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Sampling of discrete materials III. Quantitative approach—sampling of one-dimensional objects

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Abstract

Part III delineates the close relationships which exist between zero- and one-dimensional objects. The one-dimensional model of flowing streams of matter is presented in sufficient detail to appreciate how on this basis it is possible to perform a complete characterisation of the various heterogeneity components involved. This is achieved by the *variogram*, which forms the central one-dimensional TOS tool for practical sampling purposes. The *variogram* and its features and properties are introduced in detail. The three principal sampling selection modes of one-dimensional systems are delineated. Lastly it is explained how a *variographic experiment* allows estimation of the sampling errors involved in a particular sampling strategy.

Keywords: Zero-dimensional object; One-dimensional object; Autocorrelation

1. Interrelationship between zero- and one-dimensional objects

From a theoretical standpoint, the difference between zero- and one-dimensional objects concerns a difference in *internal correlation*—"autocorrelation"—and in *observation scale*.

According to the strict definition of a zero-dimensional object there is, or there should be, no correlation between its constituents. However, the concept of autocorrelation is not binary (0 or 1): it can take any value between these two limits. Autocorrelations of zero or one are practically inaccessible limits that suppose a *complete distributional homogeneity* of the material in the first case[1] a *complete segregation* of the constituents in the second. A very powerful analysis tool, the *variogram*, will be defined in Section 3. A variogram detects and quantifies the autocorrelation between the compositions of the materials to be found on two points of the time axis. It shows the quantified autocorrelation as a function of the *distance* between these two points, in fact it depicts the autocorrelation for an entire *range* of inter-distances. Usually, the smaller the distance, the larger is the autocorrelation between them.

Consider a lot $\boldsymbol{L}$ which *flows* from time $\boldsymbol{t=0}$ to time $\boldsymbol{t=T_L}$. On the time axis, this lot $\boldsymbol{L}$ can be broken up into a sequence of adjacent segments of uniform length $\boldsymbol{T_I}$. Each of these segments supports a *potential increment*, $\boldsymbol{I}$, which could be used for sampling the flow. The autocorrelation of the time series is perceptible at the scale of the total time interval $[0,\boldsymbol{T_L}]$, but is usually imperceptible at the scale of the individual time segments.[2] To all practical intents and purposes, each time segment $\boldsymbol{T_I}$ can be regarded as a zero-dimensional object. Hence the practical conclusion that for our sampling purposes, a one-dimensional object **L** can be regarded as a time series of adjacent zero-dimensional

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[1] Bed-blending. The author proposed the theory and associated practice of this technique in [18]. This technique *reduces* the autocorrelation of a one-dimensional object (e.g. a flowing stream) *to a natural minimum* which is a function of the material properties.

[2] The great French fabulist *La Fontaine* did certainly not have the autocorrelation of a time series in mind when he wrote: *De loin c'est quelque chose mais de pres ce n'est rien (Seen from afar it is something but at close range it is nothing)*—but his observation fits wonderfully.

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