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Grid-less Simulation of a Fluvio-Deltaic Environment

R. Mohan Srivastava[1], Marko Maucec[2], and Jeffrey Yarus[3]

[1]*FSS Canada Consultants, Toronto, Canada*
[2]*Halliburton Consulting and Project Management, Kuala Lumpur, Malaysia*
[3]*Landmark Software and Services, Houston, USA*

Abstract

In geostatistics, sequential simulations conventionally work on a grid (either regular or, sometimes, irregular), building realizations of rock or fluid properties by sampling from local probability distributions; they move to a specific location, x, and answer the question “What is a plausible value of Z (which could be an integer value, like a facies code, or a continuous variable, like a rock or fluid property) at this location?” This is accomplished by building a probability distribution of possible Z values at that location, and randomly sampling from this distribution.

An alternative is to fix the value of Z and to answer instead the question “What is a plausible location for this value?” In this approach, the probability distribution that is constructed is a set of possible locations where a specified value of Z might occur. This distribution can be randomly sampled, and the value of Z can be propagated to the chosen location. This approach was first presented at the Stanford Center for Reservoir Forecasting 20 years ago, but has seen little further development until the CSPG Gussow Geoscience Conference in 2011. The idea resurfaced in the presentation by Maučec et al. (2011) and was used in the fracture simulation method proposed by Srivastava (2011). During the open discussion sessions at the 2011 Gussow meeting, the possibility was advanced that innovative reservoir simulation methods exist further down the path opened by these two presentations. Specifically, models of a reservoir’s rock and fluid properties could be constructed without a pre-determined grid by propagating rock, fluid or geometric properties to locations that are sequentially chosen.

This paper begins with an explanation of how sequential indicator simulation can be viewed as a simulator of X(z), i.e. of the location where a specific value belongs, rather than in the conventional way, as a simulator of Z(x). It goes on to show how one approach to the simulation of discrete fracture networks can be regarded as a simulator of X(z) and discusses other recent simulation algorithms that have begun to exploit the same idea.

The paper concludes with an example of simulation of fluvio-deltaic channels, the example that has been the hallmark success of the multi-point statistics algorithm, SNESIM. Instead of tapping into multipoint statistics, it is possible to simulate fluvio-deltaic channel geometries that honour well data by sequentially simulating the location of the centerlines of the fluvial channels, and then adding a simulated channel width. This alternative to SNESIM is considerably faster than the multi-point statistics approach and produces realizations that are more geometrically coherent. The explicit simulation of channel centerlines and widths also enables more sophisticated post-processing of the results since

morphological properties of the channels (e.g. their curvature, and their inside and outside edges) are more readily accessible from this type of realization than from a pixel-based realization.