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Enhanced grain partitioning of microtomography segmented images

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Grain partitioning of three-dimensional microtomography segmented images provides valuable in-situ properties and statistics that allow for accurate particle and structure characterization of porous media samples. There are many applications of this technology, ranging from analyzing core samples in petroleum engineering and soil science to developing novel structures in material science. This information can be further used as a tool to generate more accurate particle packings for simulations, and also as a base for geo-mechanical models. The overall objective of this work is to improve the accuracy and reliability of grain-partitioning algorithms applied to microtomography or other three-dimensional images.

The methodology described here is broken into two separate categories: initial partitioning, and post processing refinement. The initial partitioning is based upon a Euclidean distance map of the sample and the watershed algorithm, meaning that this methodology assumes that the particle interfaces coincide with watershed surfaces. In order to combat the over-partitioning that is common with this methodology, several new iterative techniques have been implemented into particle assembly. Once the initial partitioning is completed, the user has the opportunity to interact with the resulting image and to directly apply refinement options such as planar regression for particle contacts, automatically merging particle pairs meeting a specified criteria, and manually merging individual particular pairs. Bulk and individual properties, such as porosity, particle volumes, surface areas, contact areas, and aspect ratios are calculated and updated corresponding to any refinement.

More advanced analysis through machine learning is also being investigated. After the initial partitioning, the user is shown pairs of grains, as well as their neighbors, and is prompted to make a decision on whether or not the subject grain should be merged together. All statistics regarding the grains of interest are recorded along with the user's decision. After a sufficient number of decisions have been recorded for the given sample, logistic regression is performed on the recorded data, and compared with the cross validation data. Once a specified accuracy is met, the resulting logistic regression equation can be applied to the remaining portions of the porous media sample, and other images with similar particle and structural characterization.

References

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