Landmark-Based Approaches for Goal Recognition as Planning

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The Problem

Goal Recognition is the problem of discerning the intentions of autonomous agents or humans by observing their interactions in an environment.

- **Goal and Plan Recognition as Planning**;
  - *Domain Theory* (STRIPS, PDDL, .), no Plan-Libraries (e.g., a set of pre-computed plans);
- We develop fast and accurate **heuristic recognition approaches**;
  - We use no planners (or search);
  - Our heuristic approaches rely on the concept of **Landmarks**;

Definition 1 (Goal Recognition Problem). *A **goal recognition problem** as planning is $T_{GR} = \langle \Xi, \mathcal{I}, \mathcal{G}, O \rangle$:*

- *$\Xi = \langle \mathcal{F}, \mathcal{A} \rangle$ is a **planning model** (STRIPS, PDDL); $\mathcal{I}$ is the **initial state**; $\mathcal{G}$ is the set of **possible goals**, including the **intended goal** $G^* \in \mathcal{G}$; O is an **observation sequence**, i.e., a sequence of observed actions.*

Contributions

We develop fast and accurate **heuristic recognition approaches** for *Goal Recognition as Planning*;

- We use no planners (i.e., search procedure);
- Our heuristic approaches rely on the concept of **Landmarks**;

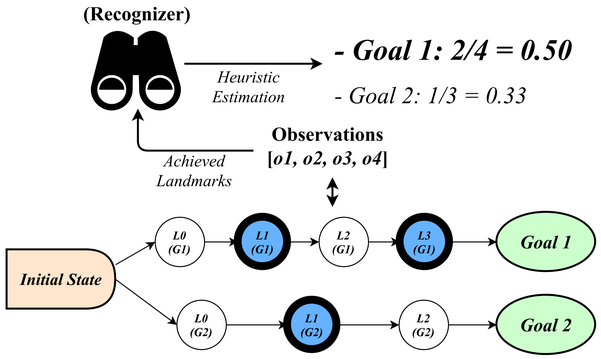
Landmark-Based Goal Recognition

Definition 2 (Landmarks). *In Automated Planning, Landmarks are **facts** (or **actions**) that cannot be avoided to achieve a goal from an initial state.*

- Our approaches rely on **the concept of landmarks**. Essentially, our recognition heuristics estimate the correct goal by computing the **ratio between achieved landmarks and the total number of landmarks**.

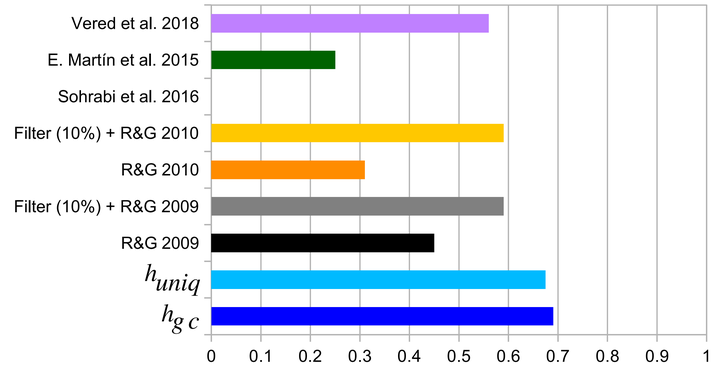
$$h_{\widetilde{GR}}(G) = \left(\frac{\mathcal{AL}_{AchievedLandmarks}}{\mathcal{L}_{TotalNumberLandmarks}} \right)$$

- **Ranking goals** according to their **percentage of achieved landmarks**.

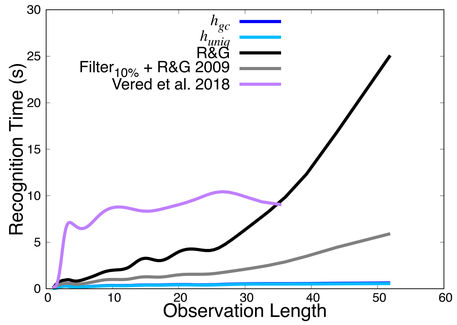


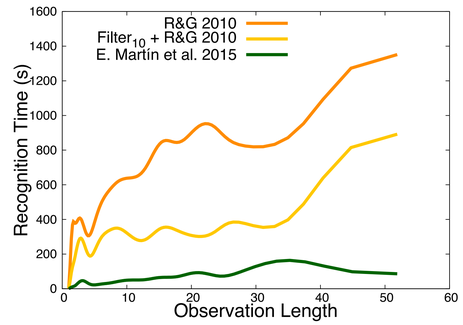
Experimental Results

- *Precision* = $\left(\frac{Accuracy}{|ReturnedGoals|} \right)$ and *Recognition Time* (in seconds);



Precision comparison for *missing* and *full observability*.





Comparison of *Recognition Time* for *missing* and *full observability*.

Conclusions

We introduce **novel goal recognition approaches** based on planning techniques that rely on **Landmarks**. We show that they can be used to efficiently build simple heuristics to recognize goals from incomplete and noisy observations.

- For more details, please have a look at our paper:
  https://doi.org/10.1016/j.artint.2019.103217
- Our code is available on GitHub:
  https://github.com/ramonpereira/Landmark-Based-GoalRecognition