UNIVERSITÄT BIELEFELD
Faculty of Technology

Bachelor / Master Thesis

RAG for Robotic Plan Generation

Semantic Computing Group
Jan-Philipp Töberg
jtoeberg@techfak.uni-bielefeld.de

Intelligent agents 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, LLMs have been investigated as potential plan generators, due to the huge amount of knowledge available to them. However, these LLMs struggle with hallucinations and a providing knowledge not explicitly represented in their training data.

In previous work [1], we used state-of-the-art LLMs to generate manipulation plans within a complex cognitive architecture called CRAM [2]. We found that these models struggle to handle the complexities of the architecture, despite being provided with a comparable manipulation plan as a reference in the prompt. As an extension, we are we are investigating **Retrieval-Augmented Generation** (RAG) techniques [3], in which the prompt of an LLM is enhanced by chunks extracted from external resources based on their similarity and relevance for the initial user command.

In this thesis, you will create and investigate a RAG-based pipeline for generating manipulation plans for these complex architectures. For this, you will need to answer the following questions:

1. How should the LLMs be prompted (Prompt Engineering)?
2. What resources can be used to provide context to the LLMs?
3. How can the approach be evaluated?

No prior knowledge regarding is required. Regarding the programming language, it is advised to use Python. The thesis can be taken in English or German.

Related literature

[1] J.-P. Töberg, P. Frese, and P. Cimiano, 'Generation of Robot Manipulation Plans Using Generative Large Language Models', Int. J. Semantic Computing, vol. 19, no. 01, pp. 79–103, Apr. 2025, doi: 10.1142/S1793351X25410041.

[2] M. Beetz, L. Mösenlechner, and M. Tenorth, 'CRAM - A Cognitive Robot Abstract Machine for Everyday Manipulation in Human Environments', in Proceedings of the 2nd IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2010), R. C. Luo and H. Asama, Eds., Taipei, Taiwan: IEEE, 2010, pp. 1012–1017. doi: 10.1109/IROS.2010.5650146.

[3] P. Lewis et al., 'Retrieval-Augmented Generation for Knowledge-Intensive NLP Tasks', in Annual Conference on Neural Information Processing Systems (NeurIPS), Curran Associates, Inc., 2020, pp. 9459–9474. doi: 10.48550/arXiv.2005.11401.

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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