UNIVERSITÄT BIELEFELD
Faculty of Technology

Master Thesis

Parameterizing Robot Manipulation Plans Using Probabilistic Graphical Models

Semantic Computing Group
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Recent approaches have shown the huge potential of LLMs for the generation of robot manipulation plans. Due to their size and the amount of knowledge they are trained on, they can handle unknown situations, unknown objects or unknown environments more reliable then previous approaches [1]. However, there are still limitations for these models, especially for scenarios with very complex cognitive architectures [2].

Another possibility for letting the robot dynamically adapt to the situation at hand is to parameterize a general manipulation plan. As an example, consider a robot that has a general idea of cutting fruits and that knows what knife to use depending on the specific fruit in front of it. We want to parameterize these general manipulation plans using probabilistic graphical models [3], to also be able to handle unseen situations based on the learned distributions.

In this thesis you investigate this general idea, creating and evaluating a working approach. Important research questions are the following:

- What concrete PGM fits best for this area of application?
- How can the model be trained? Where can we get suitable training data?
- How can the approach be evaluated? What tasks are suitable for the demonstration?

No prior knowledge regarding Robotics or PGMs is required, but a general understanding of probability and statistics is recommended. You can use the programming language of your choice, but Python is recommended. The thesis should be taken in English but can also be taken in German.

Related literature

[1] J. Liang et al., 'Code as Policies: Language Model Programs for Embodied Control', in 40th IEEE International Conference on Robotics and Automation (ICRA), London, UK: IEEE, 2023, pp. 9493–9500. doi: 10.1109/ICRA48891.2023.10160591.
[2] J.-P. Töberg and P. Cimiano, 'Generation of Robot Manipulation Plans Using Generative Large Language Models', in 2023 Seventh IEEE International Conference on Robotic Computing (IRC), Laguna Hills, CA, USA: IEEE, Dec. 2023, pp. 190–197. doi: 10.1109/IRC59093.2023.00039.
[3] L. E. Sucar, 'Probabilistic Graphical Models: Principles and Applications', in Advances in Computer Vision and Pattern Recognition. Cham: Springer International Publishing, 2021. doi: 10.1007/978-3-030-61943-5.

The Semantic Computing Group researches and develops methods that enable machines to acquire relevant knowledge as well as linguistic capabilities. Using methods from *natural language understanding* and *machine learning*, we are aiming at machines that are capable of knowledge acquisition by reading unstructured textual data. In particular, the group focuses on methods for information extraction, semantic parsing, ontology learning, sentiment analysis, entity linking, as well as question answering.

More information is available at: `http://www.sc.cit-ec.uni-bielefeld.de/`

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