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A Temporal High-Order Partitioned Method for Fluid-Structure Interaction Problems

A.H. van Zuijlen, A. de Boer and H. Bijl

Aerospace Engineering, Delft University of Technology, The Netherlands

Abstract. For a wide range of problems fluid-structure interactions play a role: from blood flow through flexible arteries to aircraft wing flutter. Due to the unsteady nature of many fluid-structure interactions, computational times are typically large. Using a higher order accurate in time, partitioned integration scheme (IMEX) combined with a smooth mesh deformation algorithm we obtain an efficiency increase of a factor three. The scheme is based on a combination of an implicit, L-stable, multistage Runge-Kutta scheme and an explicit Runge-Kutta scheme. Fluid and structure dynamics are integrated using the implicit scheme and only the pressure loads acting on the structure are integrated explicitly. For an academic problem we show that mesh optimization functions, which are often necessary in standard mesh deformation algorithms, can have a detrimental effect on the temporal order and accuracy. We use a radial basis function (RBF) interpolation with a thin plate spline to create a smooth displacement field for the whole fluid domain, which does not affect the order of the IMEX time integration scheme. For reasonable accuracies the IMEX schemes outperform a second order staggered scheme by a factor of 2 to 3.

Key words: *Fluid-structure interaction, Partitioned coupling, Higher order time integration, Mesh deformation.*

1. Introduction

For a wide range of engineering problems, dynamic multi-physics interactions like fluid-structure interaction play a key role in the safety of the design. For example the construction of a wing can fail when flutter occurs. The computation of fluid-structure interaction phenomena has therefore received a lot of interest over the past decades. Nowadays, complex real-world fluid-structure interaction problems can be simulated such as complete jet-fighter aircraft [1], although simulation times are very high.

In the fluid-structure interaction literature, two distinct ways are identified for solving the coupled problem: the monolithic approach and the partitioned approach [2]. In the monolithic approach the equations governing the multiphysics are discretized and solved within the same solver. A monolithic approach

*Correspondence to: P.O. Box 5058, 2600 GB Delft, The Netherlands, `h.bijl@tudelft.nl`.