The Controllability of Granular Packings

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Force Network Ensembles & Network Control Theory

- Stress-distributing structure
- Operates on the mesoscale
- Changes in a way that is difficult to predict when materials break or deform due to applied forces
- NCT is a novel way to describe force network evolution
- Used NCT in conjunction with particles undergoing compression

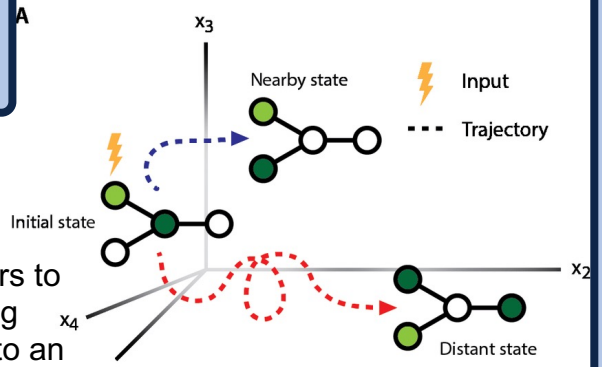
Simulated Controllability Analysis

- Compressed different system sizes of disks interacting harmonically with a specified potential
- Created force networks and contact networks during the compression process

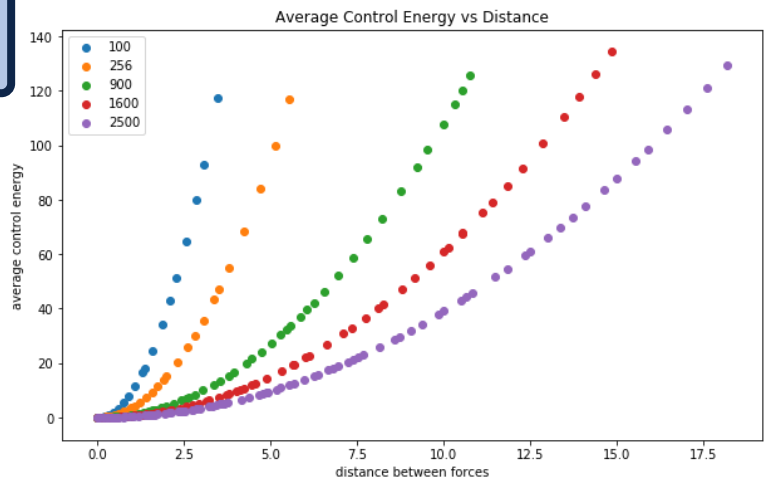
Results

- Average control energy of the system as a function of the Euclidean distance between system states and as a function of frame

  Control energy energy increases with system size and jamming



Control energy refers to the system changing states in response to an input (8)



Average control energy as a function of Euclidean distance between states for different system sizes, with a steeper slope indicating more energy needed to transition to a state at a given distance.

Conclusion

- Physical intuition for characterizing force chain architecture evolution
- Larger systems are easier to manipulate on a per-particle level
- Link between structural and topological properties and control energy
- Control energy tools provide a more complete description of the system

References

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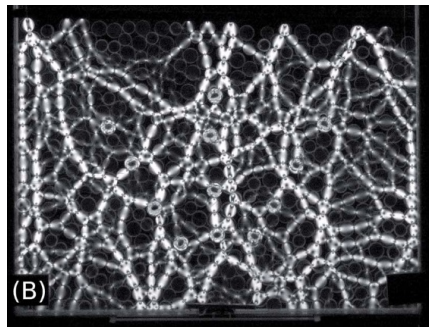

Force chain network due to stress distribution over the particles (2)