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STRONG COUPLING SOLUTION METHODS APPLIED TO FLUID-STRUCTURE INTERACTION PROBLEMS

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ABSTRACT

There is a huge demand for strong coupling solution methods tailored to specific coupled problems. The building blocks of such coupling methods are well known, however the construction of specific methods and their application in real world computations remain a challenge in contemporary computational engineering. The aim of this presentation is to illustrate a general purpose strong coupling solver framework and its application to fluid-structure interaction problems.

Fluid-structure interaction (FSI) problems constitute interface coupled problems of two nonlinear fields. The field solvers are challenging by themselves and for both fluid and structural field very advanced solution techniques are required. A further difficulty arises from the fact that the interface between fluid and structural field moves, thereby changing the fluid field domain size. The FSI solution method has to take these into account.

Various solution schemes have been suggested for various kinds of FSI problems [1,2]. The schemes that can be applied to solve a particular FSI problem are determined by the problem characteristics, the fluid and structural model to be coupled, as well as the available software environment.

For the present discussion we assume coupling an incompressible fluid with a flexible structure. The fluid domain deformation is described by an additional Arbitrary Lagrangian–Eulerian (ALE) field. This is an important model that is applicable to a wide range of FSI problems. In addition it poses numerical challenges, because a strong coupling scheme is needed for this class of FSI problems in order to obtain a stable solution algorithm.

There are different means to construct strong coupling solution schemes for nonlinear interface coupled problems like the FSI problem considered here. There are monolithic methods that treat all fields and the coupling conditions at the same time, most often by means of a preconditioned Newton-Krylov method. To do that direct access to the field solver internals is needed. Alternatively there are iteratively staggered schemes, that build on a Dirichlet-Neumann domain decomposition of the coupled problem.

These schemes work with black box field solvers. All that is required is the exchange of coupling information at the interface.

In the present discussion monolithic methods as well as iteratively staggered schemes tailored for FSI problems are presented. The coupling behavior of both monolithic and iteratively staggered schemes is discussed. The suitability of various schemes is evaluated, taking into account numerical behavior and applicability in an engineering context. Particular emphasis is put on problem specific preconditioning of monolithic methods and its relation to staggered schemes.

REFERENCES

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