ABSTRACT

If a robotic system is assumed to ride on a compliant foundation, then the force as well as the trajectory control can be achieved by controlling its impedance. Application of Bondgraph technique makes it possible to convert this model of a robot resting on a physical foundation to an equivalent conceptual model residing on a virtual foundation implemented in the controller domain that adds only passive degrees of freedom to the system. In this work, modelling and simulation of robotic manipulators for force control and object manipulations using virtual dissipative foundation have been presented. The passive degree is so designed that the impedance at the robot environment interface becomes a function of modulated compensation gain. This facilitates the accommodation of the needed forces arising during interaction of the manipulator with the environment. An effective and stable coupling between trajectory and force controller, in order to tackle switching over transients has been established. Thus, an interaction controller has been developed using programmable impedance modulation technique. The trajectory control is performed through an overwhelming controller, wherein the robustness to the system is imparted by high feed forward gain.

In the present work a fairly close estimate for the foundation compensation gain is derived in order to provide the necessary impedance for the desired force control. During the force control phase, there is a loss of positional accuracy which is suitably compensated during the subsequent trajectory control phase. The trajectory calibration can be performed by using adaptive command flow modification and also by modulation of the foundation compensation gain itself. Trajectory calibration based on modulation of foundation compensation gain, eliminates a separate controller and also extends the effective interaction time till the trajectory error is removed.

An interaction controller having directional impedance charecteristics for a two degree of freedom robot has been designed, which can be used as an hybrid impedance force and motion controller for multi-degree of freedom

systems. It has also been shown that the system degenerates not only due to kinematic constraints of the manipulator, but also due to combination of environmental, geometric and internal control constraints. A scheme to avoid this system degeneracy has been proposed. The presently developed force control strategy, has also been used to manipulate objects by cooperative robots. The gripping forces are controlled to prevent the slipping of the object, while moving it along a prescribed trajectory and also interacting with the environment. No attempt has been made to look into the efficacy of the proposed control strategy in the digital domain. The derivation of system differential equations and the simulation of the control processes have been carried out using bondgraph modelling software COSMO.