Smart Discrete Elements based on the A-CD2 approach

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This paper focuses on the enhancement of a discrete-elements approach to model the evolution of a crowd of people in emergency evacuation situations.

The selected discrete element model is based on the non-smooth mechanics principles [1]. The application of the principle of virtual work in association with appropriate constitutive laws relating internal stress and velocities, result in a set of equations of motion, valid both for smooth and for non-smooth evolutions. The atomized efforts contact dynamics approach respecting the Clausius–Duhem inequality (A-CD2) [2] provides the numerical framework of the approach and guarantees the existence and the uniqueness of the solution without the need of penalty formulations.

As a further step, the method has been enhanced to develop « smart » particles, i.e. pedestrians. Level-sets have been introduced to provide to each grain a desired velocity or, in other terms, « willingness ». Each particle representing a human being has specific and unique properties such as its own velocity, mass, reactivity, etc. and actively interacts through « social » forces with the external environment (i.e. other pedestrians and/or obstacles). The system evolves naturally, thus simulating pedestrian traffic and the behavior of a crowd of people.

Some typical situations are finally illustrated and compared, when possible, with real safety exercises in configurations such as the presence of a bottle-neck, emergency evacuations and platform-train exchange.

[1] M. Frémond, Rigid bodies collisions. Phys Lett A 204:33–41 (1995)
[2] S. Dal Pont, E. Dimnet, A theory for multiple collisions of rigid solids and numerical simulation of granular flow. Int J Solids Struct., 43/20:6100–6114 (2006)

Figure 1 : Signage system proposed at RATP : photograms of one typical simulation of the platform/train passenger interchange with (on the left) and without (on the right) signage