Issues in Modelling a Stewart Platform in a Multibody Dynamics Software

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Abstract
The availability of various multi-body dynamics software (MBDS) always motivates to verify and compare in-house dynamics algorithms for complex mechanical systems. For instance, studying a 6-degrees-of-freedom Stewart Gough platform and comparing its kinematics and dynamics results with programming tools like MATLAB [1], etc., requires building a correct MBDS model [2]. This paper focuses on issues in building, analyzing and comparing spatial manipulator models built in MBDS with the in-house algorithms. To illustrate the issues, a CAD model of the Stewart platform was built using RecurDyn software [3] and its kinematic and dynamic analysis results were compared with the in-house developed MATLAB model. The issues addressed in this work would be very helpful in designing and comparing similar systems in MBDS, which otherwise consume a lot of unproductive time for novice users.

Methodology
Figure 1 shows a RecurDyn model of the Stewart platform having six symmetrical legs. These legs are connected to a fixed base and a moving platform with spherical joints, enabling translations and rotations along Cartesian axis. Each leg is a combination of two links connected with a prismatic joint. For any successful dynamic analysis, three major components are required. Firstly, building of a non-singular model, and secondly running of the dynamic analysis, and lastly the comparison of results.

Building the model
Before building the CAD model, design parameters like link dimensions, platform shape etc. should be available. Any arbitrary combination may lead to singular configuration in the beginning itself, e.g., a regular hexagonal platform based model. In this work we chose a semi-regular hexagon for the base and the platform. An important step while building the model is to keep the position and orientation of the global coordinate frames as per the DH frames in the proposed algorithm. This will simplify the efforts to compare the results for any input trajectory. The model was developed by constructing the fixed base and the moving platform as per the initial configuration, followed by six symmetrical legs. Joint location between the base and moving platform with the particular leg is important for correct analysis. A universal joint at the fixed base end was alternatively attempted as the motion along axis of the leg is redundant.

Dynamic analysis
Typically in parallel manipulators, the trajectory of platform is of interest. Any non-singular path trajectory of the platform is achieved by leg actuation. The same can be given in RecurDyn MBDS by defining a suitable joint between the moving platform and ground. Dynamic analysis using such technique would not estimate the required forces at the actuators in typical MBDS. In order to know the force requirements at the joints, the joint motions should be given directly at the joints in the MBDS. Hence, to generate the joint motions, kinematic analysis is first performed in the MBDS, which are then interpolated with a spline fit for each actuating prismatic joint. The required joint forces are then obtained by performing the dynamics analysis in the MBDS.

Comparison of results
For accurate comparison of the results between the proposed algorithm and any MBDS, kinematic and dynamic properties of the model should be same. In order to use the dynamic properties like moment of inertia of a particular link, platform, etc., an important thing to note is that the coordinate frame's

position and orientation may vary in every software. Hence, the dynamic properties measured in different coordinate frames, may not be exactly in the corresponding DH frame of the proposed algorithm. A certain rotation matrix may be needed to avoid such mistakes or the components of the system itself may be designed as separate parts along the desired coordinate frame. Incorrect information of the dynamic parameters may result into severe variation in the results.

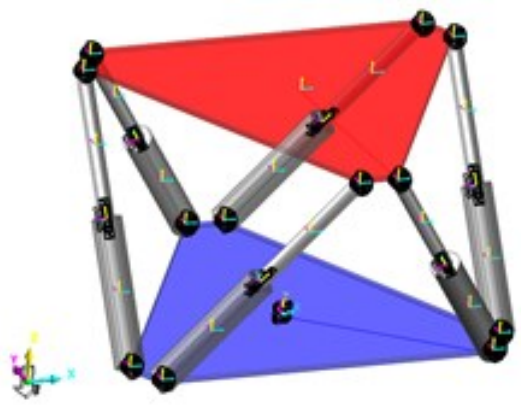

Figure 1: The Stewart platform – RecurDyn model

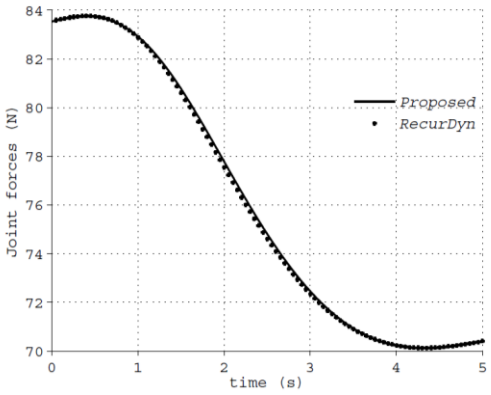

Figure 2: Inverse dynamics results for heave motion

Building a complex mechanical system in any MBDS and its comparison with in-house algorithms helps to understand the behaviour of the real system while simultaneously acting as a good debugging tool. The comparison of inverse dynamics results for the heave (up and down) motion of the Stewart platform is shown in Figure 2. The detailed information on the issues in modelling and comparison along with the guidelines on how they were taken care of will be communicated in the complete version of the paper.

References

[1] Matlab, 2013, MATLAB-The Language of Technical Computing, Version 8.1, Release 13a.

[2] M. Sadana, S. K. Saha, P.V.M. Rao. Dynamic analysis of vehicle simulator using CAD applications. Proceedings Nat. Conf. on Machines and Mechanisms (NaCoMM), pp. 329-336, Durgapur, India, 2009.

[3] RecurDyn, 2013, Version 8, Release 2.