Investigation on the modeling of membranes in large scale multi-body systems using co-rotational formulation

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Abstract

In large scale multi-body systems, such as solar arrays, there are always many deployable modules, which consist of thin and slim structures that may be beams, cables, shells or membranes. These structures make systems deploy easily and safely compared to complex mechanisms. On the contrary, it is much more complicated to simulate the response of them due to the large rotation and displacement in one structure. Furthermore, the most troublesome problem should be handled is the efficiency of the intensive computation.

In recent years, researches on large deformation (rotation and displacement) focus on Geometrically Nonlinear Theory [1], Absolute Nodal Coordinate Formulation [2] and so on. Almost all the formulations are classified as typical Total Lagrangian description, and a large number of articles show that an accurate result relies on a strongly nonlinear internal force and its Jacobian, which should be computed for every step, even every iteration. Therefore, these articles present fine answers to the question that is simply small scale system with few beams or shells, but for a large scale system, most of methods do not work well for the intensive computation of stiffness matrix, internal force, etc.

In this paper, a co-rotational method [3] is used to generate a shell model with a rotation-free element. In traditional co-rotational formulation, the rotation degree of freedom is introduced to express the bending strain, meanwhile, the rotation variable makes the computation complex and increases the degrees of freedom of the overall system. A rotation-free element in co-rotational method simplifies the internal force and avoids the singularity of rotation, and it also fits the co-rotational formulation for its simpler local bending strain expression compared to computing the local rotation in co-rotational coordinate frame. Moreover, a quite straightforward internal force matrix can be assembled with co-rotational formulation, and which is element-independent, hence, different elements lead to a similar high efficiency. The Time-Complexity and Space-Complexity analyses show a co-rotational description is good at solving a large scale system, which is verified by a solar array case.

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References

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