

Multipoint Facies Modeling - Examples of a Turbidite and a Fluvial System

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Summary

The Multipoint Facies Modeling algorithm is a pixel-based algorithm to create facies models which can look like object models. Traditional geostatistics like Kriging or Stochastic Simulation techniques are working on the basis of point-to-point correlation in space. The fundamental tool to describe this relationship between two points is the (semi)variogram. In cases of sufficient well data in all directions the variogram explains the spatial structure adequately for static modeling. When it comes to questions of connectivity especially related to a sparse dataset the traditional geostatistical approach via variogram analysis has some limitations. In multipoint facies modeling the variogram will be replaced by a training image (2D or 3D) and the pattern out of it. The training image describes the geological facies in relative position to each other. The pattern stores the neighborhood probabilities and is the main input into the modeling similar to the variogram model.¹

Theory

Multipoint statistics is a relatively young discipline. Due to the challenging tasks geoscientists are facing these days, the call for algorithms describing more complex geological features more accurately is imperative. Especially the connectivity of facies models is a critical issue when it comes to dynamic modeling. The principal approach of the multipoint facies modeling algorithm is similar to the two-point algorithms, in that it is still required to find a local conditional probability distribution function at any location by a given description of the spatial variability. The main tool to achieve this is the training image.

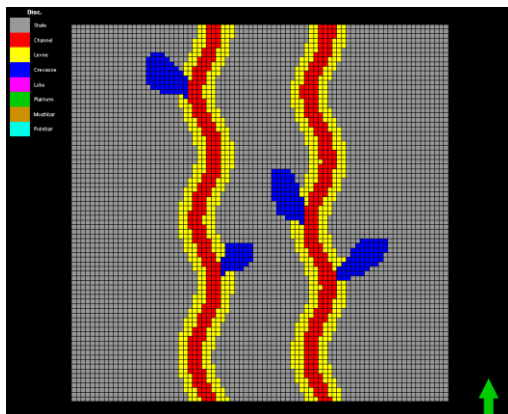


Figure 1: Simple 4 facies training image

As seen in figure 1 above at a specific point (cell) the algorithm is looking at the relationship of this cell to a set of other cells and creates conditional probabilities like: a channel cell is surrounded by 60% channel cells close to the origin, 30% levee cells and 10% splay cells. In this way the training image works in a multi-point way like the variogram works in a two-point way.

Examples

Turbidite and fluvial systems have always been challenging to model using traditional geostatistics due to the relationships within the facies assemblages and the different regions in these depositional environments. Using multi point statistics a variety of training images can be used to model these settings more accurately. There are 4 processes that need to be considered while modeling these systems. The first is a conceptual idea of the end result, secondly the system needs to be split into regions, thirdly a training image needs to be created for each region, and lastly the data may need to be conditioned and scaled to represent the conceptual idea. The training image must not show any trends, therefore trends may need to be applied during the conditioning and scaling stage.

Turbidites can be broken into 3 regions: the canyon, shallow mobile channels with wings, and the fan fringe frontal splays.² These regions may have very different depositional mechanisms. For example the canyon might be mainly large singular channels that cut steeply into the underlying sediment. As a result the training image would have to reflect this. Alternatively the fan fringe region (or the basin the floor region) may have sheet like deposits. The training image in this region would represent large interbedded sand bodies.

Fluvial facies systems can be broken up into single channel or multi channel complexes. These complexes may also be braided, meander or be straight. The first step is to consider the conceptual model and how these facies relationships vary in proportion, geometry and aerial distribution. In the case of meandering channels, the system generally flattens out as it approaches a flood plain and the channels move in a sinuous fashion cutting into the floodplain.³ The resulting property would have few channels with relatively wide levees and associated point bars.

Conclusions

The key here to modeling these systems is the ability to break out the system into regions then model each region with a particular training image specific to the region. The main advantage of the multipoint statistics modeling is that it is capable of producing models with considerably more geological complexity than traditional pixel based methods.

References

¹Hodson, Paul, 2009, "Documentation of the new MP Facies Algorithm in Petrel 2009.1", InTouch best practice ID#4913581.

² www.sepmstrata.org/Deepwater/Ross-Formation.html

³ <http://www.geo.uu.nl/fg/palaeogeography/results/fluvialstyle>