Continuum Modeling and Simulation of Dry and Wet Granular Media

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To model granular materials, one can attempt to track every grain with discrete particle methods but realistic systems are often too large for this approach and a continuum model is desired. This talk will provide an overview of our recent developments in continuum modeling and continuum simulation methods for dry and fluid-saturated particulate systems.

We begin with dry flows, for which we have developed a family of continuum models and solvers. We will discuss a simple yet effective constitutive relation for cohesionless media and discuss a meshless implementation method that lets us implement this method to compute flows in arbitrary geometries. We will present some key application areas where this dry flow solver has found important uses. Next, we discuss a technique for submerged granular flow problems, which treats the granular phase and the fluid phase as two separate yet coupled continuum models. Using mixture theory, the forces of bouyancy and drag couple the Navier-Stokes behavior of the fluid phase to a dilatant, rate-sensitive granular flow continuum model. The final mixture formulation is simulated using two coupled, overlapping continuum simulations, one for the fluid phase and one for the granular phase. This methodology is shown able to replicate experimental results for saturated granular flows over a range of conditions and packing fractions. It can be extended to account for more obscure mixtures, including the dramatic shear-thickening seen in fine-particle suspensions such as cornstarch-and-water mixtures. Lastly we will show how the approach can be specialized for the case where the fluid is a gas, e.g. with higher Reynolds number, thermally-sensitive equation of state, and possibly high Mach number.