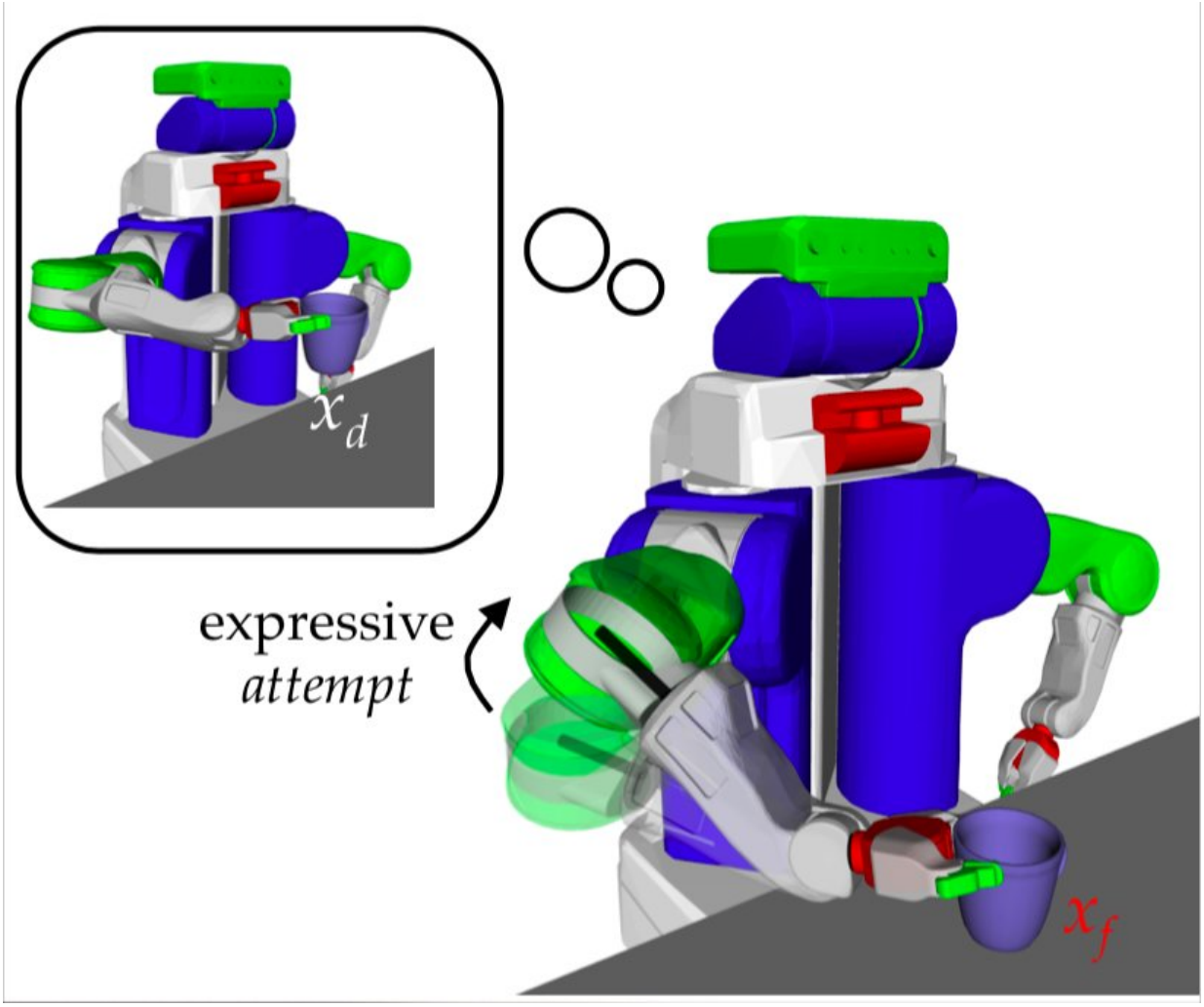
A new method to express robot incapability

November 1 2018, by Ingrid Fadelli



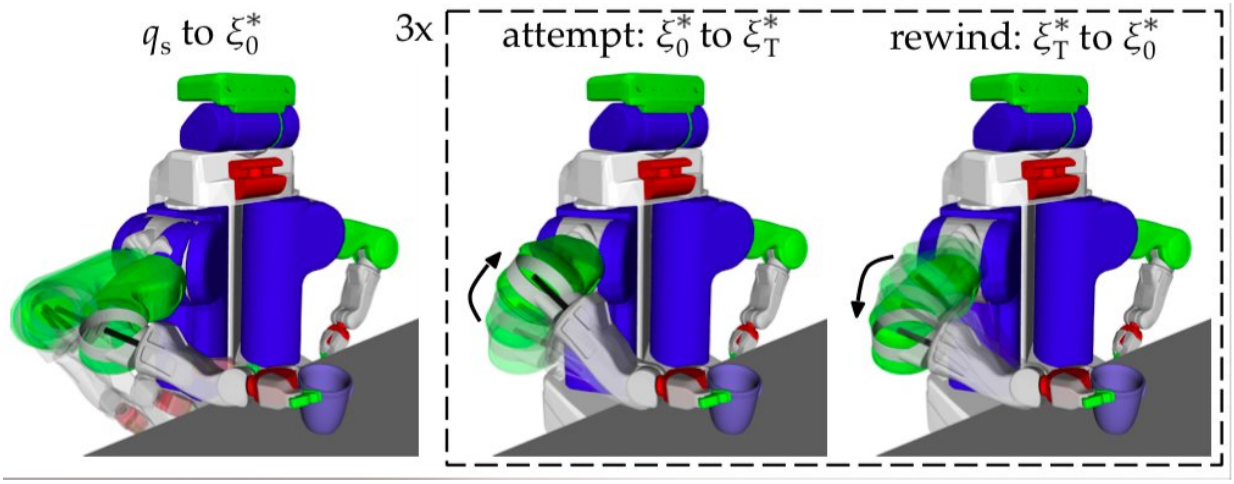
The method devised by the researchers generates an attempt motion meant to resemble successful execution (e.g., moving the end-effector from xf to xd) while obeying the constraints on the robot's limitations. In this example, lifts its elbow to communicate that it is trying to lift the cup, but the cup is too heavy to be lifted by it. Credit: Kwon, Huang and Dragan.

Researchers at Cornell University and the University of California, Berkeley, have developed an a method to automatically generate motions with which robots can express their inability to complete a given task. These generated motions clearly communicate both what task the robot cannot complete and why it is unable to complete it.

"When interacting with robots, it is important for humans to have accurate expectations of robot capabilities," Minae Kwon, one of the researchers who carried out the study, told TechXplore. "One way to set accurate expectations is to understand what robots are incapable of doing and why."

Currently, most robot failures are extremely uninformative. In other words, when the robot is unable to complete a task, it might stop abruptly in the middle of an action or even refuse to begin the task in the first place. This makes it hard for humans to understand the cause of the robot's failure, as well as to generalize its abilities.

"We wanted to find a way in which robots could more intelligently communicate their incapabilities (i.e., what they are trying to do and why it will fail) even before a failure happens," Kwon said. "Specifically, we focused on incapabilities related to motion planning tasks (e.g. lifting a cup, pushing a door), as we wanted to solve this problem using expressive motion."



For a given incompletable task, the robot first executes the task until the point of failure (left), at which point it executes the attempt trajectory ξ ∗ (center). To emphasize this motion, the robot then executes the reverse of ξ ∗ to rewind back to ξ ∗ 0 (right), and repeats this two more times. Credit: Kwon, Huang and Dragan.

Kwon, her colleagues Sandy Huang and their advisor Anca Dragan addressed this problem in the context of trajectory optimization. Their approach minimizes the similarity between the motion expressing incapability and what would allow the robot to successfully execute the task, while also considering the physical limitations of the robot. When the researchers evaluated different similarity measures, they found that one in particular generalized well to a broad range of tasks, producing expressive motions that are tailored to individual tasks.

"We generate an attempt motion, or a motion where the robot tries its best to complete the trajectory it would have followed, which is subject to a constraint," Kwon explained. "Following the desired trajectory illustrates the robot's goal and the constraint illustrates the failure. To communicate the incapability, we consecutively rewind and repeat these

attempt motions."

The method employed by the researchers automatically generates motions that express robot incapability, communicating both what it is trying to achieve and the reasons behind its failure. This could ultimately improve communication between end-users and robots, facilitating their collaboration on a broad range of tasks.

"We think it's important that people were not only able to recognize the robot's intended goal and the cause of incapability more clearly compared to other approaches, but that our motions also created a positive image of the robot,' Kwon said. "For instance, people were more willing to help the robot and collaborate with it. We hope that these positive implications for human-robot collaboration will help to improve the way we interact with robots."

In the future, the method developed by Kwon, Huang and Dragan could aid the development of more communicative robots, further enhancing interactions between humans and machines. The researchers are now planning to develop their approach further, in order to generate motions for a broader variety of task failures.

"We've only targeted a subset of possible incapabilities the robot can have, leaving out other types of failures, such as perception failures," Kwon said. "Coming up with creative ways to express different types of incapabilities is an interesting challenge that we leave to future work."

More information: Expressing robot incapability. arXiv:1810.08167 [cs.RO]. arxiv.org/abs/1810.08167