Bachelor or Master Thesis

Generating Robot Manipulation Plans in Python Using LLMs

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For a robot to perform successfully in new situations, their used manipulation plans are often written manually by experts, making the extension for e.g. unknown objects a huge time investment. This limitation can potentially be mitigated by generative large language models (LLM), which are trained on vast amounts of natural language data. Using such LLMs to generate manipulation plans for specific tasks can potentially decrease the development time and the need for human experts to be involved in the robot's learning process.

In [1], we published an experiment where we used generative LLMs like ChatGPT and GPT-4 [2] to generate robot manipulation plans within the CRAM framework [3] in a one-shot fashion. Since then, a Python-based version of the framework called PyCRAM [4] has been released. Due to the popularity of Python as a programming language, generating Python code is easier for most LLMs, leading us to wonder whether our experiment results can be replicated for this new framework.

In this thesis, you repeat and extend the experiment performed in [1] for the PyCRAM framework [4]. You need to collect or create PyCRAM manipulation plans, engineer a fitting prompt and evaluate the results. Depending on the type of thesis (BT or MT) you can either try simulate the generated plans to assess their qualities and shortcomings, or perform a more extensive study for the incremental creation of a new plan using ChatGPT.

No prior knowledge regarding Robotics or LLMs is required. You should be familiar with Python. The thesis can be taken in German or English.

Related Work

[1] J.-P. Töberg and P. Cimiano, 'Generation of Robot Manipulation Plans Using Generative Large Language Models', Accepted at 2023 Seventh IEEE International Conference on Robotic Computing (IRC), Laguna Hills, CN, USA: IEEE Computer Society, 2023.
[2] OpenAI, 'GPT-4 Technical Report', OpenAI, 2023. Accessed: Jul. 13, 2023. [Online]. Available: `https://cdn.openai.com/papers/gpt-4.pdf`.
[3] 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.
[4] J. Dech, A. Augsten, D. Augsten, C. Pollok, T. Lipps, and B. Alt, 'PyCRAM'. Institute for Artificial Intelligence, Bremen University, GitHub, 2023. [Online]. Available: `https://github.com/cram2/pycram`

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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