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MODEL TSUNAMI IMPACT ON COASTAL PROTECTIONS BY A MULTI-SCALE PARTITIONED STRATEGY

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ABSTRACT

The numerical computation of coupled problems is characterized nowadays by more and more complex simulations, with respect to presence of different time scales characterizing each of coupled subproblems [3]. Despite this complexity, the practical applications require us to master the interaction between the different fields of physics (e.g.: thermomechanics, fluid-structures interaction or coupling of mechanics with physical-chemistry. . .), pushing the coupled problems into the mainstream of current research.

THE CONSIDERED SUBPROBLEMS

In this work, we focus on the modeling of the impact of tsunami waves on coastal protection (see Fig. 1); such problem is intrinsically a multi-physics one, and need the use of complex numerical tools to solve:

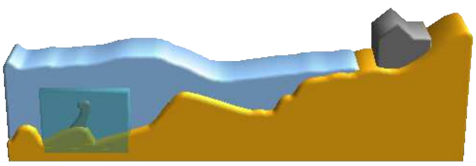

Figure 1: Coupled problem considered : the left part (wave propagation, viscous flow and structure)

- The propagation of tsunami wave, which is a fully non-linear problem is the domain considered (coarse scale). This problem is discretized with a Boundary Element Method (BEM) and solved by a Fortran code using C routines to solve the fast multipole algorithm [2].
- The viscosity effect that can not be neglected very close to the beach or near the coastal engineering protections (fine scale). This incompressible viscous flow is discretized with a Finite Volume strategy and the code used is OpenFoam, a very general C++ library to solve fluid problems.
- The mechanical behavior of the structures: very complex non-linear laws that represent at the macro-scale the behavior of engineering materials can now be implemented on Finite Element Method (FEM) based codes. This mechanical part is solved by FEAP, a FEM code programmed in Fortran.

As the reader can see, the different parts of our problem are solved by different software from different research teams, and one of the goal of our work is to enforce the possibility to re-use existing codes in a multi-physics context.

THE COUPLING STRATEGY

Each program is considered as a component. The communication between the component above is insured by the Component Template Library (CTL) [4], and each component can be launch on the same personal computer or processor, on different processors of the same cluster, but also on different machines through network communication.

This tools given, remain the question of coupling algorithm: which data (physical quantities) exchange, and in which order ? In our talk we will consider partitioned but strongly coupled algorithm that can converge that converge only under some conditions [1]. We consider independent time integration solvers in a window (i.e. $t \in [T_n, T_{n+1}]$). For this reason not only the value at synchronization points T_n or T_{n+1}, but the interpolated evolution of considered variables on the whole window as to be exchanged. Furthermore the strongly coupled problem considered need an error evaluation to know if there is convergence. This error is for us based on the coupling data.

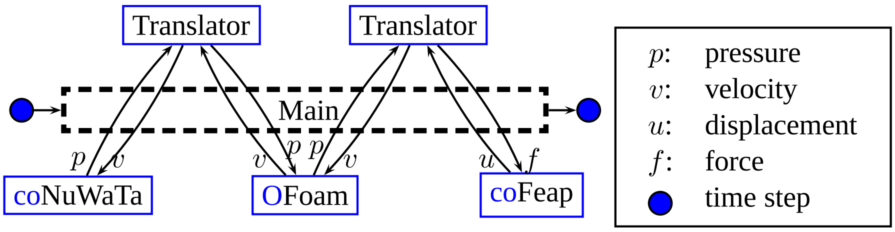

Figure 2: Software implementation and data exchange between components

CONCLUSION

In this talk we will explore a partitioned strategy to solve strongly coupled fluid-structure interaction problems under a moving free surface. Such an approach arise naturally when one want to use methods and software developed independently to solve each sub-problems; in this strategy new computing tools, like CTL, and coupling algorithms that preserve independence of sub-problems and numerical stability for the whole problem become the key point.

A useful direction for future research is a multi-scale modeling of tiny obstacles that can represent, for instance, the see flora that recent events in Sud-Asia have shown to be of great importance.

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