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Investigation of Indirect Force Control Strategies on Parallel Manipulator

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Abstract

Parallel Manipulators are seeking attention due to its applications in the areas of simulators, computer-aided manufacturing, biomechanical devices, space exploration equipment, nondestructive testing (NDT), ship cleaning/inspection, cooperative manipulation [1][6]. In such applications, manipulator interacts with the environment, which eventually imposes constraints on its behaviour. While interaction, such constraints may cause a rise in reaction forces, which may affect its stability or may even cause physical damage. This problem can be addressed either by making the motion compliant or overcoming the interaction forces by an appropriate force control strategy. Driven by this motivation, an attempt has been made in this work to develop a framework for implementing different indirect force control strategies on the parallel manipulator, namely 3-RRR planer parallel manipulator and Stewart Platform.

In this paper, first, the dynamic models and constraint Jacobian matrix of the closed-chain system are obtained. The dynamic model was obtained using the DeNOC [2] based formulation and closed-loop constraint equations. Implementation of the force control strategy includes environment modelling, integration of position, velocity and force feedback, and control of joint torque to achieve the desired objective. Environmental interaction model can be implemented in two ways; i.e., either the robot approaches the stationary wall or the wall approaches the still robot. The latter is selected as a part of environment modelling as it allows setting up a reference for comparison of different strategies. Overview of various force control strategies for the industrial robot can be found in [3][4]. A comparison of different force control strategies for the open-loop system, i.e., serial robots, was shown in [5]. Recently, sensorless full-body active compliance in 6-DoF parallel manipulator was successfully demonstrated in [6]. This paper presents a framework for implementation of the force-control strategies, namely, Stiffness, Impedance and Admittance control, on parallel manipulators viz; 3-RRR parallel manipulator, Stewart Platform. The architecture for Impedance control model for parallel manipulator is shown in Figure 1.

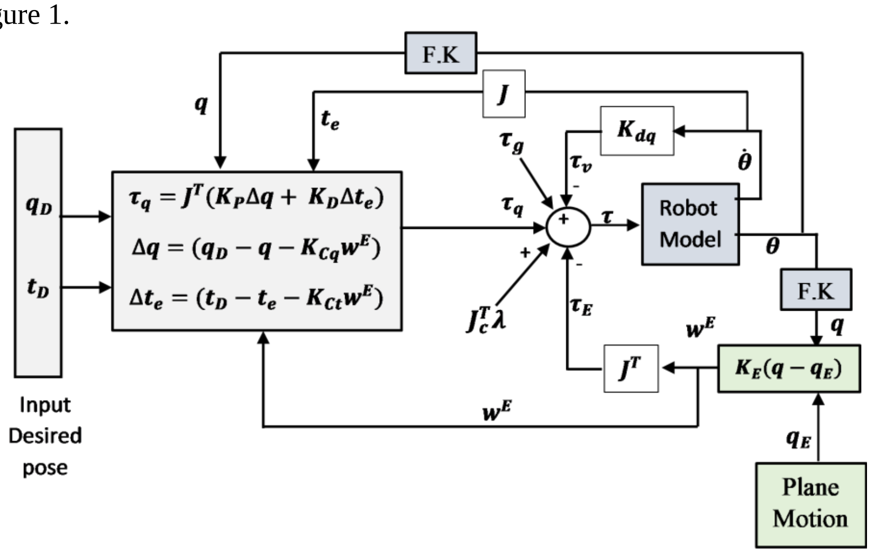

Figure 1: Impedance Control Model for Parallel Manipulator

Results of environmental interaction of Planer 3-RRR Parallel Manipulator (Figure 2) and Stewart Platform (Figure 4) with Impedance Control are shown in Fig. 3, 5 respectively. All the three control models would be discussed in detail in the paper.

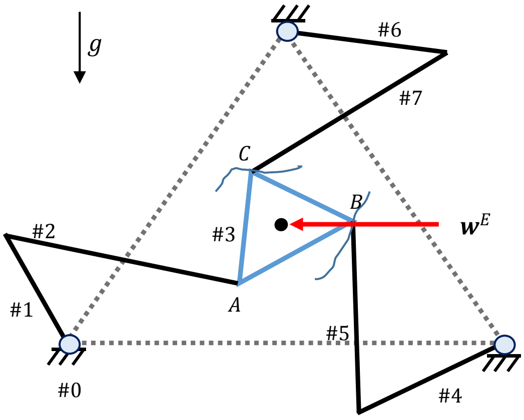

Figure 2: Planer 3-RRR Parallel Manipulator

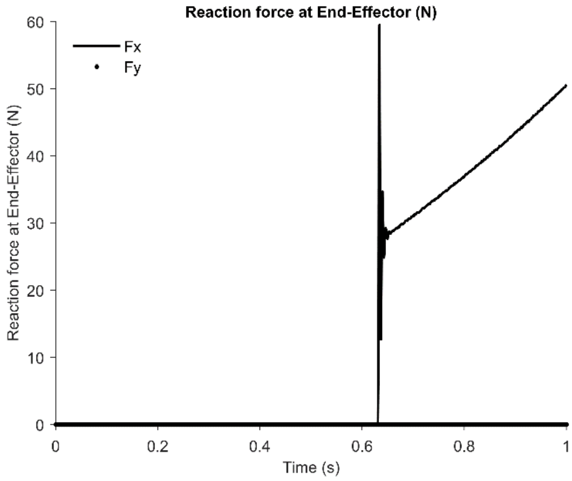

Figure 3: Reaction force at End-Effector

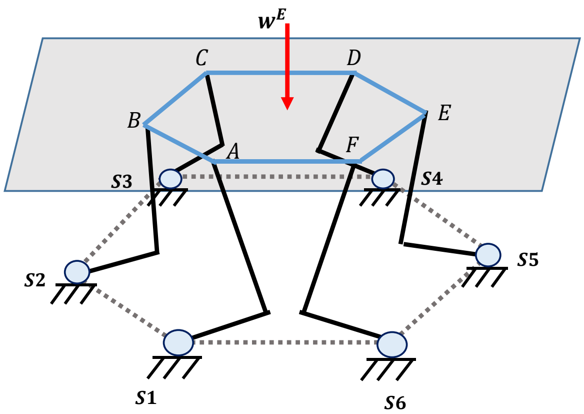

Figure 4: Zamanov Configuration Stewart Platform

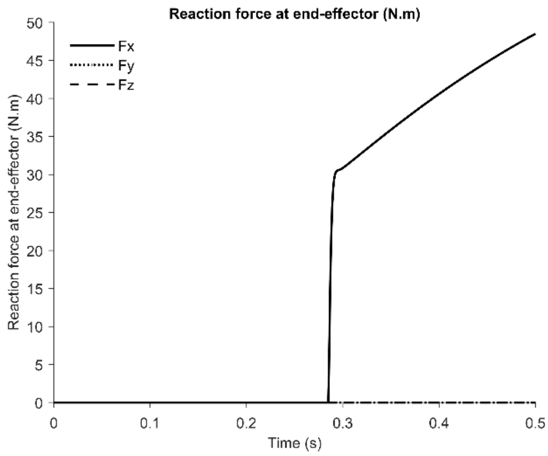

Figure 5: Reaction force at End-Effector

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