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THE CHALLENGE OF THREE DIMENSIONAL DYNAMIC FLUID STRUCTURE INTERACTION

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ABSTRACT

Three dimensional dynamic fluid structure interaction for the solution of problems involving the dynamic interaction between a linear elastic body and the fluid with which it is in contact was implemented in the late 1990's using the single software framework (SSF) for multi-physics simulation, PHYSICA [1].Taking advantage of the SSF context, it was possible to demonstrate that the method was both time and space accurate [2].

Research into fluid structure interaction (FSI) continues to be highly active as may be seen by a simple search on the web revealing over 1 million hits. However, many workers do not have dedicated multi-physics codes readily available and, as such, have tried to address FSI problems through using a combination of approaches. Typically these involve simplifying either the solid mechanics or the fluid mechanics and ignoring the effects on one of the domains, i.e. one way coupling. However, increasingly, researchers wish to use phenomena specific structural and fluid simulation software to take advantage of the physics functionality embedded within each code. This is not a trivial task because structural dynamics and computational fluid dynamics may have different approaches to temporal and spatial discretisation requiring different mesh densities and differing time steps, which may lead to inaccuracies in interpolation. Hence, the challenge of coupling these classes of codes is not trivial as even exchanging information in the most loosely coupled fashion is not without its challenges.

Our work within the advantages of a SSF has highlighted a number of serious challenges beyond simply exchanging data between the structural and fluids solvers, some of which are:

- managing the mesh movement in such a way as to preserve adequate element quality
- embedding the ALE-GCL procedure within the FSI procedure
- consistent time stepping between the fluid and structural solvers

- the issues of running the FSI procedure in parallel with good scalability

Thus the current challenge is to utilise existing commercial phenomena specific solvers i.e. those originally conceived to focus on only one class of physics, such as ANSYS and CFX and interface them in such a way that they facilitate the full coupling amongst the fluid and structural response to yield results that are as time and space accurate as those using an SSF approach.

To this end there have been a number of attempts at coupling existing software, where one of the main tools to facilitate code coupling is MpCCI [4]. At the recent NAFEMS World Congress [5], it became apparent that there are a number of issues concerning the physics of the coupling that may not be apparent if simply focusing on the exchange of data between the physical domains, such as the implications of spatial or geometric conservation in three dimensions. This paper seeks to address some of the current challenges in this area.

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