

A Novel Deterministic Alternative for Facies Modeling

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Summary

One of the most crucial tasks in the geological and environmental sciences is spatial prediction. Spatial predictions are important for planning, risk assessment, and decision-making. Typical applications include among others determining the profitability of mining an orebody, management of soil resources, designing a network of environmental monitoring stations, and quantifying the uncertainties inherent in spatial predictions (Weisz et al. 1995; Gotway et al. 1996; Moyeed and Papritz 2002; Babak and Deutsch 2009).

Before the spatial prediction models can be built, however, major reservoir/deposit architecture needs to be established. Different rock types need to be distinguished to describe mineralization (porphyry, schist, etc.), sedimentary facies (channel sand, crevasse splays, levees, floodplain, etc.) or diagenetic alteration (limestone, dolomite, anhydrite, etc.). This is because the properties of interest are often different between different rock types. For example, grades distribution usually changes from one rock type to another: high grades may be associated with one rock type and low grades with a second rock type. Spatial continuity or variography may also differ. Rock type modeling is a crucial validity of stationarity assumption.

Currently nearest neighbor and indicator kriging are the two commonly used approaches for semi-automatic deterministic categorical variable modeling (e.g., for facies, facies groups and/or formations) and the only two alternatives available in many commercial software packages, including GOCAD and MineSight. Nearest neighbor approach is a simple interpolation technique by which the estimate at the unsampled location is set to the value of the nearest data point. By the definition of the technique it follows that the result of interpolation does not have a reasonable geological appearance; it is equivalent to polygonal declustering. Kriging, on the other hand, is a statistically optimal interpolator in the sense that it minimizes estimation variance when the variogram (measure of spatial continuity of the variable under study) is known and under the assumption of stationarity.

In the case of continuous random variables, another viable alternative is inverse distance weighted (IDW) interpolation. IDW estimates the variable of interest by assigning more weight to closer points. It is a simple technique that does not require prior information, that is, variogram model, to be applied to spatial prediction. In practical applications, IDW interpolation may be preferred over kriging-based techniques when there is a problem of making meaningful estimates of the field spatial structure from sparse data (Duchon 1976; Wahba 1990; Hutchinson 1993). It is also used when a quick visualization of the variable under study is required (Borga and Vizzaccaro 1997). Moreover, a large number of comparative studies among different interpolators found that depending upon the situation at hand, IDW can be as good or better than geostatistical kriging based techniques (Weber and Englund 1992; Gallichand and Marcotte 1993; Dingman 1994; Boman et al. 1995; Brus et al. 1996; Declercq 1996; Dirks et al. 1998; Moyeed and Papritz 2002; Kravchenko 2003; Mueller et al. 2004; Brouder et al. 2005). These studies were based on geologically sound visual appearance; cross validation and jackknife, which involves consecutively removing a data value from the sample data set and interpolating to that site using the remaining conditioning data values, then comparing the estimated values against the true data (Isaaks and Srivastava 1989); robustness; or measures of response variables derived from the interpolated property.

Because of the advantages of IDW interpolation, it is interesting to consider an extension of this approach to discrete/categorical variable modeling. In this paper we propose just that. We develop IDW (Categorical/Discrete) interpolation based on the well known indicator formalism. As in the case of indicator kriging, IDW (Categorical/Discrete) provides a direct estimate of the distribution of uncertainty in the categorical variable. The most probable values at unsampled locations can be then be easily extracted. To supplement the proposal with a practical application, a case study of facies group modeling for Total's Jolsyn Lease is considered.

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