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Cyril Bordreuil, Frédéric Dubois

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A Generic Framework for Natural and Finite Element Method

C.Bordreuil[1], F. Dubois[1]

[1] *Laboratoire de Mécanique et Génie Civil, Université Montpellier 2/CNRS, UMR5508 , France, bordreuil@iut-nimes.fr, dubois@lmgc.univ-montp2.fr*

Numerical techniques are more and more sophisticated and each kind of method have its own field of applications. Concerning multi-physics analysis, it is more and more relevant to be able to combine different methods to solve complex problems.

Finite Element Method has shown its efficiency to solve different kinds of partial differential equations. Recently, meshless method and in particular the Natural Element Method (NEM) [1] shows its great interest in solving problems with large deformation by avoiding any remeshing. Combining both methods and transfering results from one analysis to the other could be tedious. The paper propose a framework to use both methods into a single application.

In this paper, the availability to implement a generic library to treat Finite Element Method and Natural Element Method is based on generic programming. Generic Programming was successfully applied for a finite element library dedicated to adaptive meshing [2].

The philosophy of this work is the one developped in the Standard Template Library [3], where the container is independent of the algorithms. This kind of design imposes to have robust interfaces (and respect some concepts checking) between software components but lead to interoperable and extensible pieces of codes.

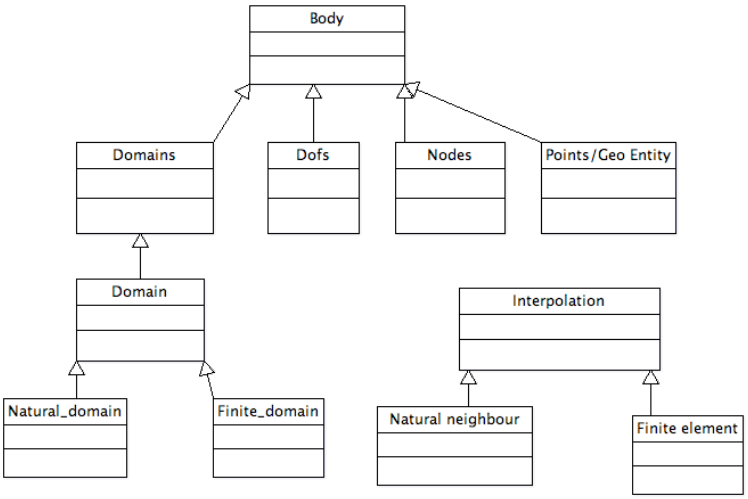

Figure 1: UML diagram for the body and a part of the geometry module

A short UML description of one part of the library is depicted on figure 1. In the presented library, geometry was separated from the discretized description of the body to better manage geometry evolution. For NEM, the geometry of the domain is mainly implemented with help of [4] and for FEM, the development of [5] are followed.

One of the originality of the design is the separation of the interpolation from the domain (mesh, constrained triangulation,...). This design needs to add more abstract classes but it seems a good opportunity to extend the library with other kinds of interpolation method.

In a weak formulation, quadrature must be performed. As shown by Chen [6], stabilized conformal nodal integration must be prefered to insure good numerical performances with meshless methods. These kind of integration could also be used with finite element analysis when strain softening occurs. One more time, this will influence the requirements of the integration algorithms implementation and this will be detailed.

The weak formulation and the overall resolution of the partial differential equations are not shown in figure 1 but it follows the design of Archer [7]. The design of the library is done in order to be embedded in the multi-body (domain) research code of the lab [8].

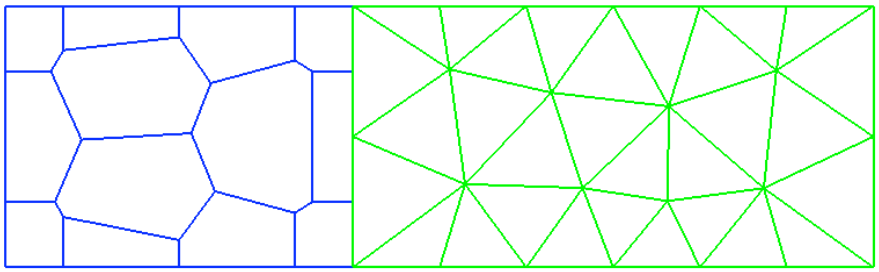

Figure 2: Benchmark to test the natural and mesh domain definition inside a body

Finally, a non-transient thermal model example is treated with the two types of domains as shown on figure 2. This benchmark will show the behaviour of the results of such analysis with the two types of domain.

References

[1] Alfaro.A, Yvonnet.J, Chinesta.P, Cueto.E "A study on performance of natural-neighbour based galerkin method", *International Journal of Numerical Methods in Engineering*,2006

[2] B. Kirk, J. Peterson, R. Stogner and G. Carey, 'libMesh: a C++ library for parallel adaptive mesh refinement/coarsening simulations", *Engineering with Computers*,2006, Vol 22, p237-254

[3] Austern.M "Generic Programmic and the STL" 1999 - Addison - Wesley

[4] CGAL Library "http://www.cgal.org"

[5] Remacle J-F, Shephard M.S "An algorithm oriented mesh database" *International Journal of Numerical Methods in Engineering*,2003 ,Vol58, p349-374

[6] Chen.J-S, Wu.C-T, Yoon.S You.Y " A stabilized conforming nodal integration for galerkin mesh-free methods", *International Journal for Numerical Methods in engineering*, 2001, Vol 50, p435-466

[7] Archer.D "Object Oriented Finite Element Analysis", 1996,PhD, Berkeley University

[8] LMGC90 "http://www.lmgc.univ-montp2.fr/~dubois/LMGC90/"