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Interactive Rigid Body Contact Force Problems

Experiences on Bridging the Gap between Eye–Candy and Real–World

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Abstract How far are interactive simulation models and methods from more physical correct simulations? This talk will lift the curtain on some of these aspects by stating one of the most used contact force models – the NCP model – and relate it to the well-known LCP model. The talk will briefly touch upon numerical methods for the NCP model and conclude with ideas and motivation for future work in the field of interactive contact force computations.

Keywords Interactive Simulation · Contact Force Models · Numerical Methods

Interactive Simulation for Serious Applications

Iterative methods for interactive rigid body simulation has become a popular solution for many software libraries such as Bullet and Open Dynamics Engine. Such methods offer great robustness over accuracy and is well suited for interactive game–like scenarios. However, the methods suffer from some drawbacks. One coming from a simplified contact force model known as the NCP contact model and the other coming from linear convergence rate which results in a viscous and damped appearance of the contact response. If such iterative methods are applied to dry stone masonry structures as those shown in Figure 1, the simulation will result in an immediate collapse of the structure. An animation effect that would serve the purpose of violent exaggeration in an action game. However, for more serious applications, such as virtual prototyping, the game-like effect is unwanted.

Our work tries to improve the simulation quality of interactive contact force simulations. We will cover the evolution of experiences and lessons learned through a series of papers on the subject [7, 5, 6, 8, 15, 18, 16, 17, 14, 13].

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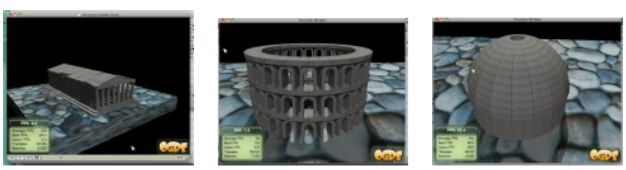

(a) Greek temple (b) Colosseum (c) Pantheon

Fig. 1 Dry stone masonry structures cause large mass ratio problems and stability relies on interlocking phenomena that requires accurate static friction forces. The screen shoots are from an in-house benchmark tool at Department of Computer Science, University of Copenhagen, Denmark.

The Evolution of Models and Methods

For interactive simulation, the current trend is either impulse based paradigms [11, 9] or constraint based paradigms [3, 20].

The impulse based paradigm is well suited for computer games and open source engines exist [4]. However, they tend to add jittering giving a noisy appearance of structures[6]. Thus, for faithful simulation of complex structures, constraint based methods are popular [19]. Recent developments in the field (re-) introduced the cone complementarity formulation [1, 22] and proximal map formulation [21], taking a interesting new turn.

The idea of fixed time stepping and iterative methods for constraint based formulations date back [12, 10]. The often used solution is based on a friction cone approximation [3] that simplifies the numerical methods by ignoring maximum dissipation principle and is often limited to dry friction only. From a model viewpoint the simplification changes the LCP model [20, 2] into that of an NCP model where various numerical methods have been developed for [14, 13, 17]. In this talk we compare the LCP model with the NCP model and address advantages and disadvantages of both seen from an interactive simulation viewpoint. We will present a coarse walk-through of numerical methods for the NCP model and comment on these by showing examples. Finally, if time permits we will draw relations to our latest ongoing work on parallelization of numerical methods for contact force models, based on proximal map formulations.

Discussion and Conclusion

The talk will try to summarize and collect 10 years experiences on interactive simulation. The result is far from a global answer to all problems. Yes, we have models and methods that are sufficient for rigid body simulation in computer games and special effects. However, looking beyond these application scopes it is our opinion that there is room for a lot more research to make interactive simulation more feasible to a wider scope. For instance virtual design where accuracy and physical correctness can not be compromised too much in the name of performance. This leads naturally to open problems for research on interactive contact force computations? Will the research field develop new contact models? Or focus on studying efficient numerical methods? This talk will finalize on giving pragmatic unproven statements that can fertilize the research community as inspiration or as provocation to be proven wrong.

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