Reduced order modeling for realtime simulation with granular materials

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ABSTRACT

The discrete element method (DEM) is a versatile but computationally intense method for simulation of granular materials. It is therefore rarely used in applications that require realtime performance, e.g, interactive simulaions with a human operator or hardware in the loop.

We investigate the use of reduced order modeling for achieving realtime performance in coupled discrete element and rigid multibody simulations. First, a large data set is produced from a series of simulations that cover a selected state-space. The particle data is coarse-grained into discrete field variables, representing mass density, velocity, strain and stress. A reduced order representation of the state-space is identified. Different methods for predicting the fields are explored, given certain observations and assumptions about the state of the simulation e.g., motion of boundaries, rigid bodies or control signals. The particle positions and velocities can then be advanced in time using the predicted fields plus a model for particle diffusion [4] and a local incompressibility constraint [1]. The resulting method can be seen as an extension to the one in [5], by extending the reduced space from rigid body motion of particle aggregates to a low-dimensional space of flow fields [2, 3].

The precision and computational performance of the reduced order simulation method is analyzed on simple test systems, including silo flow and a blade cutting a granular bed. Finally, coupled simulation of an articulated rigid multibody system and a reduced order granular system is demonstrated.

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