EFFICIENT INTERFACE TREATMENT FOR FLUID-STRUCTURE INTERACTION ON CARTESIAN GRIDS

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Abstract. In a partitioned fluid-structure interaction approach, where the solution of the fluid and the solution of the structure are performed by independent simulation codes, an efficient interface treatment is crucial. In particular, there are two major objectives: On the one hand, an application connecting the two codes must provide the developer with a programming interface as simple as possible including an independent data model and a flexible communication model in order to facilitate reutilisation and compatibility. On the other hand, of course, numerical issues such as accuracy and stability for the coupling scheme and data transfer must not be neglected.

In this paper, we present a client-server approach for the interface treatment. In our concept, the coupling scheme is separated from the simulation codes and realised as a third application. This client sends requests to the simulation codes, who act as servers returning the physical state at the interface, e.g. displacements and loads. This data transfer is based on a unique and consistent spatial representation of the interface, realised as a triangulated surface mesh in 3d space, in our case derived from the grid of p-FEM on the structure side.

Since our objective is to use cartesian grids for the computations of the fluid flow, we derived an embedding octree model with respect to the spatial decomposition of the...
interface geometry. Such a hierarchical volume-oriented model enables us to directly create the computational domain. Hence, we can especially handle the moving structure in the fluid simulation very easily, where a finite-volume discretisation is used that preserves the symmetric behaviour of the differential operators of the Navier-Stokes equations. The influence of this discretisation to accuracy and stability of the coupling process is analysed.

We demonstrate the potential of our concept and present first results with a prototype implementation of our client-server based fluid-structure interaction approach.

1 INTRODUCTION

2 Design of the Coupling Interface

2.1 Client-Server Concept

2.2 Geometrical Representation of the Coupling Surface

- Dominik 0.5 to 1 pages
- closed triangulated surface representing the coupling surface
- physical quantities exchanged at the nodes
- current realisation: subset of a p-FEM mesh

2.3 Programming Interface

3 Symmetry-preserving discretisation on semi-staggered grids

- Miriam 1 - 2 pages
- motivation for semi-staggered grid
requirements to fulfill in order to achieve conservation of momentum and energy

- properties of the operators
- linear interpolation in the ‘triangle’ \( \Rightarrow \) conservation of mass in the control volume

3.1 Discrete Navier-Stokes Equation

3.2 Achieving Energy Conservation

3.3 Achieving Momentum Conservation

4 The embedded Octree Model
- Ralf 0.5 - 1 pages
- octrees are smart, wonderful, efficient, …
5 Data Exchange: Interpolation and Approximation

5.1 Transferring the Stresses

5.2 Transferring the Movement

6 Testing a Structure with large Movements

7 Conclusion
Figure 7: Page layout