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A Mixed Lagrangian Eulerian Finite Element Method with ALE Formulation for Large Deformation Fluid-Structure Interaction Simulations

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Abstract

The fluid-structure interaction (FSI) effects have become an important design analysis consideration in the wide applications of finite element method to industrial problems. The effects are especially important in the microelectronics device simulations due to the relatively soft material and the increasingly dominating momentum effect of the surrounding fluid or air. The paper presents a direct-coupled mixed Lagrangian Eulerian finite element formulation for such FSI applications.

In the Eulerian flow field, an optimal Least-squares finite element formulation[1, 2] is adopted due to its numerical stability, theoretical completeness, and the direct compatible DOF's with the velocity based Lagrangian formulation for the continuum field. By adopting a velocity based Lagrangian formulation, the fluid-structure interface condition of the Eulerian flow field and the Lagrangian deformation are automatically preserved due to the direct-coupled velocity variable. Numerical results of this direct strong-coupled formulation are compared with the existing literatures to demonstrate the straightforward numerical applicability and accuracy.

To solve most of the industrial problems involving relative large deformation in the continuum field, we adopt an updated Lagrangian formulation for the continuum motion description. In the surrounding Eulerian field, an Arbitrary Lagrangian Eulerian (ALE) formulation is applied to accommodate the large deformation. The common Eulerian-Lagrangian interface becomes the ALE remeshing constraint, and the direct coupling of the Eulerian flow field ensures the compatibility of the continuum velocity and deformation compatibility. Numerical results are presented with demonstration to general industrial problems.

REFERENCES

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