Kriging Method Applied to Predict the Coverage Area of Digital TV

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Abstract—This paper proposes a method to estimate the signal propagation behavior of a digital TV. A measurement campaign was carried out in the metropolitan region of Belém for digital TV signal study. The proposed method uses a well-known geological tool, the kriging method. This method has the statistical robustness as its main feature.

Index Terms—*Kriging, Digital TV, Propagation.*

I. INTRODUCTION

Recently with the implementation of the digital transmission in Brazil, it was necessary to do studies about the behavior of the signal in the region where the system was implemented.   Thus, some analysis was done about the behavior of the transmitted signal.

The environment used for this study is the Metropolitan region of Belém (PA-Brasil) that can be characterized like a heterogeneous area, having buildings and amazonian vegetation, which interferes in a significant way in the signal strength, causing attenuations, reflections and refractions. In these article was used interpolation method of kriging [1][2][3] that is used for estimate signal level in an arbitrary point of the region (approx. area: 800 km²). These estimates are very important for design purposes.

The Kriging is considered a method of data interpolations. It uses a tabular data and the geographical positions to calculate the interpolations. Using the principle of the "Fist Law of Geography" of Tobler, which says which the closest samples are more similar than samples most way, the Kriging use mathematical functions to add weight [4].

II. METHODOLOGY

A maeasurement campaign of three Digital TV stations were treated in this work. Actually, in this abstract, only results for TV Station A will be show.

- TV Station A: channel 21, power transmission: 10Kw, gain: 12.15dBi, ERP: 56kw;

- TV Station B: channel 35, power transmission: 4.1Kw, gain: 11.6dBi, ERP: 20.22kw;

- TV Station C: channel 22, power transmission: 6Kw, gain: 11.1dBi, ERP: 52.15kw;

The Kriging method uses best linear estimators for calculate indicators functions. The method has three main stages, the first is to choose the variogram, the second is the calculation of the weights of the indicators functions and finally to interpolate a point. The Gaussian type variogram, were the best choice for the data collected in comparison with other types like exponential and spherical in the environment under study.

$$\gamma(h) = C_0 + C\left[1 - e^{-\frac{h^3}{b^3}}\right], h < a \qquad (1)$$

Where, h is the distance, C_o is the nugget effect, which is the smallest value possible, C is the Sill, which is the biggest value possible, a is the distance where the variogram reaches the maximum value and b is the scale factor for h.

To construct the variogram, first is necessary to find the experimental semivariogram. The semivariance is computed for all combinations of two points generating the "variogram cloud", after that a range of distances are defined to computer the average, using the equation below:

$$\gamma(h) = \frac{1}{2N(h)} \sum_{N(h)} [z(u) - z(u + h)]^2 \qquad (2)$$

In this way, estimated values of a, C_0 and C are computed by non-linear least squared routine. With the variogram avaliable, the weights can be calculated by solving system below:

$$[A]^{-1} * [w] = [\lambda] \qquad (3)$$

Where [A] is the semivariance matrx, [w] semivariance matrix between neighbor locations and the point for which the variable will be interpolated, [λ] kriging wight matrix.[5]

The interpolated point is computer by linear combination below:

$$X_p = \sum_{i=1}^{n} \lambda_i X_i \qquad (4)$$

Where X_p is the interpolated variable, λ_i are the weight of the neighbor location and X_i is the variable value for the location, n is the number of neighbors locations used to interpolate a point.

III. RESULTS

For the data collected from each TV station, the method of Kriging was made through the following sequence of steps. The first is to find the best fit parameters of the variogram

equation, for this variance is computed average of the distances using equation (2).

For each distance, the semivariogram considers a tolerance of 500m to calculate the average semivariance for each distance.

Figure 1 shows the variogram and semivariogram found for the TV station A.
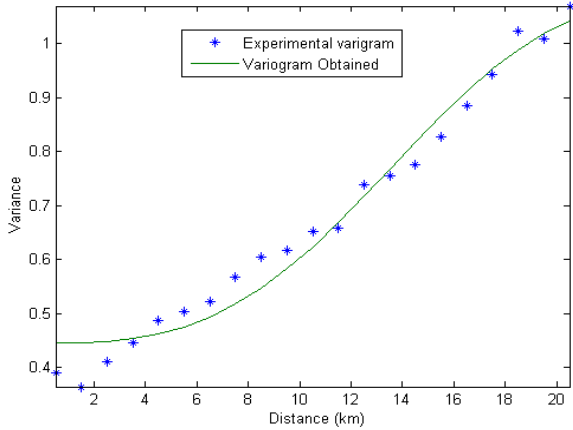

Fig. 1.   Variogram for TV Station.

The variograms are defined by 3 parameters, C0(nugget), C(sill) and parameter a(distance of range), shown in equation(1). For the three TV stations, the best values approaches are shown in the table below:

TABLE I – VALUES FOUND FOR EACH VARIOGRAM

Parameters	C	C0	a
TV Station A	0.6595	0.4459	26.7227
TV Station B	0.2899	0.5305	17.3016
TV Station C	0.5793	0.5875	32.9869

Through the variograms of three TV stations, are made interpolations of the points by equation (4). The interpolations of the data collected from three TVs stations had similar results. The result of the Kriging to station A is shown in Figure 2.
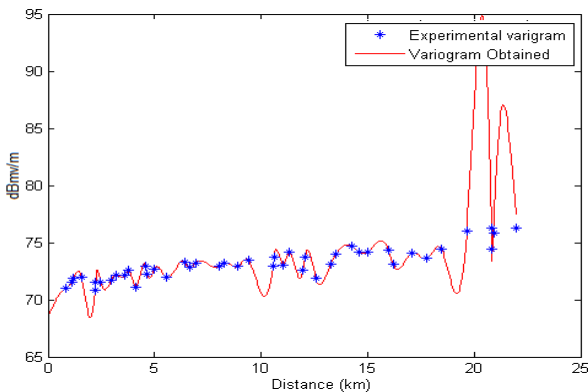

Fig. 2. Kriging for TV Station A.

The Figure 2, show the results obtained (electric field) for Stations A.

IV. CONCLUSIONS

In this work was done to search the adaptation of the Kriging technique for studying the propagation of digital signals to predict the coverage area broadcast systems, besides being a simple method of implementation, the results approach the real values of propagation, with only account distance from the collects point of transmission. As a suggestion for further work can be made researches for classifying features of the environment as the level of urbanization and implementations of the vegetation and also Co-Kriging technique, a type of kriging allows the insertion of an additional variable for determining the interpolated point.

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