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Design of Length Measuring System for Stewart Platform Using New Forward Kinematics Solution

Hamid Rezvani Dastgerdi
Department of Mechanics
Sakht Tajhizate Sepahan- MAPNA Group
Isfahan, Iran
hrezvany@gmail.com

Mehdi Keshmiri
Department of Mechanics
Isfahan University of Technology
Isfahan, Iran
mkeshmiri@istt.ir

Abstract— **In this paper, based on new presented approach for forward kinematic problem, length measuring system for Stewart platform is designed. The analysis is performed by using a software platform which models the system dynamics and control. A typical feedback linearization method is used to design the controller system and performance of designed controller is studied numerically with respect to measuring error and parametric uncertainties. To provide required parameters for controller, a new forward kinematic solution is designed and compared with Newton-Raphson method numerically. Based on end effector deviations from desired trajectory, actuator length measuring system is compared with moving platform measuring system, which results in more reliable trajectory tracking of controller in case of actuator length measuring system.**

Keywords— **Stewart Platform, Forward Kinematics, Measuring System.**

I. INTRODUCTION

Stewart platform consists of a moving platform, a fixed platform, and six actuators (Fig. 1). Different arrangements such as 6-6 or 6-3 exist according to the number of actuators connection points to the two platforms. For the first time, it was used by Gough in 1949 for the testing of tires, and then by Stewart in 1965, as the most practical solution for building flight simulators [1]. Forward Kinematics (FK) problem, extraction of end effector variables from joint space variables is required to have an acceptable trajectory tracking. It doesn't have an explicit solution and lots of researchers have attempted to find a reliable and rapid solution for real time application.

Raghavan was the first to establish that there may be up to 40 complex and real solutions for FK problem while Hasty succeeded in providing a polynomial of degree 40 that allows determining all the solutions [2, 3]. Dietmaier exhibited configurations for which there were 40 real solution poses [4]. Likewise, Baron and Chiu using redundant sensors solved this problem [5, 6]. Merlet as a pioneer in this field presented new method using interval analysis [7]. In the following sections, FK problem will be investigated elaborately to make an efficient and simple measuring system.

Initially kinematics and dynamics of general arrangement of 6-6 Stewart platform are introduced. Then, a suitable controller using typical feedback linearization method is designed to prepare a software platform. Afterwards, to provide required parameters for the controller a new approach is presented for FK problem and is compared with Newton-Raphson numerically. Based on selected approach, performances of measuring system candidates are analyzed and consequently, designed system including measuring system is robust against parametric uncertainties and measuring error.

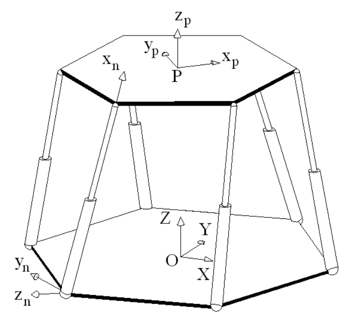

Figure 1. Stewart platform

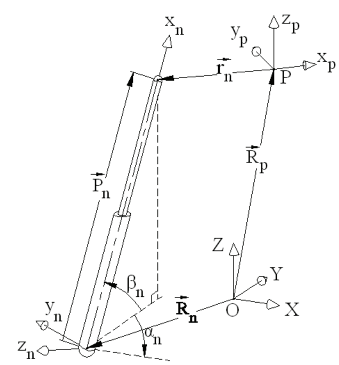

Figure 2. Coordinate systems

II. KINEMATICS AND DYNAMICS

Stewart platform has been depicted in Figs 1 and 2. It consists of two platforms, one fixed and one moving, six linear actuators which are connected to the fixed platform by six universal joints and to the moving platform by six spherical joints. To analyze the system kinematics, three different coordinate systems are defined. (Fig. 1): XYZ Cartesian coordinate system attached to the fixed platform with XY plane parallel to horizontal surface and Z-axis in vertical direction. $x_p y_p z_p$ Cartesian coordinate system attached to the moving platform where reference point P is located along Z axis in its initial position. Rotation of moving platform frame with respect