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Robust Plan Inference in the Keys and Doors Problem

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1. Introduction

Planning is extremely important in various fields:

- Train Shunting
- Manufacturing
- Vehicle navigation

A lot of research has gone into creating planners for deterministic problems. Most of the problems we encounter contain some kind of uncertainty. For the above example that would be respectively:

- Fluctuating arrival times
- Unreliable equipment
- Unpredictable traffic

Robust plans are designed to achieve their goals despite uncertainty.

"Would one be able to use deterministic planning agents to create robust plans for the Keys and Doors problem?"

2. Methods

Keys and Doors problem

- Modelled in PDDL, Planner Domain Definition Language
- Player aims to reach a goal
- Unlock rooms by picking up corresponding keys

Uncertainties

- Starting locations
- Key positions
- Unlocked rooms

The Keys and Doors problem is modelled in a probabilistic programming language (PPL). PPLs are used to create probabilistic models.

3. Inference Techniques

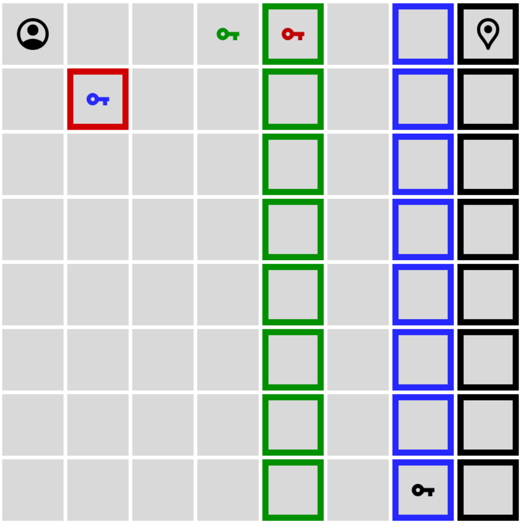
Importance Sampling

1. Create random problem
2. Create plan for problem
3. Rate robustness

Replanning

Replanning works based on the Metropolis-Hastings algorithm.

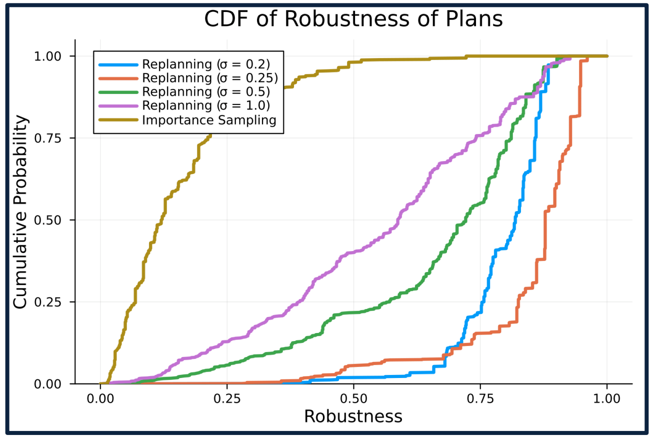
1. Create random problem
2. If previous plan succeeds: 3; else: 2a
   a) Random prefix from prev. plan
   b) Run prefix on random problem
   c) Create plan from current state
   d) Append extra plan to prefix
3. Rate robustness, r, of plan
4. Assign weight: $Norm(r, \sigma)$ at 1.0
5. Accept with probability of weight ratio

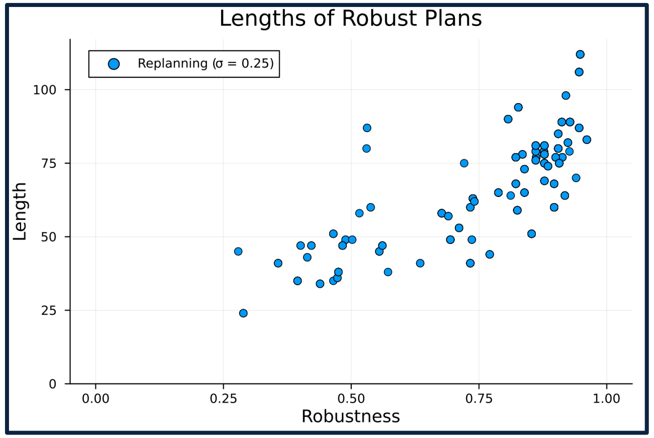


Example of original Keys and Doors problem

4. Experimental Setup

- Both Importance Sampling and Replanning generated 1000 plans
- Robustness estimated based on 1000 random problems
- $\sigma's$ used in replanning are: $0.2, 0.25, 0.5, 1.0$
- Two different problems used to assess performance, only example problem shown





5. Results & Discussion

Robustness

Replanning performed significantly better than importance sampling

- $\sigma = 0.25$ provided optimal results
- Exploration-Exploitation dilemma
  - σ set too high → Less robust plans, that allow more robust plans, rejected
  - σ set too low → Too many non-robust plans accepted

Lengths of Plans

- Length of more robust plans longer than less robust plans
- More robust plans need more moves to remove uncertainties
- Less robust plans often created from problems with many unlocked rooms and are therefore shorter