Dynamics of a Space Multi-pointing Stewart System Using the New Form of Kane's Method

Quan HU,[1*] Fei LIU,[1] and Yao ZHANG,[1]
[1] *Beijing Institute of Technology, Beijing, China 100081*
huquan2690@bit.edu.cn

Keyword : Active Multi-pointing System; Stewart Platform; Kane's equation; Reduced model.

The Stewart platform is a six-degrees-of-freedom mechanism connecting two rigid bodies by six extensible links. It has been wildly used for passive vibration isolation in imaging spacecrafts. Noting that by introduce active actuator to the extensible links, the Stewart platform can also be used for maneuvering the attitude of the payload to realize the precision multi-pointing. In this work, we focus on the dynamics modeling issue related to such application.

The considered space multi-pointing stewart system (Fig. 1) is constituted of a rigid central body, two solar panels, the stewart platform, and a flexible payload(such as a long mirror cylinder or a space truss). This is a typical multibody system subject to nonholonomic constraints. In fact, many researchworks have been performed on the dyanmics of the Stewart platform, such as Lagrange equation[1], Newton–Euler method[2], and Kane's equation[3]. The Lagrange formulation involves the partial derivatives of the Lagrangian, so a large amount of symbolic computation is required. On the other hand, the multipliers should be used to describe the constraints, which increases the dimension of the system and leads to difficulty for controller design. The Newton–Euler method have to eliminate (or calculate) the interaction forces between each bodies; however, this procedure also need some tedious derivations for the unknown forces. The Kane's method could avoid the above issues, but the unknown multipliers were also introduced for the nonholonomic constraints [3].

In this work, the new form of Kane's method[4] is adopted to obtain the equations of motion of the space multi-pointing stewart system free of multipliers. The equivalent unconstrained system(Fig. 2) is first introduced, whose governing equation is formulated by the Kane's equation in matrix form. Then, the new form of kane's equation is used to handle the nonholonomic constraints, while the equations of motion are finally reduced to a minimum order. The obtained equations of motion is quite suitable for controller design.

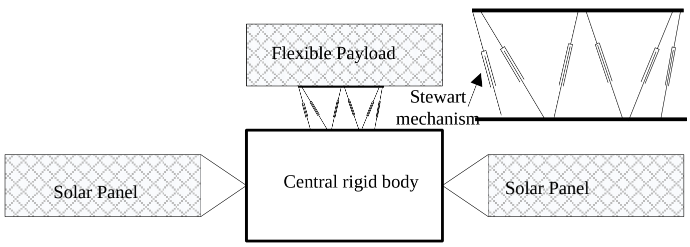

Fig. 1 Space Multi-pointing Stewart System

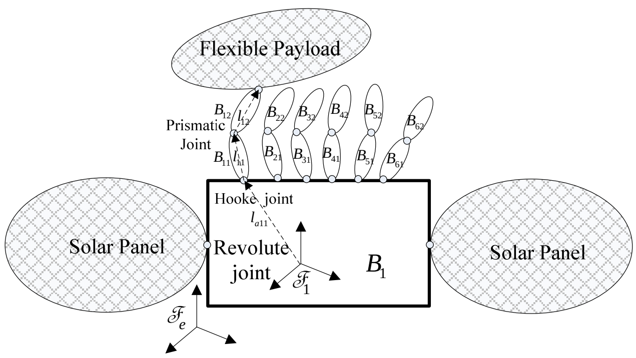

Fig. 2 The equivalent system without motion constants

References
[1]Geng, Z., Haynes, L. S., Lee, J. D., & Carroll, R. L. (1992). On the dynamic model and kinematic analysis of a class of stewart platforms. Robotics & Autonomous Systems, 9(4), 237-254.
[2]Dasgupta, B., & Mruthyunjaya, T. S. (1998). A Newton-Euler formulation for the inverse dynamics of the Stewart platform manipulator. Mechanism and Machine Theory, 33(8), 1135-1152.
[3]Liu, M. J., Li, C. X., & Li, C. N. (2000). Dynamics analysis of the gough-stewart platform manipulator. Robotics & Automation IEEE Transactions on, 16(1), 94-98.
[4] Bajodah, A. H., Hodges, D. H., & Chen, Y. H. (2003). New form of kane's equations of motion for constrained systems. Journal of Guidance Control & Dynamics, 26(1), 79-88.