Multi-scale random sets: from morphology to effective properties and to fracture statistics

Dominique Jeulin

Centre de Morphologie Mathématique, Mathématiques et Systèmes

35 rue Saint-Honoré, F77300 Fontainebleau (France)

Centre des Matériaux P.M. Fourt

Mines-ParisTech

Complex microstructures in materials often involve multi-scale heterogeneous textures, modelled by random sets derived from Mathematical Morphology.

Starting from 2D or 3D images, a complete morphological characterization by image analysis is performed, and used for the identification of a model of random structure.

From morphological model, simulations of realistic microstructures are introduced in a numerical solver to compute appropriate fields (electric, elastic stress or strain, ...) and to estimate the effective properties by numerical homogenization, accounting for scale dependent statistical fluctuations of the fields.

Our approach will be illustrated by various examples of multi-scale models: Boolean random sets based on Cox point processes and various random grains (spheres, cylinders), showing a very low percolation threshold, and therefore a high conductivity or high elastic moduli for a low volume fraction of a second phase.

Multiscale Cox point processes are also a source of instructive models of fracture statistics, such as multiscale weakest models.