Skill Generalisation and Experience Acquisition for Predicting and Avoiding Execution Failures

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Motivation

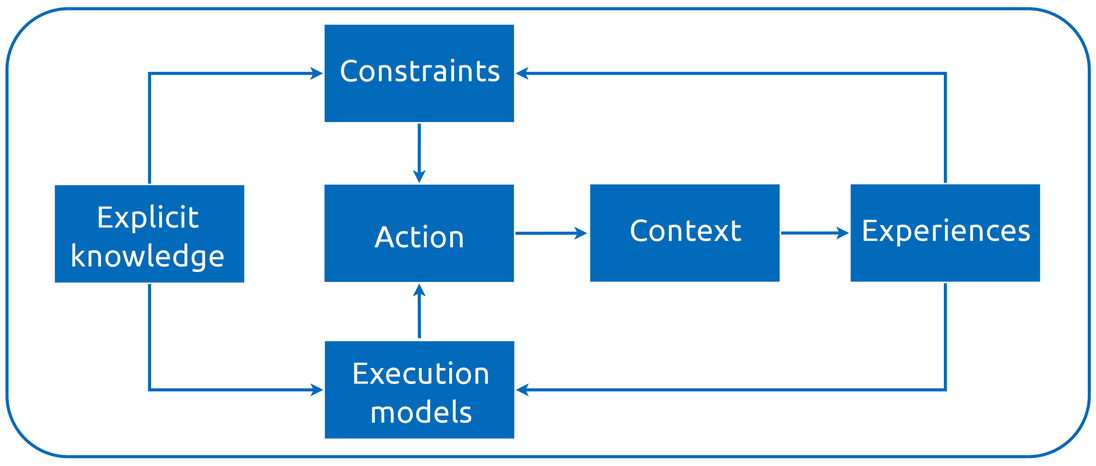
For autonomous agents, executing actions in unstructured realistic environments (e.g. in domestic scenarios) is a failure-prone activity due to the fact that the scenarios in which a robot needs to act are quite varied and not always easy to predict. Traditionally, some of the challenges in such domains have been avoided by either modelling the relevant aspects of a domain and then monitoring them or by incorporating some learning strategy into the process so that a robot can improve its performance over time. Both modelling and learning on their own are potentially suboptimal however: due to the complexity of these domains, modelling is difficult and time-consuming and the resulting models are often problem-specific; similarly, purely learning-based models are unlikely to capture all important subtleties about a domain, such as the context in which actions are executed and the seemingly arbitrary decisions that human agents make in a given context.

Focus

This PhD project focuses on two main aspects:

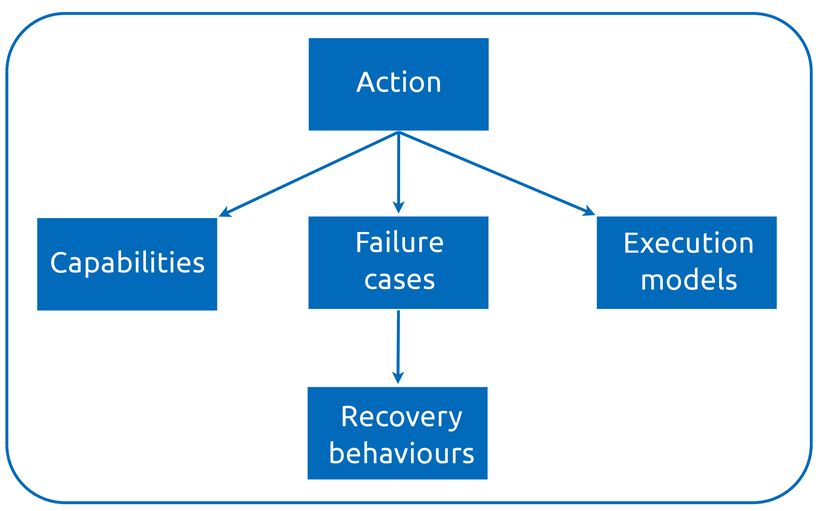
1. *Modelling actions and action execution in a general and modular manner*
2. *High-level experience acquisition for predicting and avoiding execution failures*

We thus attempt to **interleave explicit modelling and learning** actions and action execution rather than treating those aspects separately as is often the case in the literature.



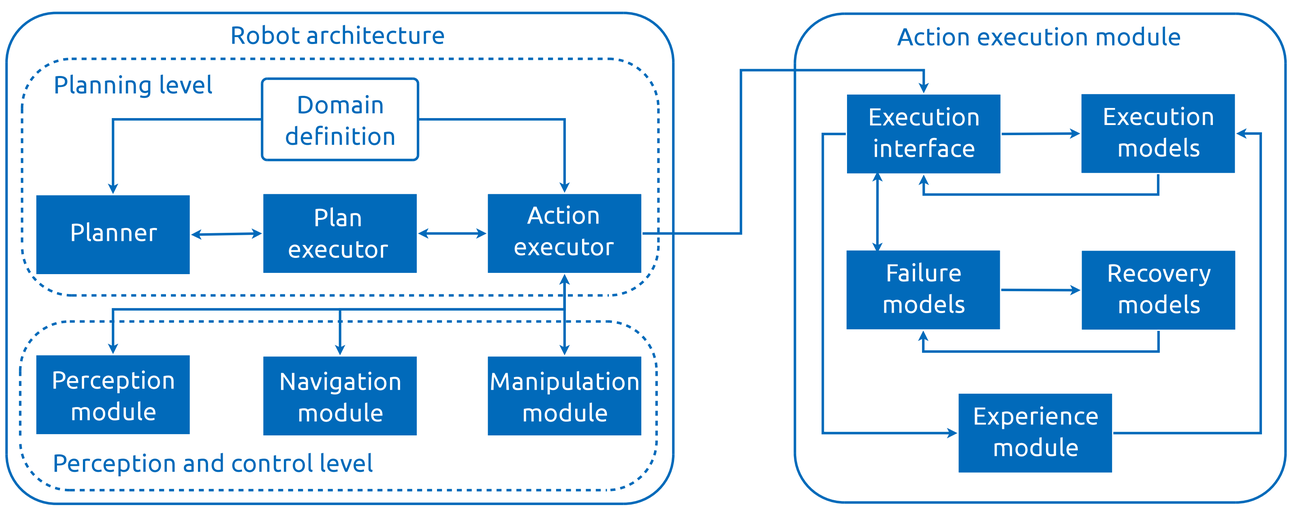
Knowledge Modelling

Part of this work is dedicated to **modelling actions and action execution** in a manner that allows specifying action execution knowledge explicitly (e.g. the geometric knowledge necessary for executing actions) and ensures modularity so that both analytical and learning-based execution models can coexist seamlessly.



High-Level Experience Acquisition

High-level experience acquisition is the second major focus of this work and is based on the hypothesis that execution failures could trigger a process of learning common failure patterns that can then be used as heuristics for guiding the reasoning process when an action needs to be executed. We particularly investigate strategies for **memorising high-level experiences** and **leveraging those memories for improving the knowledge about actions** (namely their execution models and failure cases).

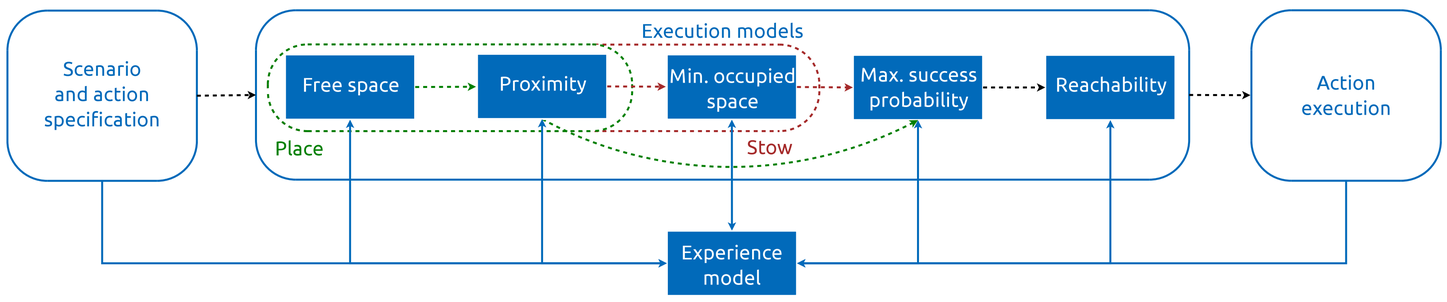


Use Cases

We consider three use cases to put our work into context:

1. *Placing a box on a surface vs. stowing the box*
2. *Placing a book on a bookshelf*
3. *Preparing a hot beverage*

The diagram on the right shows an example instantiation of the modelling + learning paradigm that we consider in this work in the context of the box use case.



Related Work

[1] A. Mitrevski, A. Kuestenmacher, S. Thoduka, and P. G. Plöger. Improving the Reliability of Service Robots in the Presence of External Faults by Learning Action Execution Models. In *Proc. 2017 IEEE Int. Conf. Robotics and Automation (ICRA)*, pages 4256–4263, 2017.

[2] L. Kaelbling and T. Lozano-Perez. Learning composable models of parameterized skills. In *Proc. 2017 IEEE Int. Conf. Robotics and Automation (ICRA)*, pages 886–893, 2017.

[3] A. Kuestenmacher, N. Akhtar, P. G. Plöger, and G. Lakemeyer. Towards Robust Task Execution for Domestic Service Robots. *Journal of Intelligent & Robotic Systems*, 76(1):5–33, 2014.

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[5] S. Höfer and O. Brock. Coupled learning of action parameters and forward models for manipulation. In *2016 IEEE/RSJ Int. Conf. Intelligent Robots and Systems (IROS)*, pages 3893–3899, Oct. 2016.

[6] J. Winkler, G. Bartels, L. Mösenlechner, and M. Beetz. Knowledge Enabled High-Level Task Abstraction and Execution. *1st Annual Conf. Advances in Cognitive Systems*, 2(1):131–148, Dec. 2012.

[7] J. Claßen, G. Röger, G. Lakemeyer, and B. Nebel. Platas – integrating planning and the action language golog. *KI - Künstliche Intelligenz*, 26(1):61–67, Feb. 2012.

Acknowledgement

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