January, 29th 2018
Université de Grenoble Alpes

Heterogeneous Asynchronous time integrators for coupling methods

A. Gravouil[1]
[1] Université de Lyon, INSA-Lyon, LaMCoS, CNRS UMR 5259, F-69621, Villeurbanne, France
e-mail: Anthony.gravouil@insa-lyon.fr

Keywords: explicit-implicit time integrators, energy-based methods, contact and impact dynamics

Abstract

In non-smooth transient structural dynamics, the choice of the time step and the time integrator has a critical impact on the feasibility of the simulation. For instance, during an earthquake, a bridge crane, usually located overhead in buildings, may be subjected to multiple impacts between crane wheels and rail. These multiple impacts cause significant damage in the structure. Then the qualification of these structures with respect to normative seismic design requirements, which are continuously developing and becoming more and more stringent, requires strengthened simulation techniques especially to model the impact phenomenon. Furthermore, multiple time-scales coexist in a bridge crane under seismic loading. In that case, the use of multi-time scale methods is suitable. Here, we propose a new explicit-implicit heterogeneous asynchronous time integrator (HATI) for non-smooth transient dynamics with possible contacts and impacts. In a first step we introduce a Moreau-based event-capturing explicit time integrator for contact/impact problems. In a second step, a two time scales explicit-implicit HATI is developed: it consists in using an explicit time integrator with a fine time scale in the contact area, while an implicit time integrator is adopted in the other parts in order to capture the low frequency content of the solution and to optimize the CPU time. 3D Transient dynamics applications illustrate the robustness and the efficiency of the proposed approach.

References

[1] Fekak F., Brun M., Gravouil A., Depale B., a new heterogeneous asynchronous explicit-implicit time integrator for nonsmooth dynamics, *Computational Mechanics*, 2017; 50:199-225
[2] Gravouil A., Combescure A., Brun M., Heterogeneous asynchronous time integrators for computational structural dynamics. *International Journal for Numerical Methods in Engineering,* 2015; 102:202–232
[3] Acary, V., Energy conservation and dissipation properties of time-integration methods for non smooth elastodynamics with contact. ZAMM-Journal of Applied Mathematics and Mechanics/ 96, 585–603 (2016)
[4] Deuflhard, P., Krause, R., Ertel, S., A contact-stabilized newmark method for dynamical contact problems. International Journal for Numerical Methods in Engineering 73(9), 1274–1290 (2008)
[5] Hesch, C., Betsch, P., Transient 3d contact problems-nts method: mixed methods and conserving integration. Computational Mechanics 48(4), 437–449 (2011)
[6] Lew, A., Marsden, J., Ortiz, M., West, M., Variational time integrators. International Journal for Numerical Methods in Engineering 60(1), 153–212 (2004)
[7] Moreau, J.J., Numerical aspects of the sweeping process. Computer Methods in Applied Mechanics and Engineering 177(3), 329–349 (1999)
[8] Jean, M., The non-smooth contact dynamics method. Computer methods in applied mechanics and engineering 177(3), 235–257 (1999)
[9] Laursen, T.A., Computational Contact and Impact Mechanics: Fundamentals of Modeling Interfacial Phenomena in Nonlinear Finite Element Analysis. Springer Science & Business Media (2002)
[10] De Saxcé, G., Feng, Z.Q., The bipotential method: a constructive approach to design the complete contact law with friction and improved numerical algorithms. Mathematical and Computer Modeling 28(4), 225–245 (1998)
[11] Armero, F., Petocz, E., Formulation and analysis of conserving algorithms for frictionless dynamic contact/impact problems. Computer methods in applied mechanics and engineering 158(3), 269–300 (1998)
[12] Alart,P.,Curnier,A., A mixed formulation for frictional contact problems prone to Newton like solution methods. Computer Methods in Applied Mechanics and Engineering 92(3), 353–375 (1991)
[13] Belytschko, T., Neal, M., Contact-impact by the pinball algorithm with penalty and Lagrangian methods. International Journal for Numerical Methods in Engineering 31, 547– 572 (1991)