Robust Task Planning with Uncertain Models

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Abstract. Many autonomous systems execute in a continuous environment with several constraints. These could include limited energy supply, restrictions in the movement or limited physical abilities. To deal with those constraints, recently predictions made by learned models have been incorporated in a new task planning framework, called hybrid planning. Within my PhD thesis, I aim at providing robustness in task planning even when incorporating uncertain models in an environment with constraints.

Keywords: robustness · constraint-based reasoning · hybrid planning · reinforcement learning · uncertainty

1 Introduction & Motivation

Imagine a robot assistant helping in the household, currently cooking dinner prior to the expected arrival of the house owner. While working, the battery powering the robot slowly reaches a critical level requiring a recharge. The robot can autonomously recharge using an in-house charging station, but would then have to leave the stove unattended for a given time. The robot in this scenario would need a sophisticated strategy to safely deal with the situation.

The challenge becomes even more evident when considering a drone scanning forest areas for wildfires (e.g. [2]). Those drones typically have very limited battery capacity and running out of battery at the wrong time can cause serious problems.

At the same time, an increasing amount of autonomous systems rely on online-learning strategies to acquire new knowledge while performing tasks [1]. Such learning strategies may be able to provide estimates about a planned tasks, such as the duration, energy consumption, or possible outcomes. These uncertain information may be used in combination with other factors to drive decision making, also known as hybrid planning [4]. Considering such uncertain information might be beneficial, but can also pose a threat to robustness.

Starting my PhD, I am interested in how such uncertain models can be employed in robust task planning. Especially when considering outside constraints, such as a limited battery capacity or a restricted area one is not allowed to enter.

2   Research Question

The research question is formulated in line with the illustrated above. At its core, I am most interested in providing robust task planning in an environment with uncertain models and additional constraints. For example, given a home assistant robot, both the predicted energy consumption and duration of a given or even only expected task should be considered, in order to adapt the charging schedule accordingly. The research question then formulates as follows:

How can we employ uncertain models in task planning with certain constraints, and still produce a robust plan?

3   Related Work

This work relates to the research conducted in hybrid planning [4], incorporating learned models in real-time applications [1], and constraint-based reasoning [3].

4   Approach

Current work is first analyzed to determine how to effectively use learned models in task planning with constraints. Existing work is then examined and considered again with additional focus on robustness. Additional sources of external information are explored and incorporated within a hybrid planning infrastructure.

Most work is expected to be performed in a simulated environment where parameters can be controlled precisely. Eventually, case studies will be executed on a real platform.

5   Planned Evaluation

Robustness will be the measure for evaluation. Therefore, the actual quality of developed plans from my system can be compared to existing ones. Hereby, it is relevant to observe whether the task has been solved correctly without violating the given constraints.

For example, a home robot assistant may be evaluated based on the number of correctly executed tasks without the need for manual interference and without running out of battery.

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