Space Robot Can Autonomously Reconfigure Itself

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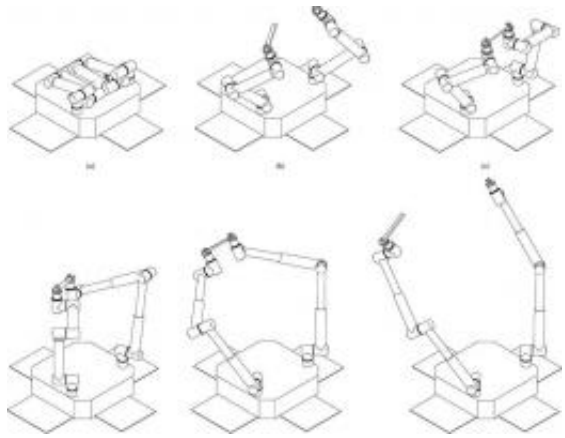

By connecting their endpoints, two reconfigurable robots autonomously change their configurations by altering the lengths of their arms and twisting their joints. Image credit: Aghili and Parsa. ©2009 IEEE.

A robot designed to work in space should ideally be a Jack of all trades, with the ability to perform a wide variety of tasks by itself. By having one robot that can handle many jobs, astronauts can cut down on weight in order to reduce launch cost. As presented in a recent study, a new type of reconfigurable robot can perform diverse tasks by changing its configuration, such as lengthening and twisting its “arms,” in a much simpler and more compact way than previous reconfigurable robots.

As Farhad Aghili of the Canadian Space Agency in Saint-Hubert, Quebec, and Kourosh Parsa of ESAB Cutting Systems in Florence,

South Carolina, explain in a recent study, most conventional reconfigurable robots have a modular design. Although modular robots can change their size and shape, they require complex joints for connecting modules, as well as a docking system for exchanging modules.

Aghili and Parsa's new design for a reconfigurable robot does away with modules, and instead uses passive joints that allow the arms to twist and change their length, depending on the task at hand. The cylindrical passive joints, i.e., joints that don't use actuators or sensors, lie in between cylindrical telescopic arms. As the joints twist and turn and the telescopic arms extend or shrink, the robot looks a bit like one of Inspector Gadget's bionic arms, but precisely controlled.

In order to reconfigure itself, the engineers explain that the robot must constrain the motion of the end of its arm in order to control its joint parameters. The robot can do this in several ways, such as when the arm grasps a fixed point or when two robot arms grasp the same object. In either case, the robot forms a closed chain. At this point, one or more of the brake mechanisms on the passive joints can be released by activating a solenoid, which allows the "elbows" of the robot to twist and lengthen or shorten its arms. When the system achieves its desired configuration, the joint brakes are locked, and the robot detaches itself from its constraining object.

The new "lockable joint" design offers several advantages compared with the conventional modular design of reconfigurable robots. The main advantage is simplicity, with the new design being compact and weighing less, which is important for launch considerations. The new design also enables the robot to autonomously reconfigure itself, since links and joints don't need to be detached and reattached as in the modular design.

"In a nutshell, this work establishes a new concept of a reconfigurable robot with supporting mathematical analysis and control method," Aghili told PhysOrg.com. "The conditions on the manipulator constraints and the passive joints to make it possible that the robot changes its current configuration to a desired one are derived. The control system then autonomously realizes the configuration change while demanding minimum actuation effort. Autonomous calibration of the manipulator after every configuration change is another significant aspect of this work."

This kind of reconfigurable robot could have many uses in space, including performing inspections, assembling devices, and carrying objects. Aghili added that a reconfigurable robot like this one could also have applications in mining, nuclear power plants and the military. He noted that a team of students from McGill University has built a preliminarily prototype of a similar reconfigurable robot.

"The Space Shuttle manipulator has been served in numerous space missions for more than two decades," he said. "However, the Shuttle is scheduled to be soon retired and the next generation of NASA spacecraft will not have a large cargo bay, such as the Shuttle's, to accommodate a manipulator with long booms. In this retrospect, a reconfigurable robot with telescopic joints, which can be contained in a small volume that is suitable for launch, is seriously considered for the next generation of spacecraft manipulators."

More information: Farhad Aghili and Kourosh Parsa. "A Reconfigurable Robot with Lockable Cylindrical Joints." *IEEE Transactions on Robotics*. To be published.

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