Bachelor Thesis

Exchanging Knowledge in Robot Manipulation Tasks

Semantic Computing Group
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Cognitive robots are challenged by unknown situations in open worlds. They cannot perform everyday tasks like cutting food or pouring drinks without encountering unknown motions, objects or environments. To mitigate this problem, multiple types of approaches exists: Approaches based on machine learning, based on human-robot interaction or based on knowledge representation [1]. In our work, we focus on knowledge representation to make the necessary knowledge for performing unknown task variations available and actionable.

We propose a methodology for creating actionable ontologies [2], in which semantic information about the task at hand and involved objects is connected in a machine-readable way. The extraction of relevant knowledge is already implemented and now we want to investigate how this extracted knowledge can be formatted for an automatic knowledge graph construction given the robotic cognitive architecture as well as the manipulation plan to execute.

In this thesis you automate this knowledge exchange by planning, implementing and evaluating a working approach. Important research questions are the following:

- How should this exchange format look? What are its in- and outputs?

- How can it be used to create knowledge graph?

- How can the approach be evaluated? What tasks are suitable for the demonstration?

No prior knowledge regarding Robotics or knowledge graphs is required. You can use the programming language of your choice, but Python is recommended. The thesis can be taken in English or German.

Related literature

[1] Y. Ding et al., 'Integrating Action Knowledge and LLMs for Task Planning and Situation Handling in Open Worlds', Auton Robot, vol. 47, no. Special Issue on Large Language Models in Robotics, pp. 981–997, 2023, doi: https://doi.org/10.1007/s10514-023-10133-5.
[2] M. Kümpel, J.-P. Töberg, V. Hassouna, P. Cimiano, and M. Beetz, 'Towards a Knowledge Engineering Methodology for Flexible Robot Manipulation in Everyday Tasks', in ESWC 2024 Workshops and Tutorials Joint Proceedings, Heraklion, Crete, Greece, 2024. [Online]. Available: https://ceur-ws.org/Vol-3749/akr3-04.pdf

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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