PROTOTYPE-BASED KNOWLEDGE REPRESENTATION OF EVERYDAY OBJECTS

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Background of the work We propose a knowledge representation based on prototype theory in order to ease human-robot interaction. A successful and well functioning interaction between users and robots becomes more and more important, since they are used more and more frequently. One example is the use in households, especially in an ageing society. It is crucial, however, that the actions taken and the solutions found by a robot have to be intuitively comprehensible for the user, particularly if he or she has not grown up with computers.
One task in a household is to tidy up, for example in the kitchen, since much domestic work has to be done there, e.g. emptying the dishwasher. Tidying up, however, is not that easy, since the place where an object belongs usually, might already be occupied, new items may need to be tidied, or after a relocation all the dishes have to be placed in the kitchen in the new flat.
In order to put objects in a suitable place, the robot has to deal with a couple of tasks and needs to be flexible to deal with different situations. First, it has to categorize the objects, in order to know whether items belong together, i.e. to the same category. This ability is required, for example, if a shelf is already full and items have to be placed somewhere else, but still in a reasonable place. Some places may still be tolerated by the user, but others won't. We aim to develop a representation that reflects human categorization, in order to solve problems in a way a human could do. In this way we want to provide humanlike solutions, thus making human-robot-interaction easier.
Existing paradigms such as ontologies already provide a lot of functionalities. They draw conclusions from available knowledge by means of inference engines. They store relations between items, e.g. if a concept A is a subclass of a concept B. And they are able to store a huge amount of knowledge [1, 3]. They consider, however, only situations where the solution is quite clear. In contrast, we want to concentrate on situations where even humans solve problems differently. Since we want the robot to act humanlike, even the robot has to be able to find a couple of possible solutions.
Our suggested knowledge representation picks up on the theoretical theory of category representations by means of prototypes, each constituting something like a *best example* of a category [2]. According to this theory, categories are not defined by clear boundaries but by a prototype, which could be generated by taking the average of all relevant feature values of already learnt examples. Crucial features could be – amongst others – height, width, and material. These objects are represented as points, which can be described as vectors in a feature space [4] with indices referring to the dimensions of the space.
The final question is to what extent the proposed knowledge representation is able to reflect human categorizations and if the resulting behavior of a household robot is intuitively understandable for users.

Goal of the work We suggest a prototype-based knowledge representation that is easily understandable for users, flexible, and efficient all at once. Human categorizations are supposed to be

Figure 1: One test environment
Objects can be placed by a drag and drop function.

mimicked by this paradigm. We want to investigate whether it is suitable for the operations of an agent in a human environment and could ease interaction with humans.

Approach Kitchen objects are supposed to be stored as vectors containing indices for crucial features such as their geometrical information, e.g. width, height, inward arch, diameter, and others, the relation to other objects, such as cupboards, and how often they are used. Items having similar feature values belong to the same category. The average of their values constitutes the prototype of this category. A new item is categorized based on the difference between its feature values and the ones of a prototype. Several prototypes could build a new category on a higher level.

Applied Methods All experiments will be conducted in a simulation of a concrete kitchen scenario (Fig. 1). In this special environment human categorization will be investigated in order to build up a basis of comparison to the solutions found by our new paradigm.
There are three types of tasks. First, a new item is supposed to be put in a reasonable place with the knowledge available where objects can be found usually. Second, items need to be tidied without the knowledge where they are usually placed. This could be the case when the dishwasher needs to be emptied. Third, after a fictitious relocation all the dishes are supposed to be put in a completely new kitchen. No matter which task, objects tidied by the robot should always be put in the same place test persons choose as well, or at least in a place where humans can recover the items easily.

References

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