function**:

$$P(s' | s, a)$$

- Execute composition most likely to achieve **composed effects**:

$$\operatorname{argmax}_a P(s' | s, a)$$

Furniture Assembly Tasks

