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Quantitative 3D characterization of cellular materials: Segmentation and morphology of foam

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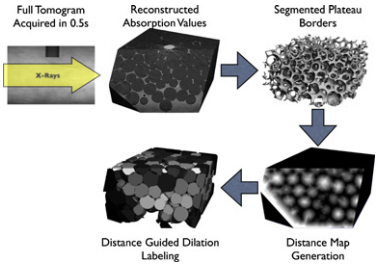
HIGHLIGHTS

- A new, fully automated, open method for labeling and analyzing cellular material.
- Labeling and quantitative characterization on mono- and poly disperse liquid foam.
- Validation against existing published technique with thousands of bubbles.
- Applicable to other materials from in-silico metallic foams to volcanic rock.

GRAPHICAL ABSTRACT



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ABSTRACT

Wood, trabecular bone, coral, liquid foams, grains in polycrystals, igneous rock, and even many types of food share many structural similarities and belong to the general class called cellular materials. The visualization of these materials in 3D has been made possible in the last decades through a variety of imaging techniques including magnetic resonance imaging (MRI), micro-computed X-ray tomography (μCT), and confocal microscopy. Recent advances in synchrotron-based ultra fast tomography have enabled measurements in liquid foams with thousands of bubbles and time resolutions down to 0.5 s. Post-processing techniques have, however, not kept pace and extracting useful physical metrics from such measurements is far from trivial. In this manuscript we present and validate a new, fully-automated method for segmenting and labeling the void space in cellular materials where the walls between cells are not visible or present. The individual cell labeling is based on a new tool, the Gradient Guided Watershed, which, while computationally simple, can be robustly scaled to large data-sets. Specifically we demonstrate the utility of this new method on several liquid foams (with varying liquid fraction and polydispersity) composed of thousands of bubbles, and the subsequent quantitative 3D structural characterization of those foams.
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1. Introduction

Dispersions, which by definition consist of at least two phases mixed together, are an interesting class of materials, principally because the mechanical properties of a mixture are not a linear sum of its components. Furthermore these materials are particularly useful because their properties can be tuned by adjusting the

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