Implementation of a general mapping framework for different discretizations in distributed memory environments

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ABSTRACT

The simulation of coupled problems such as the assessment of wind loads on lightweight and flexible structures is associated with a high computational cost. Not only the solution of the computational domains is expensive, also the strong interaction of the wind with the structure makes an iterative coupling scheme necessary. This means that data has to be exchanged among the domains multiple times per timestep.

One way of transferring the data is to use mapping algorithms. Depending on the discretization of the domain-interfaces, this can also include some interpolation or filtering. Furthermore the interfaces can be partitioned among several processors if the simulations are executed in a distributed memory (MPI-parallel) environment.

Mapping algorithms can have many things in common such as the neighbor-pair-search on the other side of the interface or the exchange of data among the domains itself. The presented framework introduces a common approach to deal with those tasks, suitable for serial as well as for MPI-parallel simulations. Thus the workflow of many mapping algorithms is unified.
This unification consists besides defining a common interface also in the usage of the mapping matrix which works analogously to the global system matrix in a finite-element problem. Moreover the searching in a distributed memory environment is implemented in a general way to provide a unified and efficient way of conducting the gathering of data needed for assembling the mapping-matrix.

Different mapping algorithms are considered, interpolation-based such as nearest-neighbor and nearest-element as well as weak-form-based such as mortar-type methods. To show the flexibility and generality of the framework also the mapping between an isogeometric discretization and a regular finite-element discretization is discussed.

The implementation is realized within the finite-element-based open-source multi-physics platform Kratos Multiphysics. The presented algorithms are systematically tested and validated regarding their accuracy, robustness and parallel performance in distributed environments.
Furthermore examples of applications to MPI-parallel FSI simulations as well as in isogeometric analysis are shown.

REFERENCES

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