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IMPLEMENTATION ISSUES FOR A COMPACT 6 DEGREE OF FREEDOM FORCE REFLECTING HANDCONTROLLER WITH CUEING OF MODES

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Teleoperated control requires a master human interface device that can provide haptic input and output which reflects the responses of a slave robotic system. The effort reported in this paper addresses the design and prototyping of a six degree-of-freedom (DOF) Cartesian coordinate hand controller for this purpose. The device design recommended is an XYZ stage attached to a three-roll wrist which positions a flight-type handgrip. Six degrees of freedom are transduced and control brushless DC motor servo electronics similar in design to those used in computer controlled robotic manipulators. This general approach supports scaled force, velocity, and position feedback to aid an operator in achieving telepresence. The generality of the device and control system characteristics allow the use of inverse dynamics robotic control methodology to project slave robot system forces and inertias to the operator (in scaled form) and at the same time to reduce the apparent inertia of the robotic handcontroller itself.

The handcontroller unit which was designed and simulated in the initial effort uses brushless DC servo motors, integral pancake resolvers, and limited gearing to produce an extremely simple and rugged mechanical design requiring minimal routine maintenance. The electronic control unit designed is a compact low power robotic driver which supports robotic manipulator systems needing up to nominally 1500 W of power from a personal computer sized package. The current control design, which is not multiple fault tolerant, can be extended in this area to make flight control or space use possible.

The proposed handcontroller will have advantages in **space-based applications** where an operator must control several robot arms in a simultaneous and coordinated fashion. It will also have applications in intravehicular activities (within the Space Station) such as microgravity experiments in metallurgy and biological experiments that require isolation from the astronauts' environment. For ground applications, the handcontroller will be useful in **underwater activities** where the generality of the proposed handcontroller becomes an asset for operation of many different manipulator types. Also applications will emerge in the **Military, Construction,** and **Maintenance/Manufacturing areas** including ordnance handling, mine removal, NBC (Nuclear, Chemical, Biological) operations, control of vehicles, and operating strength and agility enhanced machines. Future **avionics applications** including advanced helicopter and aircraft control may also become important.

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2. Poster version.