Lessons Learned at JPL About Servicing

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The Telerobot Project

- Initiated/Funded by Ron Larson/Mel Montemerlo/Dave Lavery of NASA HQ ~1984-1992.

- Sought to develop and demonstrate needed technology for satellite servicing .

- Attempted integration of force-reflecting teleoperation with autonomous robotics, shared and traded control, predictive displays, etc.

Mechanical Primitives

- Every task can arguably be decomposed into a sequence of operations that each reduces the number of DoFs by one – e.g. move to contact, rotate to edge contact, rotate to face contact, etc.

- In general, these require maintaining modest contact forces/torques in N dimensions while "sliding" in the remaining free 6-N dimensions until some termination condition is met.

- These commands can all be described as "Slide Until" commands, even though some of the degenerate cases don't involve sliding.
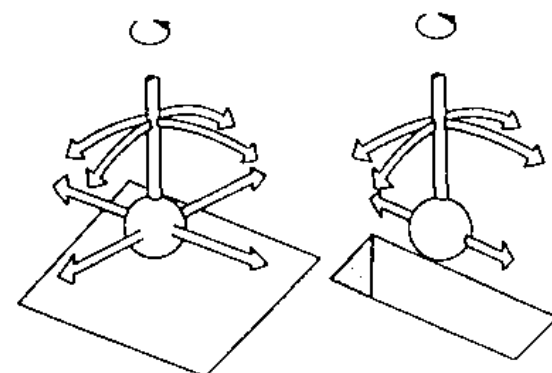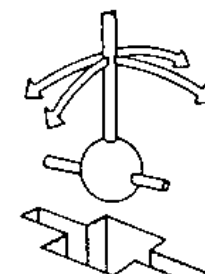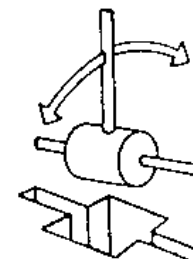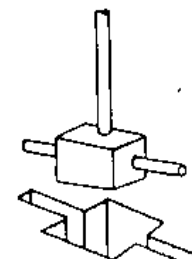

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1-DOC TASK
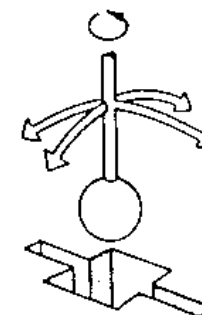
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5-DOC TASK

Key Elements of a Workable Satellite Servicing System

- The ability to associate objects in the work site with their associated computer representation, probably by some combination of manual and automated process. Verification back to the operator that correct identification and localization has been achieved (e.g. wire-frame overlays in widely-space images).

- Ability of human operator to indicate key physical elements – e.g. hinge axes, drawer slide axes, handles, keep-out zones.

- Ability of remote-site robot to manage forces and torques at reasonable bandwidth.

- Ability of remote-site robot to execute "slide-until" commands (or equivalent) to change number of DoFs of worksite to accomplish assembly, disassembly, repair or maintenance tasks. Common tasks can be stored macros of such primitives, including conditionals for error recovery.

- Assumes time-delay to human operator is ~ few seconds.

Acknowledgements

References

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- Wilcox, Brian H. "An Evolutionary Strategy for Telerobotic Operation via Geosynchronous Relay", IEEE International Conference on Robotics and Automation, Workshop on Integration of AI with Robotics, Scottsdale AZ, May 1989.