Structuro-elasto-plasticity (StEP) model for plasticity in disordered solids

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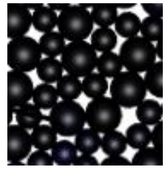
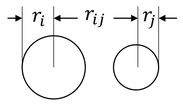
We study disordered solids made of soft particles

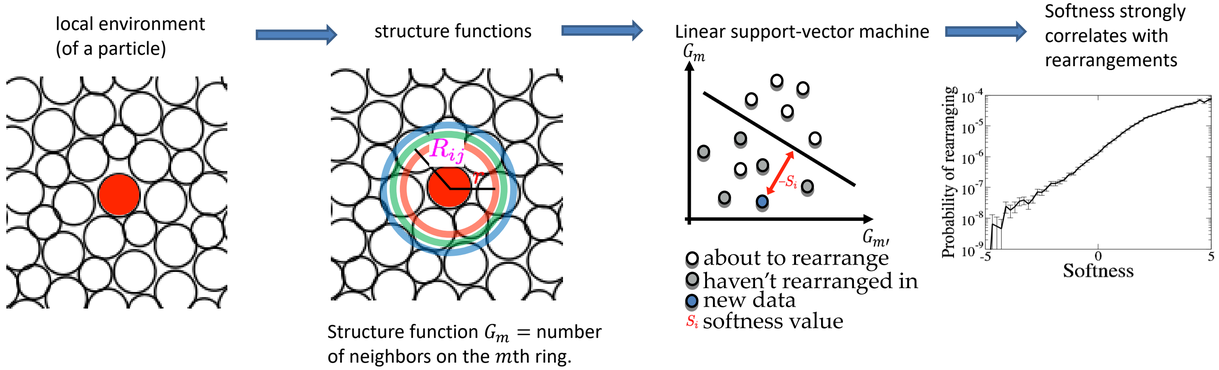


These soft disks repel each other when they overlap, and have no interaction otherwise

One model interaction: $v(r) = \begin{cases} \left(1 - \frac{r_{ij}}{r_i + r_j}\right)^{2.5} & \text{if } r_{ij} < r_i + r_j \\ 0 & \text{otherwise} \end{cases}$



Train softness using SVM

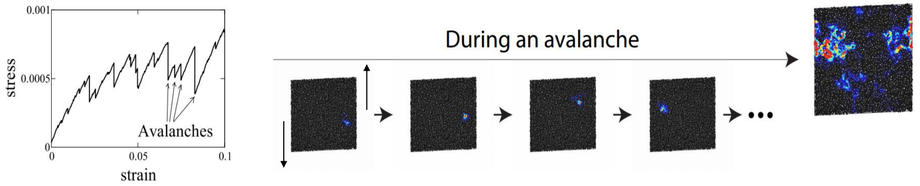


Structure function G_m = number of neighbors on the mth ring.

Different disordered solids behave differently under shear. Why?

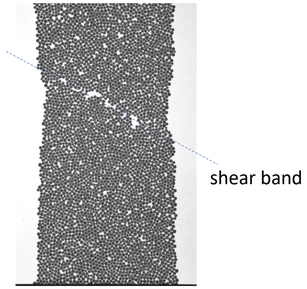
Under external force, some disordered solids form shear bands, and some doesn't. Those forming shear bands are usually more brittle.

Non shear-banding system



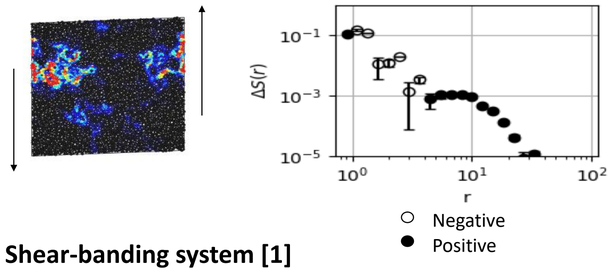
Color indicate rearrangements (particles changing neighbors)

A different shear-banding system [1]

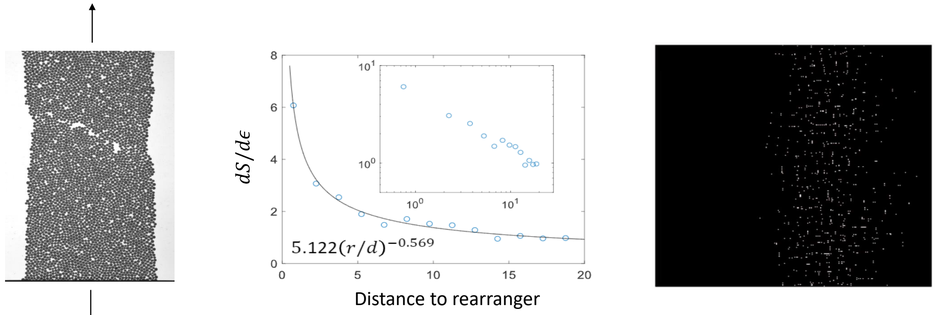


Incorporating softness into elasto-plastic model allows predicting if a shear band forms.

Non-shear-banding system

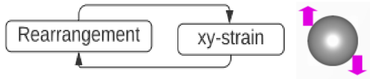


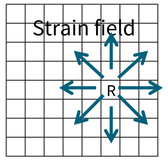
Shear-banding system [1]



Elasto-plastic models: rearrangement and strain interplay

A family of known model for these disordred solids are elasto-plastic models, in which particle rearrangements sends out strain fields, which triggers more rearrangements.





We want to consider another factor: local structure (softness)

Local structure should also play a role here, since particles in a less stable local environment rearranges more easily. We capture this using a machine-learned quantity, softness.

I rearrange easily!

I am soft,
I have softness S>0

I don't!

I am hard,
I have S<0

[1] H. Xiao, R. Ivancic, and D. Durian, Soft matter, **16**, 8226 (2020)