SEMI-AUTONOMOUS FRAMEWORK FOR COMPLETING CONTACT TASKS IN THE PRESENCE OF LATENCY. E. Akita[1], and M. Pryor[2], All authors are with the Walker Department of Mechanical Engineering and Texas Robotics at The University of Texas at Austin, 2501 Wichita St., Austin, TX 78712 [1]efakita@utexas.edu, [2]mpryor@utexas.edu.

Robots play a crucial role in executing tasks within dangerous settings, including space exploration, handling nuclear materials, military operations, and emergency responses, among others. Although the ultimate objective is to achieve fully autonomous robotic systems, the current approach of supervised autonomy serves as an interim solution to reduce the workload of human operators as we advance toward higher levels of autonomy. In this framework, the human operator guides an inexperienced yet competent robotic agent by issuing high-level commands and overseeing the robot's performance. However, the operator is not burdened with the details of execution, such as collision avoidance, joint control, and contact force management.

Using robots to perform complex contact tasks, such as turning a wheel valve (**Fig. 1)**, is still extremely challenging [1], [2], [3]. These tasks demand continuous contact between the robot and its environment and variable force profiles throughout their execution.

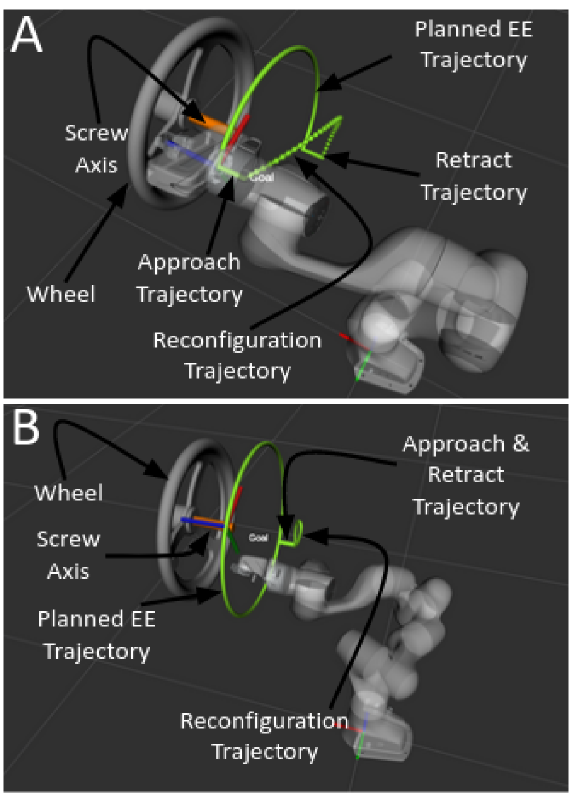

Fig. 1. Contact task planning showing an EE trajectory and joint reconfiguration. The robot reconfigures to the task start state in **A** and reconfigures to the next waypoint in **B** [3].

The difficulty of these tasks is amplified by constrained motions that exceed the manipulator's dexterous workspace, and by the latency experienced between the robot's operator and the remote system.

Teleoperation will remain a fundamental feature for any autonomous system, ensuring users can directly control robot resources whenever necessary. However, for teleoperation to be effective, it is essential for the robot to autonomously adjust its actions to manage task uncertainty and latency. This capability becomes particularly crucial during contact task execution.

Moreover, previous efforts have explored the use of Affordance Templates to allow robots to perform these challenging contact tasks [5]. An Affordance Template is "a construct that contains virtual 3D visualizations of task-relevant objects and robot waypoint goals that a human operator can adjust at run-time to fit the demands of the run-time context" [6]. Results from the literature indicate that Affordance Templates are helpful in modeling tasks for robots, especially in uncertain environments [1], [2], [7]. Screw Theory builds on Affordance Templates by modeling articulated object manipulation with pure rotational and translational elementary motions [4].

In this presentation, we show the results of a task-based situational awareness module for low-level teleoperation that is robust when completing contact tasks in the presence of uncertainty and latency, as shown in **Fig. 2**.

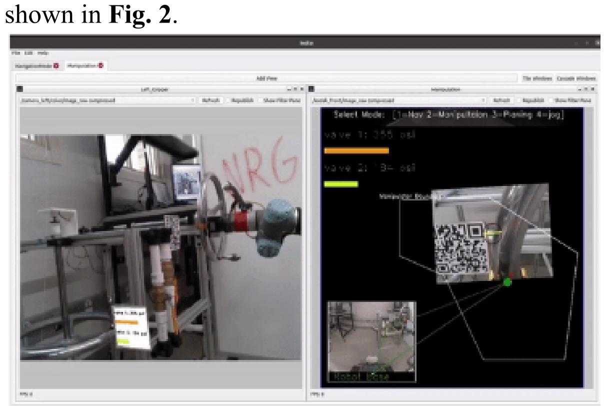

Fig. 2. Task-based situational awareness user interface for low-level teleoperation.

Furthermore, we extend previous efforts utilizing Screw Theory to construct a multi-path stepping algorithm using a Sequential Path Stepping Screw Framework [4] and Cartesian task wrenches to generate constrained motion plans. This allows for creating continuous configuration space paths within the reachable workspace for tasks that exceed the manipulator's workspace. Experimental simulation testing with different inverse kinematics solvers and task orientations shows a 90% success rate with BioIK and PRM when enforcing joint reconfiguration to the next waypoint pose in the trajectory, and a 100% percent success rate for various task orientations when enforcing reconfigurations to the motion start state [3]. Our framework improves the execution success of contact tasks by integrating kinematics and statics into motion planning, and by leveraging the teleoperation module as a fallback. Current efforts are directed towards measuring the enhancement achieved with the combined teleoperation module compared to the existing state-of-the-art.

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