Predicting local yielding in dry foams using machine learning tools

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ABSTRACT

Foams yield via topological changes in the bubble structure, known as T1 events [1]. The complex dynamics of yield events define the macroscopic response of a foam to an external deformation. This makes the study of T1 statistic an extremely relevant research topic. We apply a convolutional neural network (CNN) to identify soft areas about to yield from snapshots of a sample foam. The idea is closely related to similar approach used to predict soft spots in granular material with machine learning tools [2]. We manage to identify snapshots preceding T1 events from those of stable configurations with over 90 % predictability, which is the fraction of correct predictions of all predictions. The predictability decays exponentially with time when the time between an yield event and a snapshot is increased (we also predict choosing the snapshot after a T1 event). We attribute the high predictability to the local structural features of the foam related to the vertices connecting liquid films, such as angles between the films and positions of the vertices.

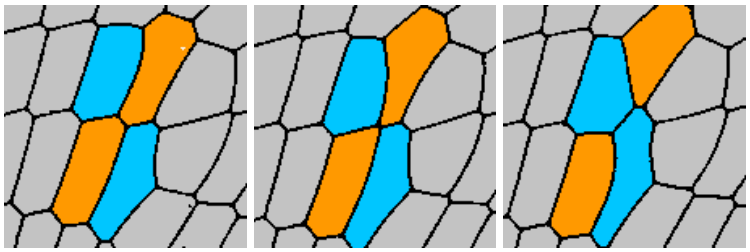

Figure 1: Figure shows a time series of images with bubbles going through a T1 event. The image times are starting from the first frame: 0.0 s, 0.9 s, and 1.1 s.

[1] S. Cohen-Addad, R. Höhler, and O. Pitois. Flow in Foams and Flowing Foams, Annu. Rev. Fluid Mech 45:241-267, 2013.

[2] E.D. Cubuk, S.S. Schoenholz, J.M. Rieser, B.D. Malone, J. Rottler, D.J. Durian, E. Kaxiras, and A.J. Liu. Identifying Structural Flow Defects in Disordered Solids Using Machine-Learning Methods, Phys. Rev. Lett. 114:108001, 2015.