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On The Solution Of The Three-Field Coupling Approach For Aeroelastic Applications

*** Ralf Unger[1], Matthias C. Haupt[2] and Peter Horst[3]**

Institute of Aircraft Design and Lightweight Structures
Technische Universität Braunschweig
Hermann-Blenk-Str. 35
38108 Braunschweig, Germany
http://www.ifl.tu-bs.de

[1] r.unger@tu-bs.de [2] m.haupt@tu-bs.de [3] p.horst@tu-bs.de

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ABSTRACT

The computational simulation of fluid and structural interaction problems has reached a standard industrial tool for many applications in e.g. civil and aerospace engineering. By far, the most common approach to handle the coupled problem is the so-called partitioned approach where well-validated fluid and structural solver as well as data exchange libraries are combined into one flexible software environment. Although, a lot of aspects has been investigated within this topic, there is still a need for research, e.g. accuracy of the data transfer, computational efficiency regarding the equilibrium iteration, mesh deformation to name a few.

By using a partitioned coupling approach, two coupling schemes can be distinguished. By far, the most used scheme is the Two-Field approach, where each subdomain is linked to each other by one Lagrange multiplier. However, it is also possible to use a Three-Field formulation, which uses a connectivity frame to whose each subdomain is linked only [1]. Therefore, the fluid and structural subdomain are coupled through this connectivity frame by two Lagrange multipliers. With the aid of the Three-Field formulation conservation of linear momentum as well as of angular momentum can be reached by construction of an appropriate connectivity frame. Furthermore, by using a higher order interpolation in space for the connectivity frame, a smooth data transfer can be constructed, which is particularly important for high compressible fluids, see Fig. 1.

Unfortunately, up to now, using the Three-Field formulation, the fluid and the structure are treated as Neumann problems, which is uncommon for most of the CFD codes available or requires a special fluid formulation [2]. However, it could recently be shown, that a solution based on a block variant of a Krylov subspace iteration procedure can be used to solve the fluid-structure interaction problem [3].

On the basis of [3], the objective of the present contribution is twofold. First, the scheme is extended to two-dimensional interface problems to show the applicability for practical engineering problems.

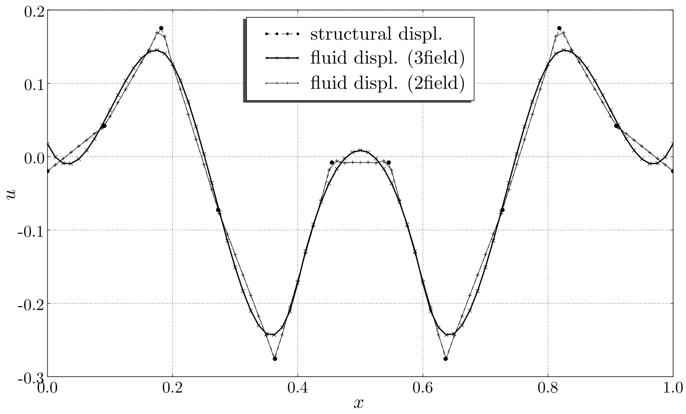

Figure 1: Transfer of structural displacements from a coarse grid (11 elements) to a fine fluid grid (80 elements) by using a) the Two-Field formulation and b) the Three-Field formulation where the connectivity frame state variable is interpolated by Hermite shape functions

This requires a proper formulation of the connectivity frame by higher order finite elements. Second, the iteration process of the Three-Field formulation is adjusted, so that the resulting scheme is a loose coupling procedure which is computationally cheaper and accurate enough for most engineering applications. First attempts on this topic were made in [4].

Examples, which are typical test problems for Computational Aeroelasticity, are shown and discussed in detail. Furthermore, a comparison of the presented schemes with the Two-Field approach will be presented.

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