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Direct sampling from N dimensions to N dimensions applied to porous media

Pierre Adler (1), Thang Nguyen (1), Daniel Coelho (2), Jean Charles Robinet (2), and Jacques Wendling (2)
(1) UPMC, Sisyphe, Paris, France (pierre.adler@upmc.fr), (2) ANDRA, 1/7 rue Jean Monnet, 92298 Châtenay-Malabry cedex

The reconstruction of porous media starting from some experimental data is still a very challenging problem in terms of random geometry and a very attractive one because of its innumerable industrial applications. The developments of Computed Microtomography (CMT) have not diminished the need for reconstruction methods and the availability of three dimensional data has considerably facilitated the reconstruction of porous media.

In the past, several techniques were used such as thresholded Gaussian fields [1], simulated annealing [2] and Boolean models where polydisperse and penetrable spheres are generated randomly (see [3] for a combination with correlation function). Recently, [4] developed the Direct Sampling method (DSM) as an alternative to multiple-point simulations.

The purpose of the present work is to develop DSM and to apply it to the reconstruction of porous media made of one or several minerals [5]. Application of this method only necessitates a sample of the medium to reproduce called Training Image (TI). The main feature of DSM can be summarized as follows. Suppose that n points (x1,. . . ,xn) are already known in the Simulated Medium (SM) and that one wants to determine the value of an extra point x; the TI is searched in order to find a configuration (y1,. . . ,yn) where these points have the same colors and relative positions as (x1,. . . ,xn) in the SM; then, the value of the point y in the TI which is in the same relative position with respect to (y1,. . . ,yn) than x with respect to (x1,. . . ,xn) is given to x in the SM.

The algorithm and its main features are briefly described. Important advantages of DSM are that it can easily generate media with several phases which are spatially periodic or not. The searching process – i.e. the selected points y in the TI and the corresponding determined points x in the SM - will be illustrated by some short movies. The properties of the resulting SMs (such as the phase probabilities and the correlation functions) will be qualitatively and quantitatively compared to the ones of the TI.

The major numerical parameters which influence the results and the calculation time, are the size of the TI, the radius of the selection window and the acceptance threshold. They are studied and recommendations are made for their choice. For instance, the size of the TI should be at least twice the largest correlation length found in it.

Some features necessitate a special analysis such as the number of isolated points of one phase in another phase, the influence of the choice of the initial points, the influence of a modified voxel in the course of the simulation and the generation of phases with a small probability in the TI. For the real TI which were analysed, the number of isolated points was always smaller than 0.5%; they can be suppressed with a very small influence on the statistical characteristics of the SM. The choice of the initial points has no consequences in a statistical sense.

Finally, some initial tests show that the permeabilities of simulated samples and of the TI are close.

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