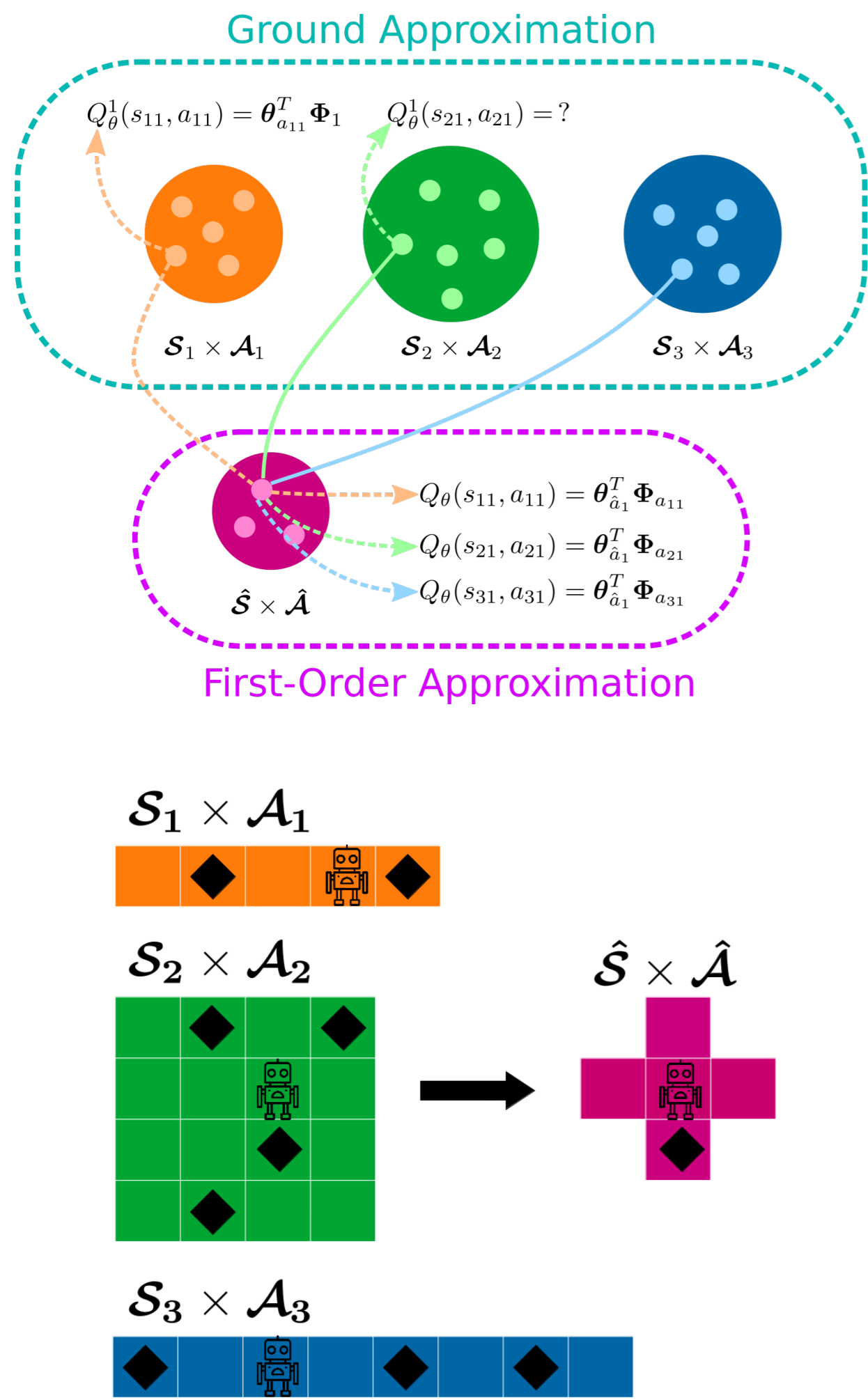


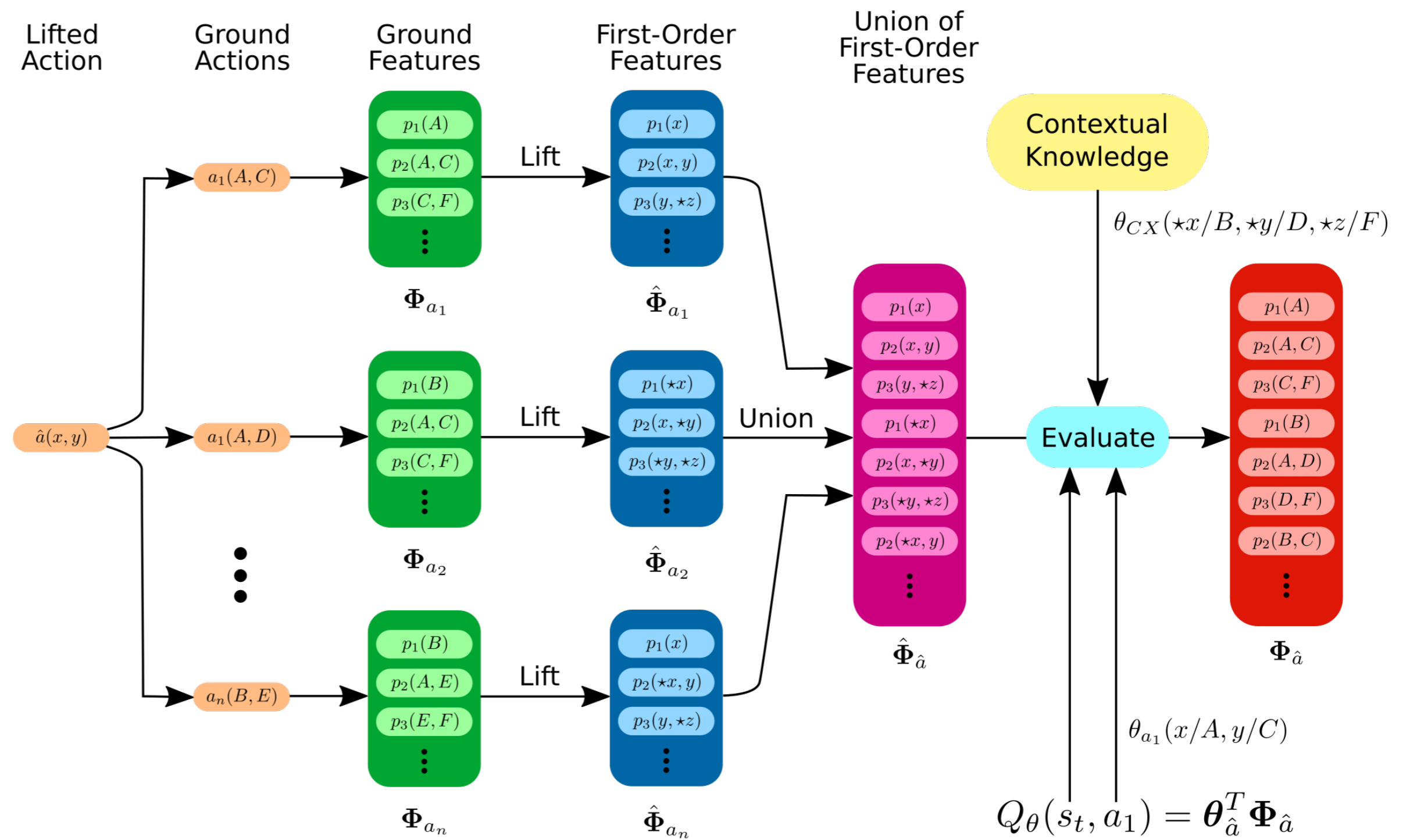
First-Order Function Approximation for Transfer Learning in Relational MDPs

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Overview



First-Order Approximation



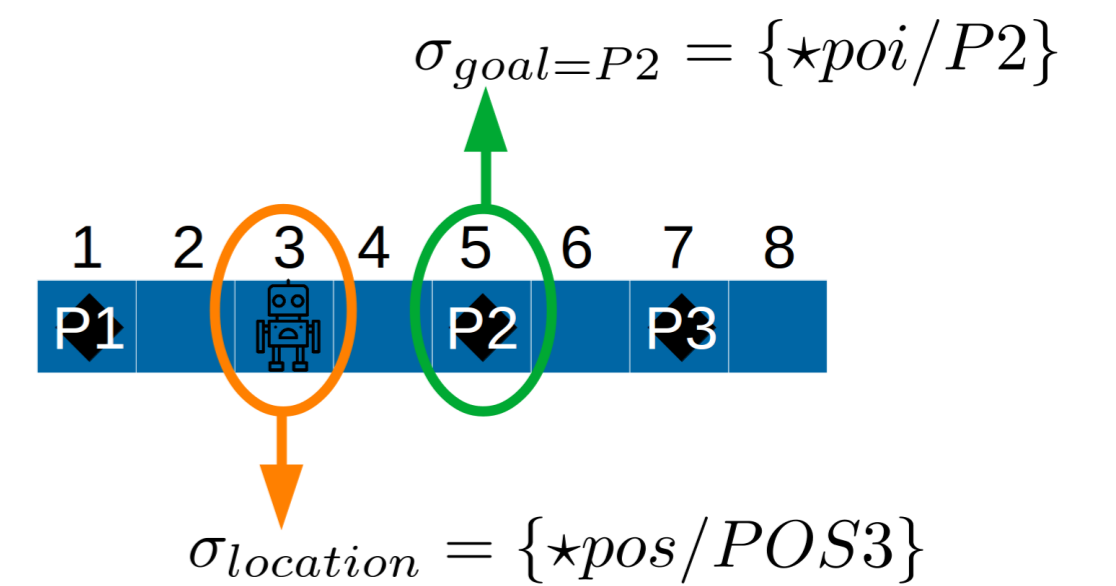
Contextual Grounding of Free Variables

Goal Context

- Use objects in fluents representing (unachieved) goals
- Fluents are determined from terminal state or reward function

Location Context

- Use location of agent
- Assume agent can only interact with objects in its proximity



Mixed Approximation

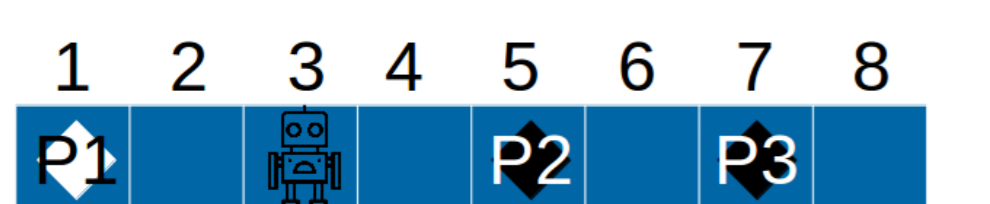
- Combines first-order and ground approximation
- Trained "independently" and concurrently
- Achieves generalisation and finer granularity
- Ground approximation serves as implicit tiebreaker

Policy with Mixed Approximation

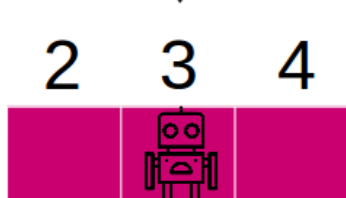
$$Q_{\theta}^{sum}(s, a) = Q_{\theta}^{gnd}(s, a) + Q_{\theta}^{fo}(s, a)$$

$$Q_{\theta}^{switch}(s, a) = \begin{cases} Q_{\theta}^{fo}(s, a), & \text{if } episode \leq E \\ Q_{\theta}^{gnd}(s, a), & \text{otherwise} \end{cases}$$

Plateaus



First-Order Abstraction

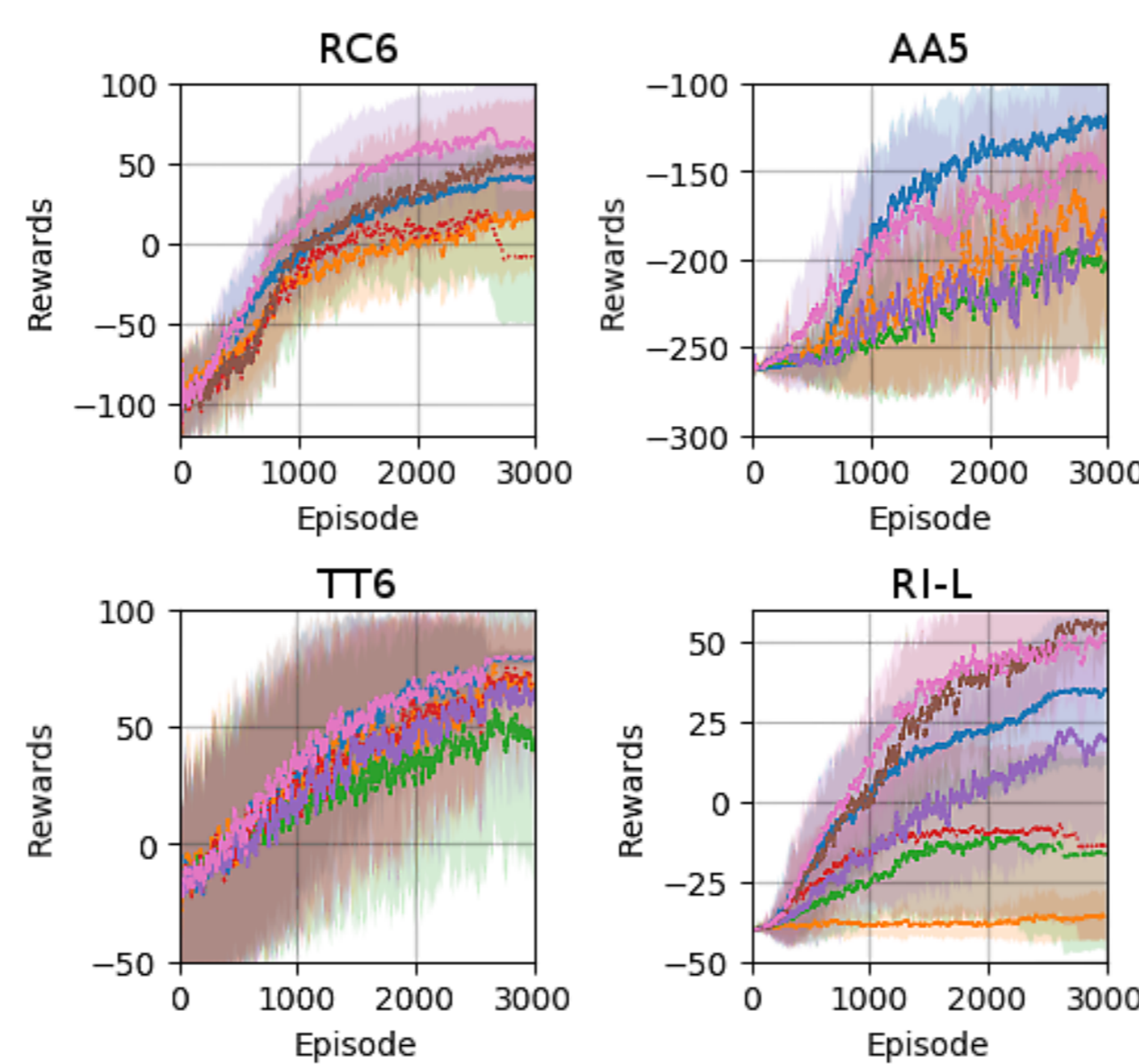


Move to POS2 or POS4?

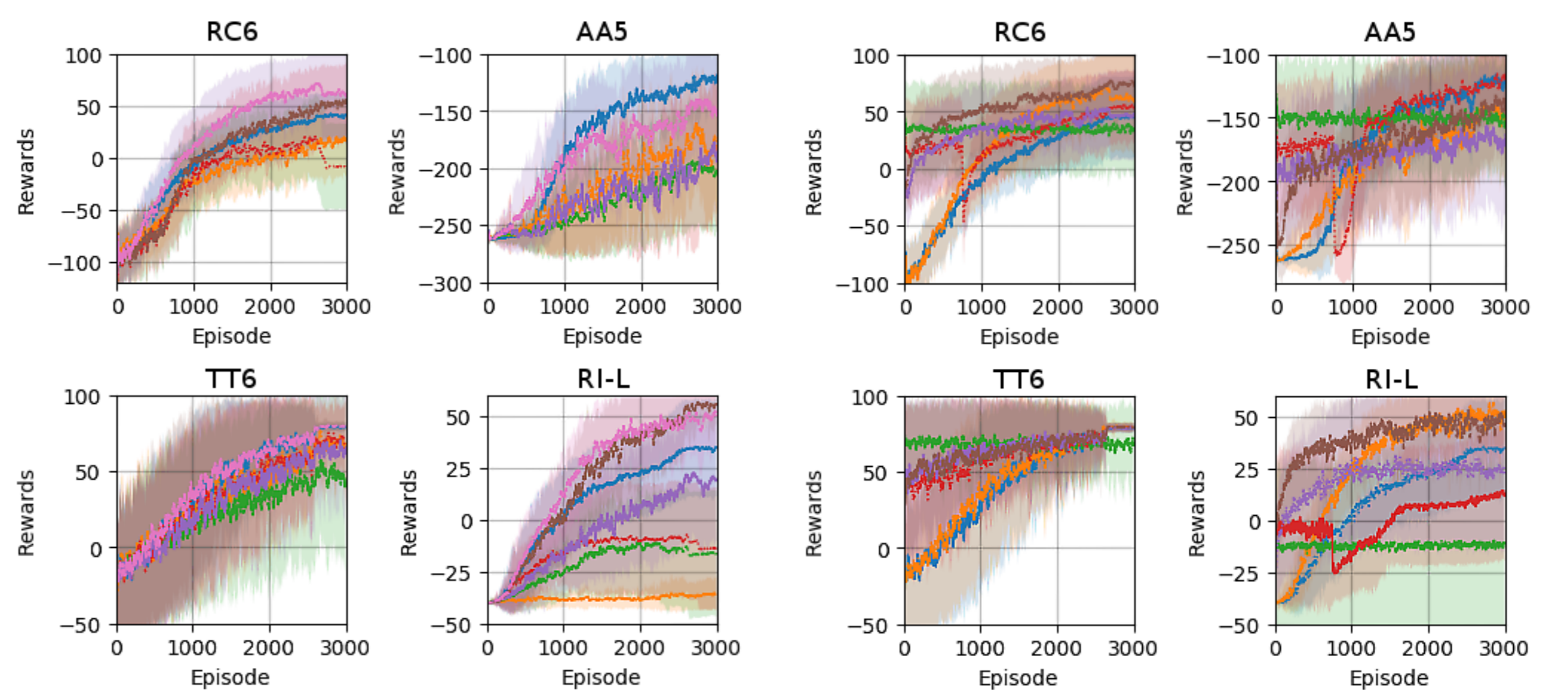
$$\phi_f = \text{robot_at}(pos) \wedge \text{ADJACENT}(pos, \ast pos) \wedge \text{POI_AT}(\ast poi, \ast pos)$$

Experimental Results

Ablation Study



Transfer Learning



Legend for Ablation Study:
 - Ground Approx. (blue solid)
 - No Free Var (orange dashed)
 - No Context (green dashed)
 - Loc. Context (red dotted)
 - Goal Context (purple solid)
 - Loc. + Goal Context (brown solid)
 - Mixed Approx. (pink dashed)

Legend for Transfer Learning:
 - Ground Approx. (blue solid)
 - Mixed Approx. (orange dashed)
 - Transfer (π_{fixed}) (green dashed)
 - Transfer (π_{switch}) (red dotted)
 - Transfer (π_{sum}) (purple solid)
 - Transfer (π_{update}) (brown solid)

RC6: Recon 6, AA5: Academic Advising 5, TT6: Triangle Tireworld 6, RI-L: Robot-Inspection (large-scale)