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Contact force structure and force chains in 3D sheared granular systems

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Faults often exhibit accumulations of granular debris, ground up to create a layer of rock flour or fault gouge separating the rigid fault walls. Numerical simulations and laboratory experiments of sheared granular materials, suggest that applied loads are preferentially transmitted across such systems by transient force networks that carry enhanced forces. The characterisation of such features is important since their nature and persistence almost certainly influence the macroscopic mechanical stability of these systems and potentially that of natural faults.

3D numerical simulations of granular shear are a valuable investigation tool since they allow us to track individual particle motions, contact forces and their evolution during applied shear, that are difficult to view directly in laboratory experiments or natural fault zones. In characterising contact force distributions, it is important to use global structure measures that allow meaningful comparisons of granular systems having e.g. different grain size distributions, as may be expected at different stages of a fault's evolution. We therefore use a series of simple measures to characterise the structure, such as distributions and correlations of contact forces that can be mapped onto a force network percolation problem as recently proposed by Ostojic and coworkers for 2D granular systems. This allows the use of measures from percolation theory to both define and characterise the force networks. We demonstrate the application of this method to 3D simulations of a sheared granular material. Importantly, we then compare our measure of the contact force structure with macroscopic frictional behaviour measured at the boundaries of our model to determine the influence of the force networks on macroscopic mechanical stability.