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NEW EVENT–CAPTURING TIME–STEPPING SCHEMES WITH HIGHER RESOLUTION AND ORDER FOR NONSMOOTH MULTIBODY SYSTEMS.

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ABSTRACT

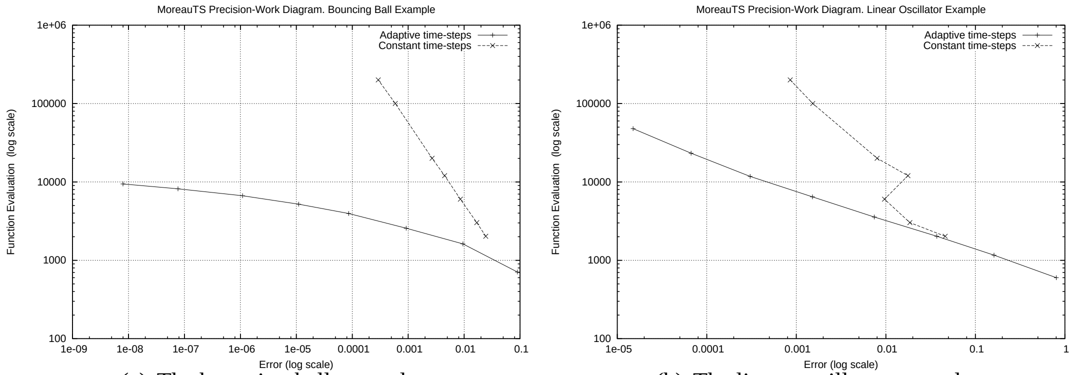
NonSmooth MultiBody Systems (NSMBS) The article is devoted to the development of new higher resolution and higher order time integration methods for nonsmooth multibody systems. Although this work may be applied to any nonsmooth second order dynamics (friction, nonsmooth bilateral constraints, cohesive zone models), we will focus our presentation to the particular class of NSMBS subjected to perfect unilateral constraints. (More details on NSMBS can be found in [1]) :

$$\begin{cases} M(q)\dot{v} = F(t,q,v) + G(t,q)\lambda \\ \dot{q} = v \\ y = g(t,q) \\ 0 \leqslant y \perp \lambda \geqslant 0 \\ v^+ = \mathcal{F}(v^-,q,t) \end{cases} \tag{1}$$

Non smooth event capturing schemes Besides the standard event-driven approach, *Nonsmooth event capturing methods* also called shortly *time–stepping schemes* perform the numerical integration of (1) on a time step, which do not dependent on the exact location of nonsmooth events(impact, take–off,. . .). The advantages of this class of methods are the convergence proofs and the efficiency even in the case of finite accumulation of impacts and the fact that are able to work without an accurate event detection procedure. The major drawback of these methods is their order. In practice, they are at best of first order at impact but also on smooth solutions. Most well-known time–stepping scheme are Moreau's scheme [2] and Schatzman–Paoli's scheme [3].

The objective of this paper is to propose two alternative nonsmooth event capturing methods, with higher–order convergence results and/or better efficiency. The first scheme is obtained by means of adaptive time–step strategy and the other one by coupling with other standard one–step schemes for smooth dynamics (Runge–Kutta schemes). The term ”higher order” applies to methods which whose global error behaves at an order greater than 1. The term ”high resolution” applies to methods that are at least first order methods when non smooth events are encountered and of higher order on smooth solutions.

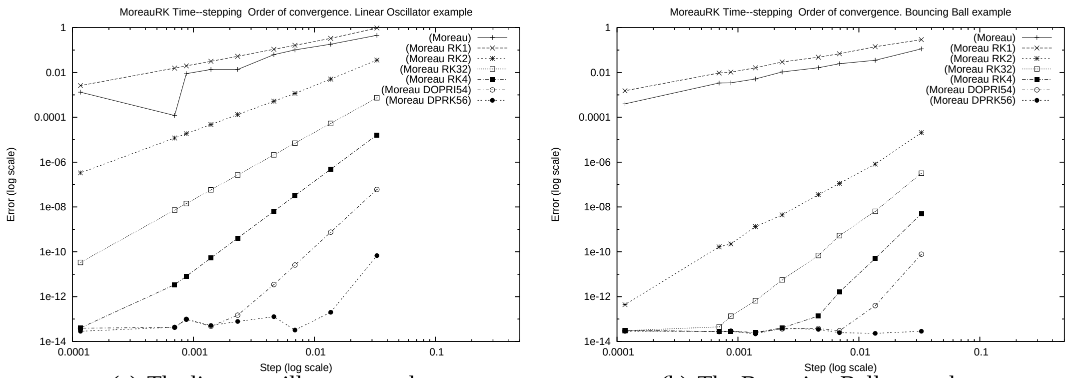
Illustrations of the results After a study of the local error estimates and practical error evaluation, an adaptive time–step strategy has been proposed. On Figure 1, the strategy is successfully applied to a bouncing ball problem and a linear impacting oscillator. Details in the development and the implementation of the schemes will be given in the final paper.



(a) The bouncing ball example (b) The linear oscillator example

Figure 1: Precision Work diagram for the Moreau's time-stepping scheme. Order 1

Schemes of any order Schemes of any schemes of any order are built by coupling any higher order one–step scheme for smooth Dynamics (Runge–kutta schemes in this paper) and the Moreau's time–stepping scheme. On Figure 2, this scheme shows to well behave even with accumulations of impacts and appears to be a good substitute the event–driven approach



(a) The linear oscillator example (b) The Bouncing Ball example

Figure 2: Precision Work diagram for the Moreau's time-stepping scheme.

Outline The paper will provide with detailed results on order estimates in practical case, the adaptive time–step strategy and also the way how several schemes are coupled without an accurate location of events. Other nonlinear examples will be also treated.

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