Dialog with Robots to Support Symbiotic Autonomy

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Position statement

Robots are expected to support human activities in everyday environments, interacting with different kinds of users. In particular, domestic robots (i.e. domestic robots operating in our homes) have already entered the market, for example as cleaning robots or telepresence robots for elderly care. In these contexts, the interaction with the user plays a key role. Given the recent advancements in spoken language recognition, dialog in natural language will be a major component of robotic interfaces, even though it will be certainly coupled with a number of multi-modal communication channels.

We have addressed Spoken Command Interpretation by implementing a cascade of reusable NLP modules, that can be adapted to changing operational scenarios, through trainable statistical models for which HRI specific learning algorithms (e.g. ASR re-ranking [1]) have been developed. In addition, to experimentally validate our command interpretation chain, we built a corpus of spoken commands, annotated with grammatical and semantic information. The corpus, called HuRIC, [2] was developed by gathering data during service robot competitions (RoboCup@Home and RoCKIn@Home) aiming at quantitative benchmarking the solutions implemented for spoken command interpretation in that context.

The current development of robotics technology is nonetheless facing several difficulties in providing general solutions, that are robust to the enormous variety of environments, tasks to be executed and users. On the one hand, the perception capabilities of the robots make it difficult to build rich and reliable representations of the operational environment; on the other hand, combining motion and manipulation capabilities on a single platform is still very expensive and makes the size

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of the robot not well suited for operation in homes. While these difficulties may require some time before we reach satisfactory solutions, a number of researchers are proposing to exploit human robot interaction to enable the robot to understand the environment and accomplish tasks that would be otherwise unachievable. This line of research has been termed as *Symbiotic Autonomy* [3] and it substantially relies on spoken dialog between robots and users.

Following the paradigm suggested by symbiotic autonomy, we have investigated several realms, where the interaction between users and robots can leverage the performance of the system, in the specific operational environment (i.e. my home), where the robot is put to work.

Specifically, we have first addressed the problem of *Semantic Mapping*, namely the construction of a representation of the environment that associates symbols to the objects and location in the environment, so that the robot can actually execute commands like *"go in my bedroom"*, without being teleoperated by the user or without requiring the user to specify a target position in terms of actual coordinates. While current automatic methods for semantic mapping can not yet provide satisfactory representations, through the interaction with the user we have been able to map a variety of environments using different robotics platforms that can share the same representation of the environment. Moreover, our approach allows an incremental construction of the representation, as well as the ability to revise it in accordance with the changes in the environment [4].

Then, we faced the problem of *Task Teaching*, namely the interaction between the user and the system that leads the robot to learn complex commands that are composed by the primitive actions that are built-in by the manufacturer. In this respect, we have extended previous approaches by enabling the robot to learn parametric commands, as well as exploiting the knowledge about tasks to simplify the learning process [5, 6].

In both the above sketched frameworks, dialog plays a central role. While our implementation at this stage is based on a rather simplistic approach to dialog, we plan to address both kinds of scenarios by leveraging the state of the art tools and solutions that have been developed in the field of spoken dialog. In particular, we are interested in the following research issues:

- understanding the contextual features (e.g. environmental or task-driven) that a dialogue system has to exploit in order to enable an effective human robot interaction in teaching the robot;
- developing an approach that learns the specific language of each individual user, as to support the deployment of robots as personal and adaptive talking devices.

The former is based on the idea that contextual information, such as environment representation and robot features, play a crucial role in the interaction, as they allow to linguistically contextualize the dialogue flow.

The latter is motivated by the idea that service robots in home environment can gather substantial knowledge of the user vocabulary and habits, therefore enabling for a significant personalization of the robot.

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