Learning Hierarchical Abstractions for Efficient Taskable Robots

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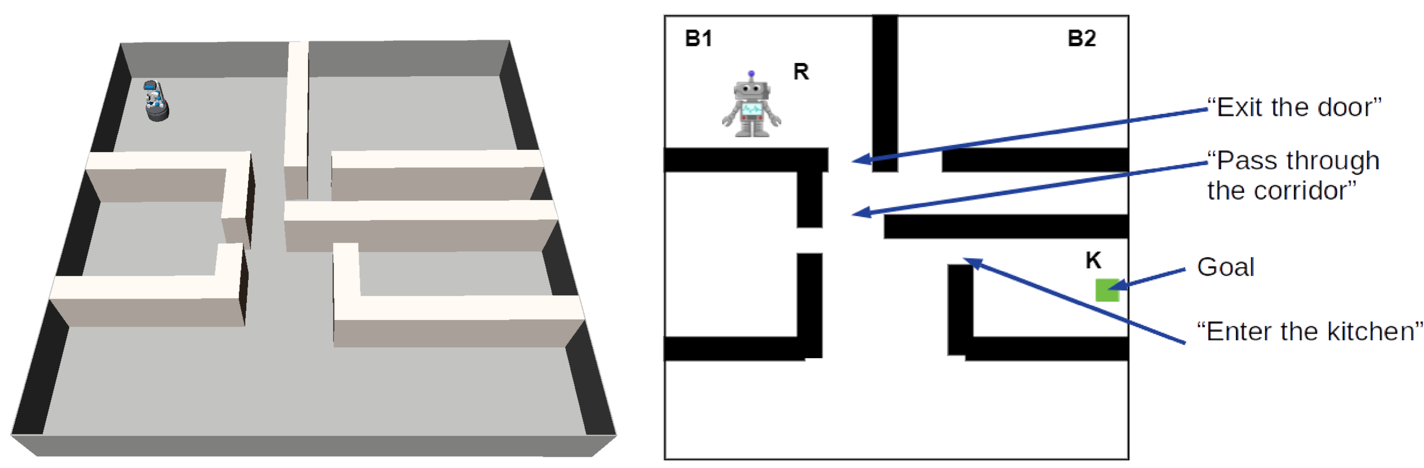
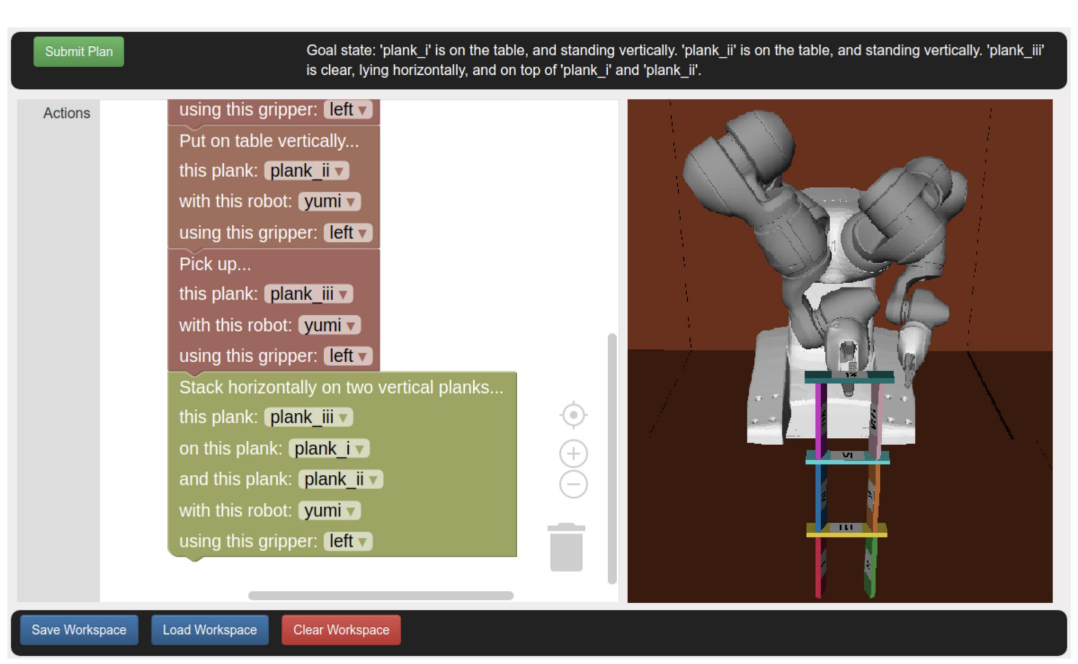
Research Direction



- Robots operate in continuous states and action space and requires to compute trajectories in the configuration space (c-space) to interact with the environment.
- Efficient robot planning require planning over a long horizon which is infeasible in the continuous c-space.
- Task and motion planning enable robots to reason over long horizon while computing policies that robots can execute in the c-space, but they require hand-coded abstractions.
- Can we automatically learn abstractions that enable efficient task and motion planning?

JEDAI: Skill-Aligned Explainable Robot Planning



- A system for skill-aligned and explainable robot planning that doesn't require an expert-level knowledge in robotics.
- Best demo award at AAMAS 2022.

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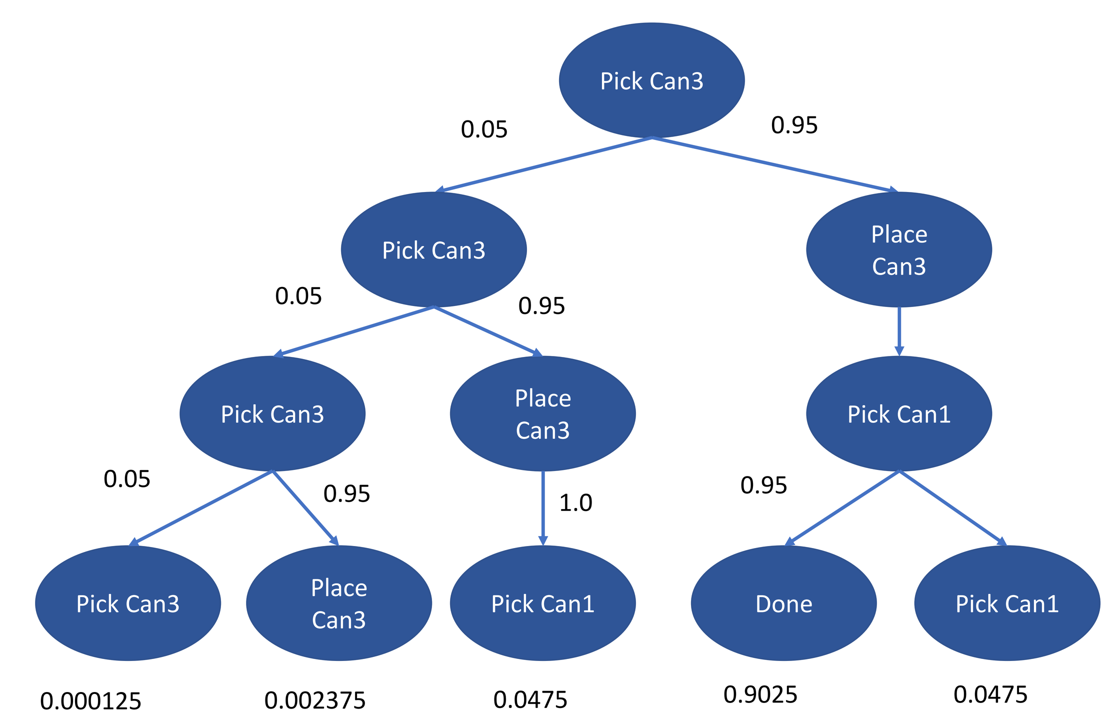
I propose an approach that learns *hierarchical states and action abstractions* using automatically identified *critical regions* in the environment and use these abstractions with an interleaved probabilistically-complete *stochastic task and motion planner*.

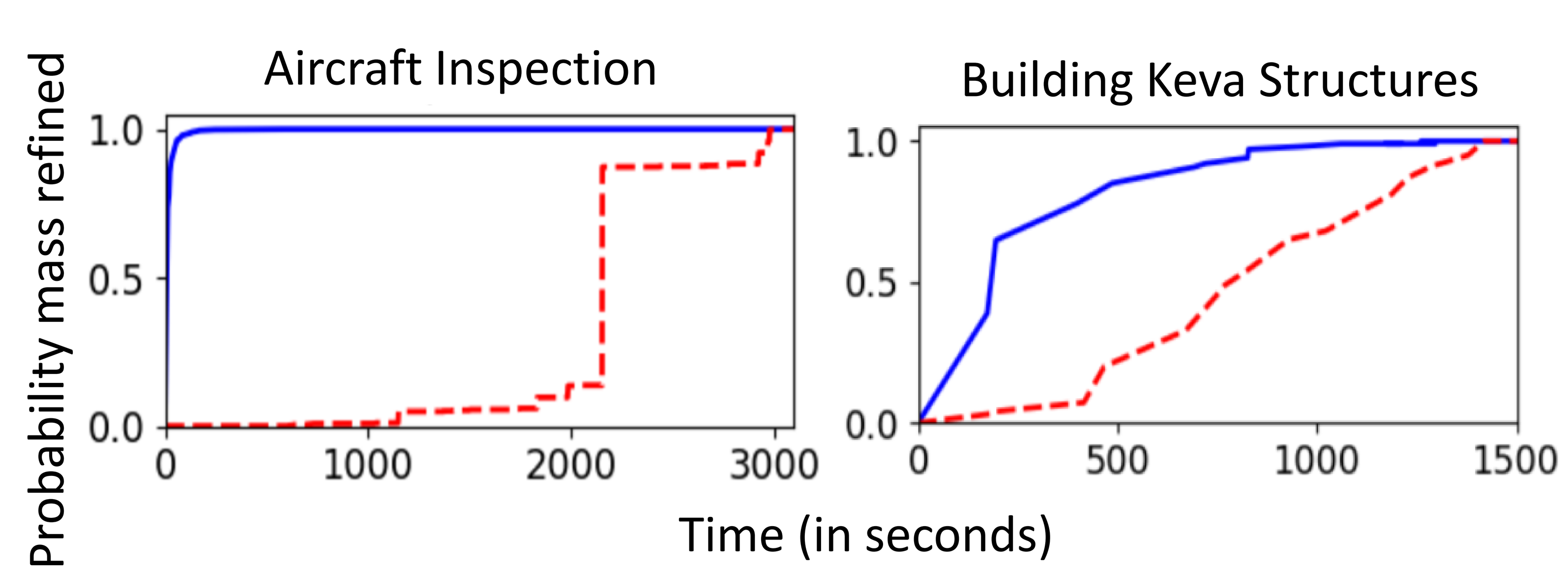
Work so Far!!

Stochastic Task and Motion Planning

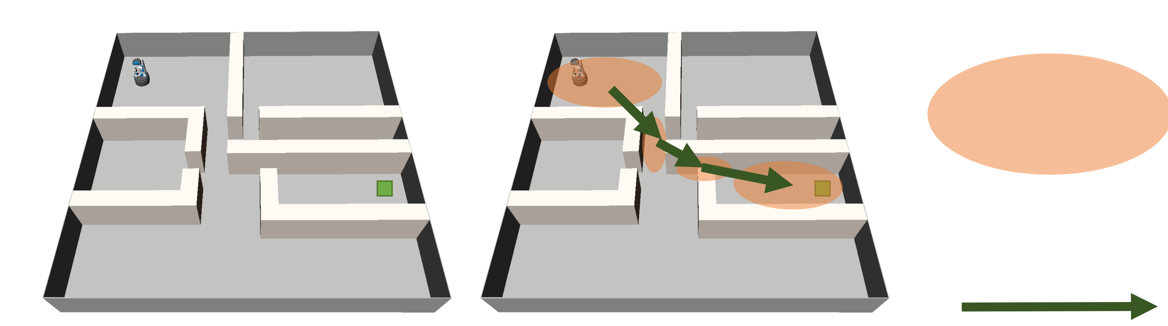


Goal: (ingripper can1)

- Safe and complete task and motion planning in stochastic environments require computing policies that not only consider most likely outcomes but all possible contingencies .
- Use interleaved search with backtracking to compute task and motion policies in stochastic environments.
- Our approach maintains multiple abstract models and switches between them using a pre-defined strategy. For every abstract model we either 1) refine the policy or 2) refine the abstraction.
- **Main challenge**: Number of RTL paths grows exponentially with horizon and the number of contingencies.
  - **Solution:** Reduce it to a **knapsack problem** and use greedy approach to prioritize path using probability of the scenario and approximated cost.



Hierarchical Abstraction-guided Robot Planner



High-level abstract states such as rooms and corridors.

High-level actions such as "exit the room

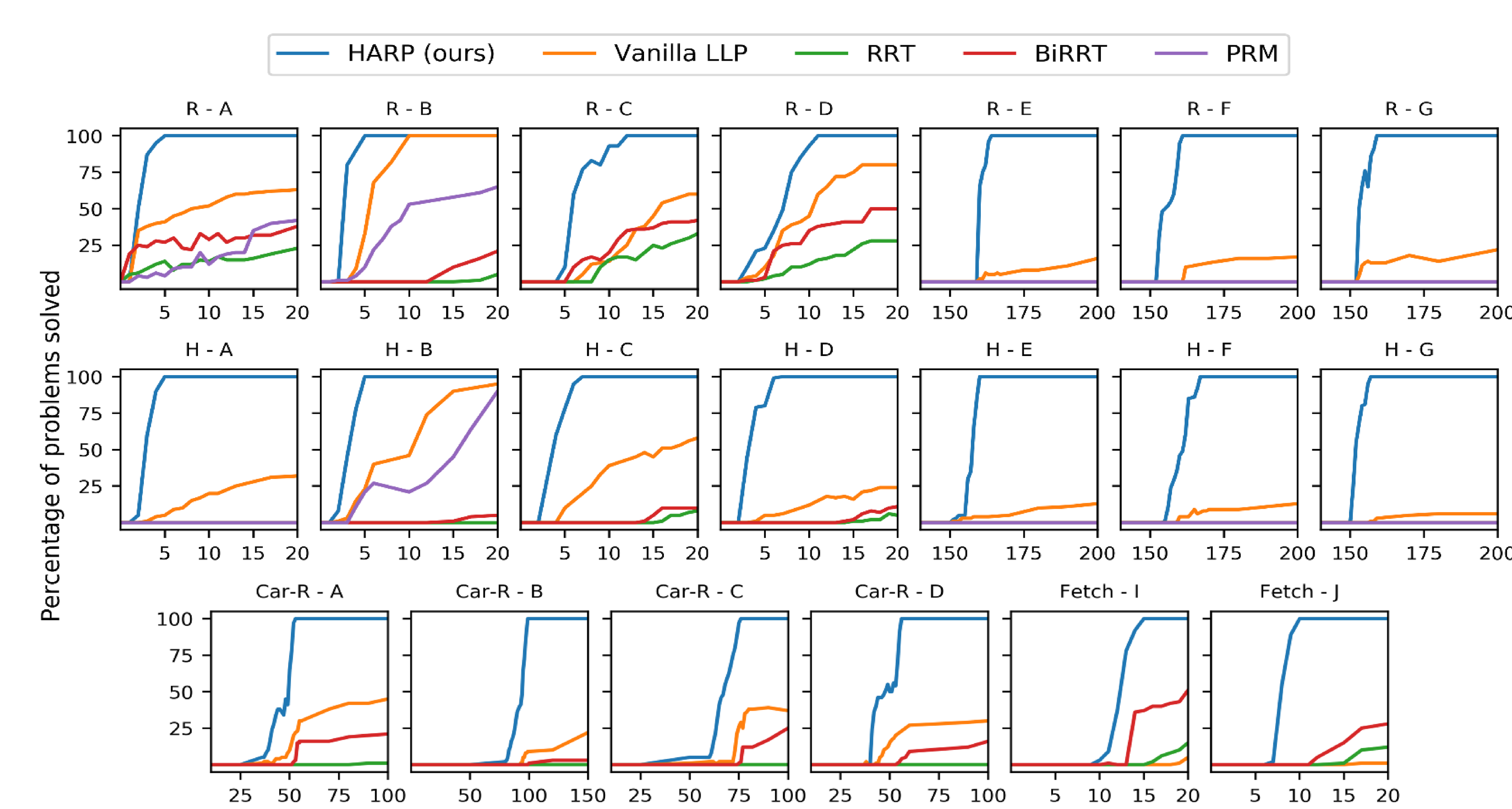
Humans excel at identifying high-level states and actions for solving a complex task. This enables efficient planning.

Research questions:

1. Can we learn high-level states and actions automatically? [**Spoiler alert: Yes!!**]
2. Do these abstractions enable efficient robot planning? [**Spoiler alert: yes!!**]

Key Contributions:

1. A formal foundation of hierarchical abstractions based on predicted critical regions learned through self-supervised learning.
2. A **probabilistically-complete** novel multi-source multi-directional planner that uses these abstractions to perform efficient hierarchical robot planning.



Key Takeaway: Learning works better when coupled with hierarchical planning