Extracting Task-Specific Knowledge for Unknown Objects in Robot Manipulation Scenarios

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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.

In our current work, we created a knowledge graph cognitive robots can employ to parameterize generalized manipulation plans focused on the task of "*Cutting Fruits & Vegetables*" [2]. In this knowledge graph, we collect task-specific knowledge about specific, pre-defined fruits and vegetables like their anatomical parts (e.g. *apples have a core*) or their edibility (e.g. *the peel of an orange is inedible & must be removed*). As an extension, we want to add reasoning to the KG so that it is able to handle **any** fruit or vegetable the user provides.

In this thesis, you create a methodology for extracting the task-specific knowledge from the knowledge graph based on its similarity to already existing objects. As an example, consider a *pear*, which is not part of the knowledge graph. Your approach should be able to find the closest existing fruit (e.g. *apple*) and use its parameters and properties instead. You need to think about the information necessary for reasoning about fruit similarity and how to extract these information from (Semantic) Web resources. In a master thesis, you would develop two or even three different approaches and compare their performance.

Prior knowledge about knowledge graphs, the Semantic Web or knowledge extraction, as well as experience with Python, is recommended but not necessary. The thesis can be taken in German or English.

Related literature

[1] Y. Ding et al., 'Integrating Action Knowledge and LLMs for Task Planning and Situation Handling in Open Worlds', Autonomous Robots 2023 Special Issue on Large Language Models in Robotics, 2023, doi: 10.48550/ARXIV.2305.17590.
[2] https://food-ninja.github.io/food-cutting-website/

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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