A dialogue system to enhance goal-oriented human-robot interactions

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Saeid Amiri working on the dialog system.

Researchers at SUNY Binghamton, Cleveland State University and the University of Washington have recently developed a new dialogue system that could improve human-robot interactions. This system, presented in a paper pre-published on arXiv, is designed to learn continuously from its dialogue experiences, augmenting its knowledge base and language capabilities over time.

"In recent years, a lot of companies and research institutes have started thinking about designing and using robots in indoor environments for various applications," Saeid Amiri, one of the researchers who carried out the study, told TechXplore. "For a robot in a human-inhabited environment, the ability of using natural language to communicate with humans is of crucial importance. However, there are a few challenges in achieving this. One is that the language could be ambiguous, even in a human-human conversation. Secondly, unlike humans, a robot's knowledge of its surroundings (e.g., objects and people around it) is quite limited."

In their study, Amiri and his colleagues set out to address the limitations of many existing dialogue systems by developing a system that can learn from its environment and thus perfect its capabilities over time. Their overall objective was to allow robots to complete a task successfully, such as delivering a parcel, while also acquiring new concepts about its surroundings.

"In human-robot communication, if a human refers to some unknown object, the robot will often have difficulty understanding it," Amiri said. "To tackle this problem, we came up with the idea of a dialogue system that asks clarification questions (e.g. Should I deliver a parcel? Is this

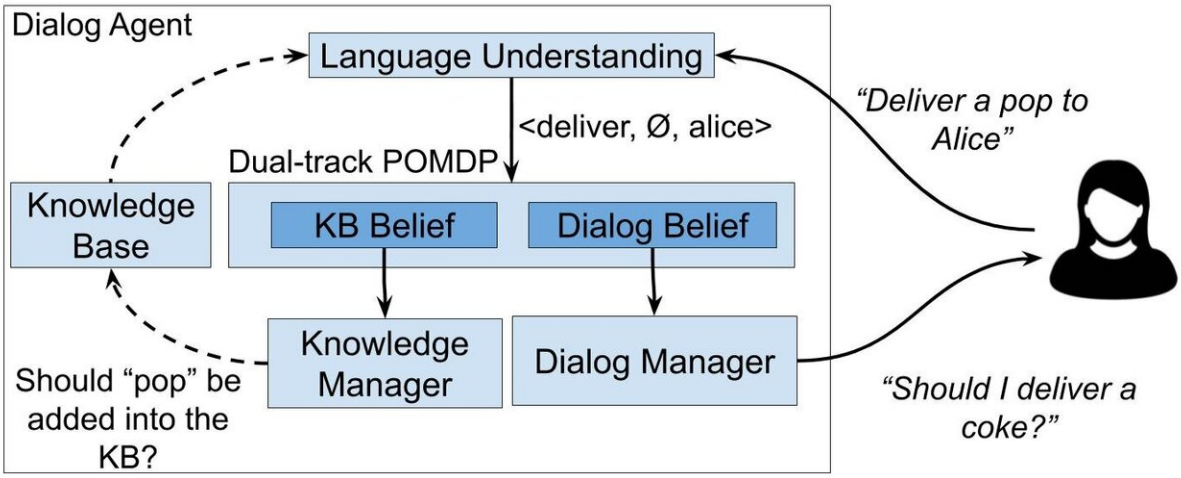
delivery for Bob?) once the human assigns a task to it. Such questions assist the robot in realizing that it has to learn new words."

The dialogue system developed by Amiri and his colleagues has four main components: a language understanding component, a dialogue manager, a knowledge manager and a language generation tool. The language understanding component parses sentences spoken by humans into formal representations and then feeds them to the robot. When the dialogue system is applied to a delivery task, for instance, such as the one the researchers focused on in their experiments, the language understanding component allows the system to identify items mentioned by human users or information related to the recipient of a parcel.

The dialogue manager component, on the other hand, decides what questions the robot should ask human users if it didn't fully grasp instructions or sentences. Based on a user's response to these questions, the robot updates its degree of certainty about the meaning of concepts that the user is referring to.

Subsequently, the dialogue system's knowledge manager component determines whether the robot needs to learn a new concept or not. If a robot already knows all the key concepts described by a user, for instance, there is no point for it to learn additional or unnecessary words.

Finally, the language generation component allows the robot to produce responses and answer users directly. In their study, Amiri and his colleagues decided to keep this component as simple as possible, and thus used a series of straightforward, predefined texts.



An overview of the dialog system developed by Amiri and his colleagues.

The researchers evaluated their system in both simulations and experiments involving human participants, who were recruited via Amazon Mechanical Turk and other platforms. Their findings were very promising, with their system outperforming other dialogue agents in human-robot interactions, both in terms of efficiency and accuracy. In their tests, the system achieved a good understanding of user queries while also continuously updating its knowledge and language capabilities over time.

"During our study, we asked a few human participants to use our robot and the robot was capable of augmenting its knowledge through the dialogue with the users," Amiri said. "A robot having the capability of knowing when to learn new knowledge by itself was a great achievement. That would mean that you can basically own a robot that incrementally learns new concepts through interaction and dialogue with humans."

In the future, the dialogue system developed by Amiri and his colleagues

could be used to enhance the interaction capabilities of both existing and new robots. Meanwhile, the researchers plan to keep working on their system to further improve its performance, efficacy, and applicability.

"Although we achieved our goal in this research, there is still a long way to make the robot act as natural as a human being," Amiri said. "I would now like to improve our dialogue system so that a robot will talk a lower number of times, otherwise humans could feel frustrated and lose trust in the robot. Also, if a human uses casual language in communication, the robot may currently have difficulty understanding his/her request, which is something else I would like to work on."

More information: Saeid Amiri et al. Augmenting knowledge through statistical goal-oriented human-robot dialog. arXiv:1907.03390 [cs.RO]. arxiv.org/abs/1907.03390

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