From Senses to Knowledge: A Multi-layered Dataset For Grounded Knowledge About Household Objects

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I. Introduction

The knowledge about household objects is desired in a service robot that is expected to perform tasks in the household environment involving objects. For instance, when a robot is operating in the real world, it can not be assumed that a tool required in the task will always be available. For a robot an effective way to carry on with the task would be to find a substitute as humans do. Baber [1] postulated that a deliberation for tool selection in humans or animals alike is facilitated by ontological knowledge about objects especially knowledge about the physical as well as functional properties of the objects. Our research work follows the same suit and is aimed at developing a knowledge-driven reasoning to determine a substitute which is aided by ontological knowledge about objects. During the development, we identified the following requirements concerning the knowledge about objects for our scenario:

- The knowledge consists of properties of objects involving physical and functional properties
- The knowledge about properties of objects is grounded in the robot's sensations
- The uncertainty in the knowledge due to the noisy sensors, variations in the object's physicalities as well as functionalities is considered and modeled

We reviewed the existing knowledge bases in [2] to determine whether the knowledge about objects from the existing knowledge bases can be exploited in our research. Of the nine knowledge bases reviewed, KnowRob [3] and MLN-KB [4] were found to be more suitable, they were deemed unsuitable since they did not fulfill all the requirements mentioned above.

II. Approach

Our current research work is aimed at creating a multi-layered dataset that can be used to build ontological knowledge about household objects which satisfies the requirements mentioned above. The central idea is to build a knowledge base about the properties of objects around how the properties of the objects are sensed by a robot. The properties are divided into physical and functional properties where physical properties describe the physicality of the objects such as rigidity, weight, hollowness while the functional properties ascribe the (functional) abilities or affordances to the objects such as containment, blocking, movability. The properties are defined on the basis of:

- Perceivability: whether the parameters in the property definitions can be perceived
- Availability: what sensors are available as well as whether the existing techniques can be exploited
- Sensibility: whether the definition make sense. In our work, we are focusing on the primitive understanding of the properties to simplify the extraction methodology.

A. Proposed Framework

The dataset consists primarily of two layers. The lowest layer consists of the data from the individuals sensors such as camera, torque extracted from the individual objects and the second layer consists of the aggregated sensor data according to the property definitions. As, for the knowledge base, it consists of two levels: the first level consists of qualitative knowledge about individual object instances, while the upper level consists of the aggregated qualitative knowledge about respective categories of object instances.

III. Our Vision

This work builds knowledge from the individual robot's perspective by exploiting its sensing as well as manipulation capabilities. Therefore, the knowledge about the properties of the objects may not be universal, rather, it is acquired from the first-person perspective.

The proposed multi-layered dataset approaches the knowledge building in a bottom-up manner. The knowledge about the properties of the objects is constructed on the basis of what is sensed. On the other hand, in the top-down approach the senses are constructed on the basis of the existing knowledge. The framework for the dataset is build such that other users can plug-in their property extraction methods. Moreover, the knowledge about the properties of objects are grounded in the sensory data as well as in the property extraction methods.

References

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