Robots learn to take a proper handoff by following digitized human examples

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A humanoid robot can receive an object handed to it by a person with something approaching natural, human-like motion thanks to a new method developed by scientists at Disney Research, Pittsburgh in a project partially funded by the International Center for Advanced Communication Technologies (interACT) at Carnegie Mellon University and Karlsruhe Institute of Technology (KIT).

Recognizing that a person is handing something and predicting where the human plans to make the handoff is difficult for a robot, but the researchers from Disney and KIT solved the problem by using motion capture data with two people to create a database of human motion. By rapidly searching the database, a robot can realize what the human is doing and make a reasonable estimate of where he is likely to extend his hand.

The researchers presented their findings at the IEEE International Conference on Robotics and Automation in Karlsruhe, Germany, where their paper was nominated for a Best Cognitive Robotics Paper Award.

People handing a coat, a package or a tool to a robot will become commonplace if robots are introduced to the workplace and the home, said Katsu Yamane, Disney Research, Pittsburgh senior research scientist. But the technique he developed with Marcel Revfi, an interACT exchange student from KIT, could apply to any number of situations where a robot needs to synchronize its motion with that of a human, such as in a dance.

In the case of accepting a handoff, it's not just sufficient to develop a technique that enables the robot to efficiently find and grasp the object. "If a robot just sticks out its hand blindly, or uses motions that look more robotic than human, a person might feel uneasy working with that robot or might question whether it is up to the task," Yamane explained. "We assume human-like motions are more user-friendly because they are familiar."

Human-like motion is often achieved in robots by using motion capture data from people. But that's usually done in tightly scripted situations, based on a single person's movements. For the general passing scenarios envisioned by Yamane, a sampling of motion from at least two people would be necessary and the robot would have to access that database interactively, so it could adjust its motion as the person handing it a package progressively extended her arm.

To enable a robot to access a library of human-to-human passing motions with the speed necessary for robot-human interaction, the researchers developed a hierarchical data structure. Using principal component analysis, the researchers first developed a rough estimate of the distribution of various motion samples. They then grouped samples of similar poses and organized them into a binary-tree structure. With a series of "either/or" decisions, the robot can rapidly search this database, so it can recognize when the person initiates a handing motion and then refine its response as the person follows through.

The team tested their method using computer simulations and, because it is essential to include a human in the loop, with the upper body of a humanoid robot. They confirmed that the robot began moving its arm before the human's hand reached his desired passing location and that the robot's hand position roughly matched that of the human receivers from the database that it was attempting to mimic.

Yamane said further work is necessary to expand the database for a wider variety of passing motions and passing distances. As more capable hardware becomes available, the researchers hope to add finger motions and secondary behaviors that would make the robot's motion more engaging. They also plan to explore new applications for the method.

More information: Project: www.disneyresearch.com/project … bjectreceivingrobots

Provided by Disney Research