Common Kriging Statistics Explained

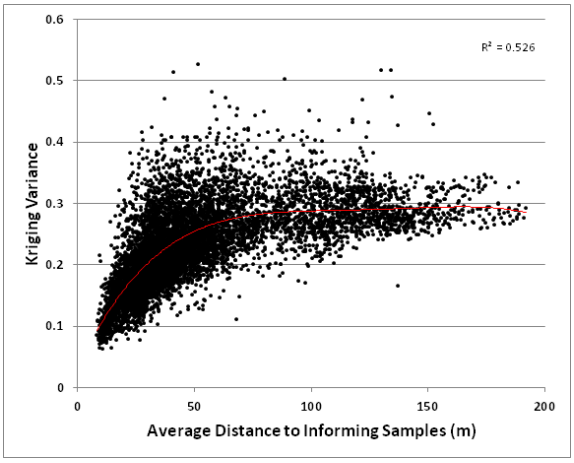
Most technical mining professionals have come across various spatial interpolation methodologies - Kriging is one of the more common of these. Kriging methodologies have gained popularity due to the reduction or minimisation of the estimation error, which has given rise to the acronym B.L.U.E. or the "Best Unbiased Linear Estimator" (Isaak and Srivastava (1989), Sinclair and Blackwell (2002)). In addition to providing an estimate at unsampled locations, kriging methods provide a set of statistics that can be used to assess the accuracy and precision of the estimated variable.

An essential parameter in the kriging process is the variogram model, which is based on the spatial relationship of sample values for the variable in question. An empirical or experimental variogram is first calculated using the data and then the user models a variogram, choosing from a set of admissible model types.

Without the use of mathematical formulae, this White Paper will explain how the additional kriging statistics can be practically applied. The examples presented below are based on a gold stockwork mineralised system and on a variogram with a 60% relative nugget effect and range of 400m.

Kriging Variance (KV)

The Kriging Variance is a measurement of the estimation precision at a given location. The kriging variance is dependent on the size and shape of the samples (i.e. support), location of the samples and the location, size and shape of the target being estimated.



The Kriging Variance will generally reduce as the number of informing samples increases and/or the position of the samples relative to one another and the estimation target becomes more favourable (e.g. the samples are closer to the target).

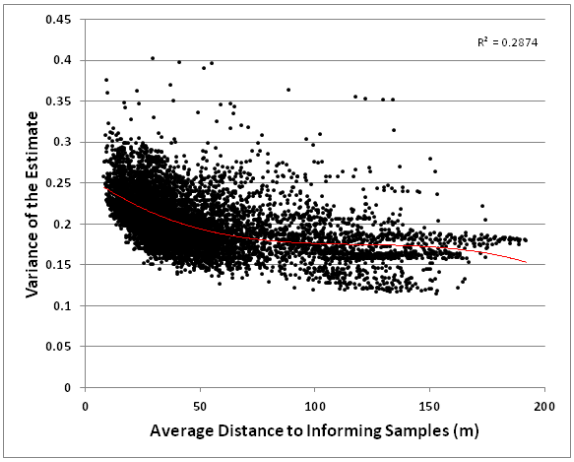
The Kriging Variance is independent of the values of the samples being used in the estimate. Analysis of the kriging variance can used to the assess the increase or decrease in the precision of different sample patterns, orientations and spacing when designing exploration, resource definition and grade control sampling or drilling programs.

Variance of the Estimate

The Variance of the Estimate is a measure of variance of the estimate given the sample configuration selected in the search neighbourhood, with respect to location, shape and size of the target being estimated.

The Variance of the Estimate is broadly inversely related to the Kriging Variance and the Weight of the Simple Kriged Mean (see below).

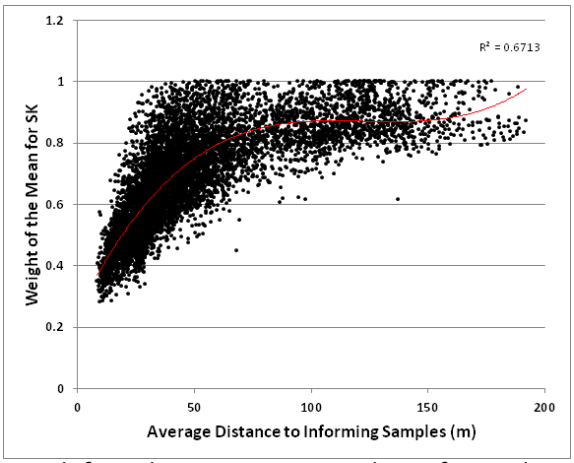
This value is used in non-linear estimation methods such as Uniform Conditioning.



Weight of the Simple Kriged Mean

The Weight of the Simple Kriged Mean is associated with Simple Kriging and is calculated as the sum of the kriging weights subtracted from 1. The Weight of the Simple Kriged Mean is a measure of the robustness of the estimate with a larger weight indicating a less robust estimate.

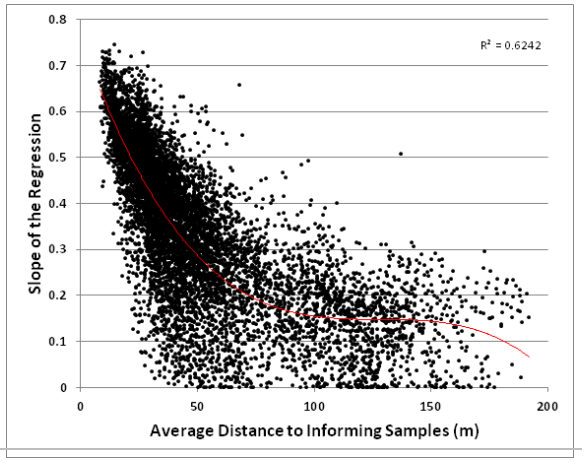
As expected the Weight of the Simple Kriged Mean is low for well-informed targets, relative to sparsely informed targets.



The Weight of the Simple Kriged Mean is a key statistic to define the minimum number of samples required within a search neighbourhood to produce robust estimates.

Slope of Regression

The Slope of Regression is based on the regression of the estimated value and the theoretical true value, which is never known. The Slope of Regression generally ranges between 0 and 1. The standardised nature of the statistic is useful for comparison between estimates.



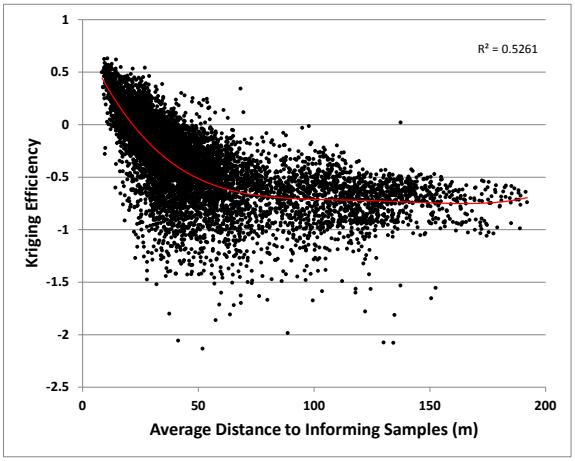
The Slope of Regression is a measure of the quality of the estimate, which is interpreted to be more robust when the slope of regression approaches 1.

The Slope of Regression is a key statistic when determining the optimum parameters for a search neighbourhood and is a good measure for determining how to reduce local estimation bias.

Kriging Efficiency

The kriging efficiency is closely related to the Kriging Variance but is a scaled statistic, such that it never exceeds a value of 1. The rescaling is related to the modelled variogram and the size and shape of the target being estimated.

Kriging Efficiency with a value closer to 1 suggests the estimate is more robust than estimates with a lower Kriging Efficiency.



Cube's Experience and Capabilities

Cube Consulting has extensive experience and skills in geostatistical estimation and Cube's Resource Geologists and Geostatisticians frequently apply the kriging outputs discussed in this document for:

1. Optimisation of estimation search neighbourhood parameters.
2. Optimisation of block size for estimation.
3. As inputs to more advanced geostatistical techniques such as the non-linear Uniform Conditioning method for estimation of recoverable resources.
4. To assist with resource classification.

References:

Isaaks, E. H., and R. M. Srivastava, 1989, An introduction to applied geostatistics.

Sinclair, A. J., and G. H. Blackwell, 2002, Applied mineral inventory estimation.