Modeling fluid structure interaction with large structural displacement using NMM-ALE

† Bin Wang [1], Qiusheng Wang[1], †Guowei Ma[1, 2] and Huidong Wang[1]

[1] College of Architecture and Civil Engineering, Beijing University of Technology, Beijing 100124, China.
[2] The University of Western Australia, Perth, Western Australia 6009, Australia

*Presenting author: wbjynl@163.com
†Corresponding author: guowei.ma@uwa.edu.au

Abstract

Simulation of fluid structure interaction (FSI) is challenging in computational mechanics, especially when the large structural deformation or the displacement present. Mesh schemes like Lagrangian description, where coordinates of mesh nodes move with the material, is most commonly adopted to solve the solid problem. And, Eulerian description, where material flows through the mesh, is more suitable to be used in fluid dynamics analysis. The Arbitrary Lagrangian (ALE) Eulerian description, inherited from both the Lagrangian and Eulerian method, is the most widely recognized method to solve FSI problems with large structural displacement. However, when extremely large structural displacements or rotations of the structure occur, ALE is no longer sufficient and techniques like remeshing and refinement should be adopted.

Relying on a dual cover system of physical covers and mathematical covers, NMM can model arbitrary discontinuity, such as voids in a solid, cracks in brittle materials and in this case moving interfaces between coupled materials, by constructing special physical covers and local approximations. Classical ALE techniques are used to update the mesh system on the time-dependent FSI domain. NMM cover system is incorporated to the mesh-updating system when the distorted mesh appears, by temporarily projecting the ALE mesh to the original fixed NMM mathematical cover system. Therefore, mesh criteria is established to determine the projecting procedure. Because of the merit from NMM cover system, singular manifold elements will not cost any computational accuracy. Lastly, the open-close iteration, which is a procedure of adding and removing still springs, is introduced to solve the contact problem between individual structures. Numerical tests illustrate that NMM-ALE is an effective and robust method for simulating FSI with large structural displacement, deformation and rotation. Remeshing techniques for traditional ALE on the study of FSI is no longer needed by the virtue of NMM-ALE. It is also proved in the tests that physical covers in NMM, carrying degrees of freedom (DOFs), can be free from the interfaces. Multi-contacts between structures in FSI problems can be successfully tackled with the ALE-NMM scheme.

Keywords: Numerical Manifold Method; Arbitrary Lagrangian Eulerian; Fluid Structure Interaction; Large Structural Displacement; Multi-contacts