The Moving Window algorithm. Coupling multiple point statistical methods with conditioning to connectivity and dependent variable data.

by Andres Alcolea and Philippe Renard

CHYN. Centre of Hydrogeology of Neuchatel. University of Neuchatel. Rue Emile Argand, 11, 2000 Neuchatel. Switzerland. andres.alcolea@unine.ch / philippe.renard@unine.ch

Preference : Oral presentation

Multiple point (MP hereinafter) statistical techniques have gained steam during the last five years. These allow simulating connectivity features (i.e., channels) that cannot be simulated using two point statistical techniques (e.g., those using variograms). MP techniques have been used mainly as “geology simulators” to delineate hydrofacies distributions from point in space characterizations of geology. However, little attention has been given to the conditioning to dependent variables (i.e. heads). These data sets contain important information about the large scale connectivity patterns and should be accounted for in meaningful characterizations of geological media.

This work presents a step in that direction. We present a novel approach coupling multiple point statistics for generating hydrofacies distributions with a fast flow simulator which allows us to condition to dependent variables. The iterative algorithm can be described as follows:

1) Generation of the first hydrofacies distribution by the Single Normal Equation method. Conditional probabilities are inherited from a training image. Conditioning data are the hydrofacies values at measurement locations.

2) Iteratively:

   2.1) Update the hydrofacies distribution. One of the following options is randomly selected:

      a. Single Normal Equation method. Only a portion of the image (the "moving window", whose size and location is randomly selected) is simulated. The rest is "frozen". Conditioning data are the hydrofacies values (categorical) at measurement locations if they fall inside the "moving window".

      b. Dilation / erosion. The geobodies generated by the Single Normal Equation method are dilated / eroded, creating a "buffer zone". Only the pixels within that zone are simulated by the Single Normal Equation method.

   2.2) Check connectivity features of the updated image: images not honoring the two point connectivity data (i.e. pixel 'i' connected to pixel 'j' but disconnected from pixel 'k') are directly rejected and a new image is generated (recall step 2.1). Images not fitting directional and global connectivity are also rejected.

   2.3) Populate hydrofacies. In this case, we simply assign a constant value. However, simulation (e.g. sequential Gaussian) may be applied in this step

   2.4) Simulate ground water flow and calculate the objective function. This measures the misfit between calculated and measured heads.

   2.5) Accept / reject the generated image by Simulated Annealing. If it is accepted, the stack of hydrofacies distributions is updated.

   2.6) Check convergence. Several convergence criteria were encoded: (1) maximum number of iterations, (2) little variation of the objective function between two consecutive accepted iterations, (3) little information added by an accepted image to the stack mean or variance and (4) small value of the objective function.

Final outcomes of the algorithm are the ‘best’ hydrofacies distribution (i.e., that honoring connectivity data (global, directional and two point connectivity) and yielding a good fit to dependent variables) and the stack of all accepted simulation (mean and variance).

We display the performance of the method on a synthetic example which mimics ground water flow to a well in a channelized geological scenario. Results show that conditioning to dependent variables and connectivity data improve dramatically the characterization of the geological scenario.