Chapter 10

Modeling, Simulation and Motion Cues Visualization of a Six-DOF Motion Platform for Micro-Maneuvering

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ABSTRACT

This paper examines the problem of realizing a 6-DOF motion platform by proposing a closed loop kinematic architecture that benefits from an anthropological serial manipulator design. In contrast to standard motion platforms based on linear actuators, a mechanism with actuator design inspired from anthropological kinematic structure offers a relatively larger motion envelope and higher dexterity making it a viable motion platform for micromanipulations. The design consists of a motion plate connected through only revolute hinges for the passive joints, and three legs located at the base as the active elements. In this hybrid kinematic structure, each leg is connected to the top (motion) plate through three revolute hinges and to the bottom (fixed) plate through a single revolute joint forming a closed-loop kinematic chain. The paper describes the mathematical modeling of the proposed design and demonstrates its simulation model using SimMechanics and xPC Target for real-time simulations and visualization of the motion cues.

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1. INTRODUCTION

In literature, research studies (Mehregany, Gabriel, & Trimmer, 1988; Jokiel, Benavides, Bieg, & Allen, 2001) investigate the initial use of Micro Electro-Mechanical Systems technology to design and fabricate parallel mechanisms. Furthermore, a parallel mechanism was built based on MEMS fabrication technology that provided translational motions in three axes as reported in Fan, Wu, Choquette, and Crawford (1997). Motion platforms with two and three degrees of freedom were presented in Jokiel, Benavides, Bieg, and Allen (2001) and Hollar, Bergbreiter, and Pister (2003).

1.1 Parallel Structures

In the design and development of manipulators, it has been realized through several research studies (Merlet, 2000; Gosselin & Angeles, 1991) that parallel structures possess intrinsic advantages over serial manipulators due to their high rigidity, large payload capacity, high velocity and notable precision. However, rigid joints with multi degrees of freedom used in conventional parallel robots affect the precision and accuracy of the system due to backlash, hysteresis and other manufacturing errors. In order to overcome these design constraints, compliant structures have been employed into parallel robots as investigated in Tanikawa, Arai, and Koyachi (1999) where notable precision is desirable at micron levels due to the fact that compliant structures possess simple configuration, do not suffer from backlash and have easy fabrication (Smith, 2000).

Typical development of motion platforms on macro scales comprise of kinematic configurations in which linear piston-like actuators are connected between the top (motion) plate and the bottom (fixed) plate through spherical or universal joints that are difficult to manufacture in MEMS fabrication technology. In literature there is a large body of work (Tsai & Tahmasebi, 1993; Ben-Horin & Shoham, 1996; Ben-Horin, Shoham, & Djerassi, 1998; Honegger, 1998; Wenger & Chablat, 2000; Tsai & Tahmasebi, 1993; Ceccarelli, 1997) that investigates the design and development of such parallel structures which employ passive sub-mechanisms to connect the motion plate.

Through literature studies (Choi, Sreenivasan, & Choi, 2008; Kallio, Lind, Zhou, & Koivo, 1998; Tang, Pham, Li, & Chen, 2004; Wu, Chen, & Chang, 2008; Hudgens & Tesar, 1991) it has...
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