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PARALLEL, REMOTELY-CONTROLLED ROBOTIC MANIPULATION

Abstract

Robotics, such as the Canadarm2, have been used for over 20 years , and are still regularly used to this day for maintenance and free-flyer capture activities. Future robotic missions such as on-orbit servicing and exploration will require enhanced capabilities, especially for achieving dependable proximity operations for remotely operated mission concepts.

Existing technologies for relative triangulation and robotic capture are limited in their performance capabilities and usually tailored to a set of tasks - compatible with a specific set of cooperative targets. To enable more flexible missions and reduce the learning curve for robotic operations, some aspects of these technologies could be improved. This is a domain where parallel remotely controlled robotic manipulation will excel, allowing astronauts to perform various tasks with a smaller scaled arm, using intuitive and natural-like movements, ultimately shortening training and operation time.

This paper describes a concept to help reduce the operational learning curve by simplification of controls and user interface, allowing operators with little training to perform safe and reliable proximity operations for on-orbit robotic servicing with precise and spontaneous motions. Since the remote arm's movements lie completely within the cognitive skills of its operator, the time to mitigate errors in motion or speed, as well as performing any recovery motions is near instantaneous due to human-reflexes directly mirrored onto the remote arm.

To study the advantages, and evaluate this new technology, Ryerson University's Responsive Ecologies Lab in Toronto, Canada set-up a two-armed system. The robotic arms are Kinova MICO, six-joint, three-finger manipulators, allowing for sixteen degrees of freedom. Leveraging a force-control mode, allowed the operator to apply minimal physical force on certain joints, having the arm respond appropriately and accurately to the force and speed of motion, without relying on any other controls, buttons or switches.

Using multi-threaded algorithms, we engineered and implemented a remote arm in parallel, mimicking the movements of the source arm, with finger manipulations mapped to a button, easily accessible to the operator.

A comparison between the parallel and manual joystick approach was performed. Each approach was given puzzles with angled objects the robotic fingers would capture. Operators with various robotic manipulation skills were observed and timed. The results and observations gave an important insight into this application of robotic manipulation, showing that overwhelmingly, the parallel approach was able to complete the puzzles twice as fast than the manual approach.