Experimental Investigations on the Contour Generation of a Reconfigurable Stewart Platform

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ABSTRACT

Reconfiguration of Stewart platform for varying tasks accentuates the importance for determination of optimum geometry catering to the specified task. The authors in their earlier work (Satheesh et al., 2008) have indicated the non availability of an efficient holistic methodology for determining the optimum geometry. Further, they have proposed a solution using the variable geometry approach through the formulation of dimensionless parameters in combination with generic parameters like configuration and joint vector. The methodology proposed provides an approach to develop a complete set of design tool for any new reconfigurable Stewart platform for two identified applications viz., contour generation and vibration isolation. This paper details the experimental investigations carried out to validate the analytical results obtained on a developed Stewart platform test rig and error analysis is performed for contour generation. The experimental natural frequency of the developed Stewart platform has also been obtained.

Keywords: Contour Generation, Natural Frequency, Reconfiguration, Stewart Platform, Vibration Isolation

1. INTRODUCTION

Serial manipulators have the advantage of sweeping workspaces and dexterous maneuverability like the human arm, but their load capacity is rather poor due to the cantilever structure. Consequently, from strength considerations, the links become bulky on the one hand, while on the other they tend to bend under heavy load and vibrate at high speed. Though possessing a large workspace, their precision positioning capability is poor. This lead to the development of parallel manipulators as alternative solution and considerable work has been done in this domain (Raghavan, 1993; Tsai, 1999; Simaan et al., 2001, 2003).

The Stewart platform, proposed by Stewart as an aircraft simulator (Stewart, 1965), is a six degree-of-freedom parallel manipulator where the end-effector is attached to a movable plate supported by six linear actuated links in parallel. Typically, the number of limbs is equal to the number of degrees of freedom such that every limb is controlled by one actuator and all the actuators can be mounted at or near the fixed base (Fichter, 1986). Recently, due
to the advantages of the Stewart platform as compared to conventional open kinematics chain machines, much effort has been dedicated to the implementation of Stewart platforms in machine tools and robotic applications (Dasgupta et al., 2000). The most important fields where Stewart platform has solved the pertinent, time immemorial problems are Machine tool applications, Precision pointing and Vibration isolation applications.

Researchers have constantly tried Stewart platform in various other fields since the time its potential as a six degree-of-freedom mechanism was identified (for flight simulation). The systems that have been developed and readily available in the market as commercial hexapods, such as VARIAX from Giddings & Lewis, Tornado from Hexel Corp., Geodetic from Geodetic Technology Ltd., are mission specific. The rigidity of the legs of the Stewart platform determines the application area. A stiff hexapod, for example, is used as a rigid interface for active damping and precision pointing applications while a soft hexapod is used, in general, for the purpose of active isolation of vibrations (Hanieh, 2003). In all the cases cited above, there is not much freedom available for the end-user to choose between structural rigidity and dexterity to use the same platform for other applications. In effect there exists a need for reconfigurable designs of robotic platforms to meet the raising standards created by the currently maturing industrial scenario. Along this line Wavering (1998) identified, among many, the potential directions for future work as the alternative kinematic configurations and improved modularity/configurability.

2. RECONFIGURATION

A modular reconfigurable robotic system is a collection of individual link and joint components that can be assembled into different robot geometries for specific task requirements. However, the machining tolerance and assembly errors at the module interconnections affect the positioning accuracy of the end-effector (Chen & Yang, 1997, 1998; Chen & Burdick, 1998). A generic approach which is better than the modular design approach for the prescribed varying tasks should be identified. The authors in their earlier work identified from the literature (Du Plessis & Snyman, 2006; Lin et al., 2003; Chen, 2000, 2001) that there is a lack of an efficient holistic methodology for determining the optimum geometry for the task of reconfiguration. It was also identified (Leger, 1999; Chen et al., 1999, 2001; Xi, 2001) that there is a need to develop a reconfigurable configuration for at least two applications.

A solution (Satheesh et al., 2008) was presented through the formulation of dimensionless parameters in combination with generic parameters like configuration. This methodology is
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