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MULTI-SCALE DYNAMIC METHOD FOR STRUCTURES WITH CONTACT INTERFACES

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ABSTRACT

The increasing complexity of calculations has created a need for techniques capable of drastically reducing computation times in finite element analysis. Today's expectations in terms of calculation accuracy lead to larger and larger numerical models, which sometimes leads to prohibitive calculation times, in particular for modelling large assemblies with connections in dynamics [1]. However, these connections play a major role in the dimensioning process, because they are the place of strongly nonlinear local phenomena: contact and friction.

Moreover, for structural engineers, the incorporation of a system's parametric uncertainties into such an analysis constitutes a challenge; however, without this information, the structural response cannot be calculated accurately. These parametric uncertainties may affect the material's mechanical properties (modulus, strength, etc.), the structure's geometric properties (cross-sectional properties and dimensions), the boundary conditions (including contact with friction), the magnitude and distribution of loads, etc. In the case of structural assemblies, the knowledge of the friction coefficients is especially limited. In order to take these uncertainties into account, it is necessary to calculate the response of the structure for each set of values of the design parameters [2]. Typically, in our case, the design parameters are friction coefficients and gaps.

In addition, one is often confronted with a problem of memory size. It is in this context that domain decomposition methods and multi-scale calculation techniques originated a few years ago. Besides the fact that they allow greater flexibility in the numerical models and savings in computation time, these methods are particularly well suited to parallel computing with shared memory. Nevertheless, they can be easily adapted to distributed memory architectures.

This paper is based on a mixed domain decomposition multi-scale approach in explicit dynamics. The aim of the present work is to develop an efficient strategy for the parametric analysis of dynamics problems with multiple contacts. The applications concern elastic, structural assemblies in dynamics with local nonlinearities such as unilateral contact with friction. Our approach is based on a decomposition of the assembly into sub-structures (representing the parts) and interfaces (representing the connections).

The problem is solved in each sub-structure by the finite element method and an iterative scheme based on the multi-scale LArge Time INcrement (LATIN) method developed at the LMT-Cachan [3], [4] is used for the global resolution.

Among the methods usually used to deal with such problems in dynamics, one can quote the two-level FETI method (often qualified dual Schur method) [5] which is based on an inter-sub-structure field continuity enforced via Lagrange multipliers applied at the sub-structure interface. The multi-scale LATIN method is a mixed method, which deals simultaneously with velocities and forces on the interfaces. This method also uses a homogenized macroscopic problem in order to accelerate the convergence of the numerical scheme. Already largely developed in static and quasi-statics, the objective of the work suggested here relates to its extension to dynamics.

The objective is to calculate a large number of design configurations [6]. Each design configuration corresponds to a set of values of all the variable parameters (friction coefficients, gaps) which are introduced into the mechanical analysis. Here we propose, instead of carrying out a full computation for each design configuration, using the capability of the multi-scale LATIN method to re-utilize the solution of a given problem (for one set of parameters) in order to solve similar problems (for the other sets of parameters) [7].

We will show first the extension of the multi-scale LATIN strategy to dynamics, in particular the construction of the macroscopic problem in space, which in this case has a less conventional interpretation than in static. The specific treatment of the interfaces ensuring the efforts and velocities continuities will be detailed in the second phase. Then, we will present the specific strategy used for the parametric study. To finish, the performances of the method will be illustrated on parametric analysis of dynamics of 3D structures with frictional contact interfaces.

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