Study on spatial interpolation method

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***Abstract*— This paper aims to compare performance of different type of spatial interpolation methods for the estimation of surface rainfall and soil lead concentration.**

I. Introduction

Spatial interpolation analysis had been divided into two techniques. First, non-geostatistical approximated values using mathematical equations to calculate the unknown points from known points. It was included variety of methods such as nearest neighbors, IDW, trend surface analysis, spline etc. Second, geostatistical using statistics to determine the feasibility of quality for interpolate based on a spatial relationship. Kriging was an interpolation method based on the variation between points but was not weighted by the distance between known points and unknown points. Group of point according to spatial relationships are intertwined in each point.

II. Methodology

A. Inversed Distance Weighted

The inverse distance weighed (IDW) interpolation is based on the assumption that the value of an attribute z at some unknown points is a distance average of data points occurring within a neighbourhood or window surrounding the unknown point. It weights the point closer to the processing cell more heavily than farther points. Either a specified number of points or all of the points within a given radius can be used to determine the value of each output cell. This method is appropriate when the influence of variable being mapped decreases with distance from the sample location. IDW algorithm can be described as follows (Burrough et al., 1998).

Zx=∑i=1nWi∗ Zi/∑i=1nWi

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Wi=Dx
Where:
the prediction value of unvisited points x.

i: the used known data point from 1 to n

the number of used known points
the value of point I
the distance to know Point I
a constant that influences the distance weighting

B. Kriging

The word "kriging" is synonymous with "optimal prediction" (Journel and Huijbregts 1981). It is a method of interpolation which predicts unknown values from data observed at known locations. This method uses variogram to express the spatial variation, and it minimizes the error of predicted values which are estimated by spatial distribution of the predicted values (Lang 2011). Kriging is a geostatistical interpolation method which is based on statistical models that includes autocorrelation. Autocorrelation is the statistical relationship among the measured points. Kriging is similar to IDW method in that it weights the surrounding measured values to derive a prediction of unmeasured location. Kriging has two elements: 1) quantifying the spatial structure of data, 2) predicting unknown values. In quantifying the spatial structure, it quantifies the spatial autocorrelation of input data which is called variography. In variography analysis, the values for each pair is compared and expressed as covariance or variance. During predicting unknown values, the weights are selected so that the estimates are unbiased and have minimum variance.

The kriging method can be described as follows (Burrough et al., 1998 Kurakula 2007).

Zx=m(x)+ ε′ (x)+ ε′′ (x)

Where:
the value of a random variable.
x a position in 1,2 or 3 dimension
m(x) a deterministic function
ε′ (x) the regionalized variable
ε′′ (x) a residual, spatial independent Gaussian noise term having zero mean and variance.

C. Trend Surface

We may think of trend surface modelling as a regression on spatial coordinates where the coefficients apply to those coordinate values and (for more complicated surface trends) to the interplay of the coordinate values. We will explore a 0th order, 1st order and 2nd order surface trend in the following sub-sections.
The first order surface polynomial is a slanted flat plane whose formula is given by: $Z = a + bX + cY$ where X and Y are the coordinate pairs.
Polynomial regression to fit a surface to the data points normally allows user control over the order of the polynomial

used to fit the surface as the order of the polynomial is increased and the surface being fitted becomes progressively more complex. Higher order polynomial will not always generate the most accurate surface, it is dependent upon the data the lower the RMS error, the more closely the interpolated surface represents the input points most common order of polynomials is 1 through 3.

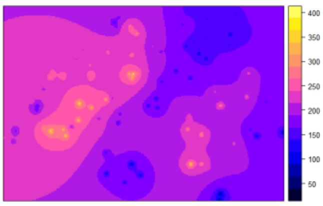
III. RESULT

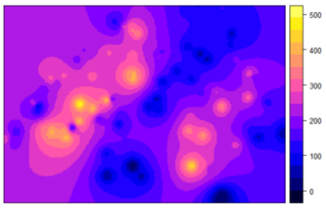
A. *IDW*

The more complex the polynomial, the more difficult it is to ascribe physical meaning to it. Furthermore, the calculated surfaces are highly susceptible to outliers (extremely high and low values).

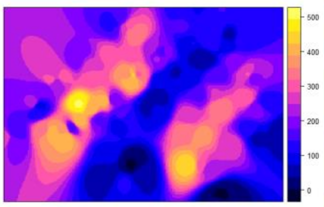
1) *Interpolation of Rain:*

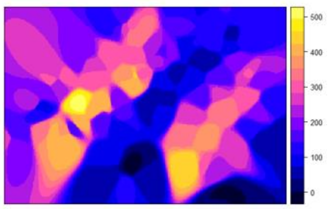
Power=1 Power=2





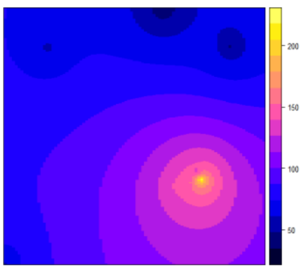
Power=5 Power=10

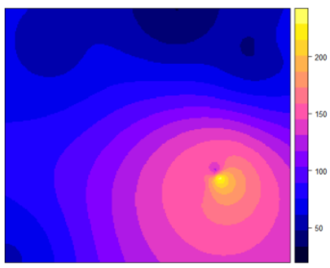




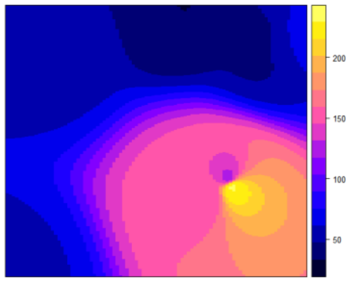
2) *Interpolation of Lead:*

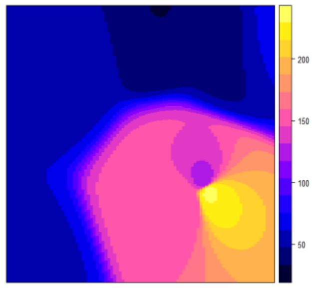
Power=1 *Power=2*





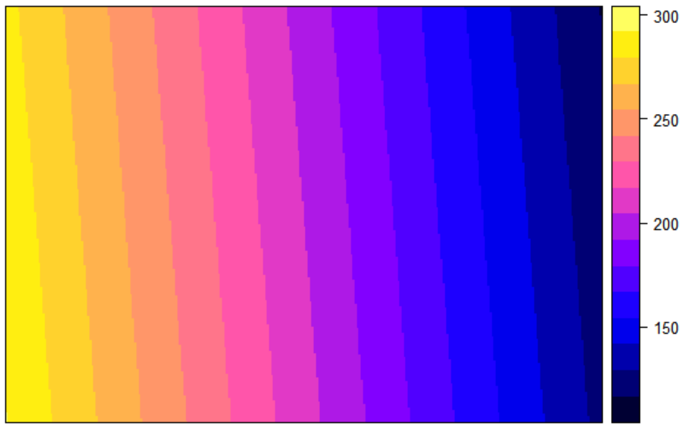
Power=5 *Power=10*



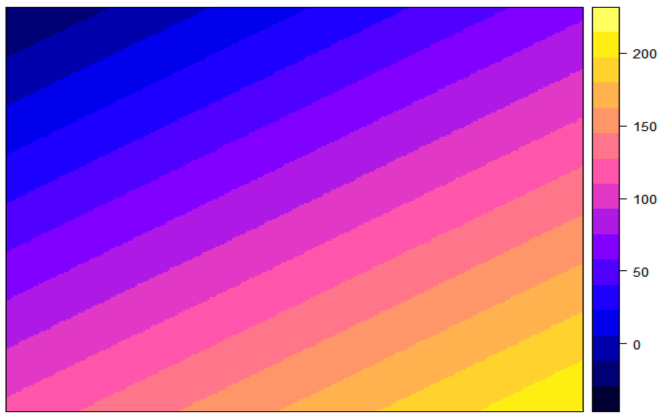


B. Linear Trend Surface

1) *Rain*



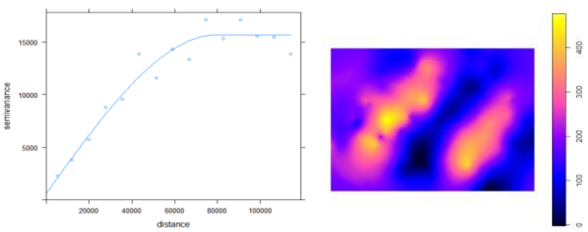
2) *Lead*



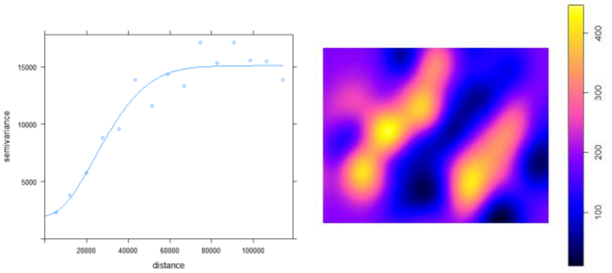
C. *Kriging*

1) *Rain*

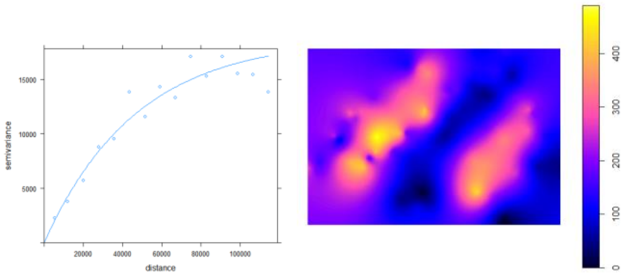
Spherical Model:



Gaussian Model:

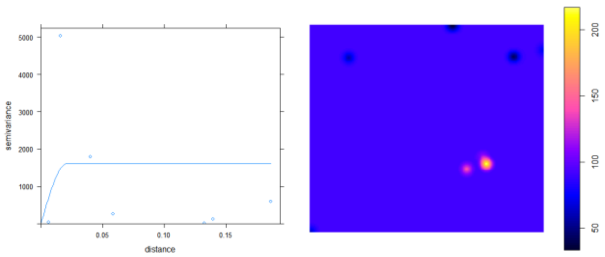


Exponential Model:

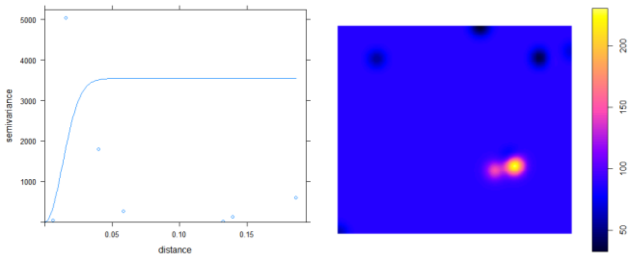


2) *Lead*

Spherical Model:



Gaussian Model:



Exponential Model:

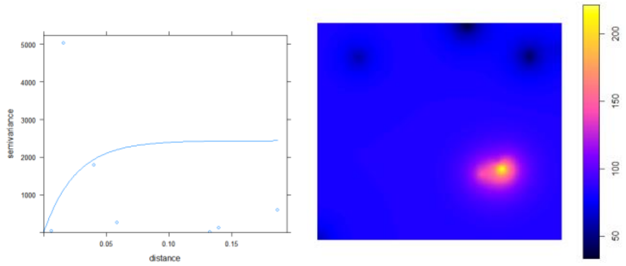


TABLE 1
COMPARISON AMONG MODELS

Model	Rainfall Data		
	Sill	**Nugget**	**Range**
Spherical Model	15074.43	604.73	79676.52
Gaussian Model	13075.2	2024.827	34309.07
Exponential Model	18792.71	0	46767.63

TABLE 2
COMPARISON AMONG MODELS

Model	Lead Data		
	Sill	**Nugget**	**Range**
Spherical Model	N.A	1608.511	N.A
Gaussian Model	N.A	3541.772	N.A
Exponential Model	N.A	2439.699	N.A

IV. CONCLUSION

Many properties of the geology vary in an apparently random yet spatially correlated fashion. In the paper, we provide information on spatial interpolation methods and can also be applied in various other fields. By comparing, analyzing and experimenting in practice, we find that 1) using Kriging for interpolation enables us to estimate the error in any interpolated value, but Kriging did not converge for Lead spatial samples; 2) using Inversed Distance Weighted is simple and fast, however, it is unable to evaluate the error. IDW is an averaging method and all interpolated values are within the sample range. So data should contain both upper bound and lower bound values and the samples should be more; and 3) Trend Surfaces interpolated surface rarely passes through the sample points and the trend surface is susceptible to outliers in the data. That is the reason it is used to find tendencies of the sample data, rather than to model a surface precisely.

The goal of spatial interpolation is to produce a smooth curve/surface that passes through all the given points, and use the points to estimate and minimize error.

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