ELEVATION SURFACE INTERPOLATION OF POINT DATA USING DIFFERENT TECHNIQUES– A GIS APPROACH

Kulapramote Prathumchai
Geoinformatics Center, Asian Institute of Technology,
58 Moo9, Klong Luang, Pathumthani, Thailand. 12120
Phone: +662-5245599 , Fax: +662-524-6147
kulapram@ait.ac.th

Lal Samarakoon
Earth Observation Research Center, Japan Aerospace Exploration Agency,
Triton Square Office Tower-X 23F, 1-8-10 Harumi, Chuo-ku, Tokyo, JAPAN 104-6023
lal@ait.ac.th

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ABSTRACT:
Interpretation of real-world occurrences or particular conditions is generally based on observed in-situ data. Whatever the phenomena or a given condition can be measured with very advanced measuring techniques available today, it is important to mention that these measuring represents are carried out on given location on the earth surface. Considering the cost and the time that need to carryout measurements, it is impossible to imagine of continuous measurements representing every physical location on the earth surface. It is the interest of everybody to know the exact amount or quantity of a given phenomenon or a given conditions such as elevation, precipitation, water quality, air pollution, in reality quantification is based on approximations. Measurements are in discrete nature but information need to be somewhat continuous. In order to achieve information continuity over space, it is necessary to carryout some form of interpolation to fill gaps. Various interpolation techniques are available based on mathematical formulas and approximations but need to apply them carefully to the given phenomenon in hand and amount and distribution of real-world information.

This paper presents results that obtained interpolating elevation data to create a digital elevation model. A study area in Lao PDR was selected and interpolation was carried out using Inverse Distance Weighting (IDW), Spline and Kriging functions available in ArcGIS. Results were compared with each other and present as statistic graphs. Finally, paper describes prospects and constraints of each interpolation technique over elevation data.

1. INTRODUCTION
In the mathematical subfield of numerical analysis, interpolation is a method of acquiring new data points from a discrete set of known points. In the context of GIS, it is a method to estimate values for cells in a raster from a limited number of sample data points. Its application is, therefore, to calculate unknown values of any geographic point data, for example, elevation, rainfall, chemical concentration, noise levels, and so on. Data collection from every location a study area to determine the height, magnitude or concentration of a physical property, may not generally be practically feasible and economically viable. Therefore, interpolation is used to create a continuous surface, by acquiring new values of parameters at points that have not been directly sampled.

The interpolation theory is concerned with spatial autocorrelation, most interpolation places are affected on sample points that are close to the unknown location than those are further away from it. This is based on the principle of spatial autocorrelation; i.e. the relationship among values of a single variable/parameters that comes from the geographic arrangement of the areas.
in which these values occur; in other words, things that are close together are more comparable than those that are far apart.

Given a set of comparable data points, the Spatial Analyst interpolation tools in ArcGIS software, determines a z-value for an empty cell using the z-values of the nearby sample points. This study, the experiment was applied in three difference methods; Inverse Distance Weighting (IDW), Spline and Kriging were approached though out the three different sampling methods. These were Regular Sampling, Stratified Random Sampling and Random Sampling.

2. OBJECTIVES

Objectives of the study were to;
- Examine the elevation surfaces obtained from difference data sample characteristic
- Compare the elevation surface obtained from difference methods and thereby to identify the better interpolation technique to obtain elevation on surface

3. SAMPLE AREA, DATA AND METHODOLOGY

An area in between Xiengkhuag and Xaysomboun provinces in Lao PDR was selected for the study. Approximate dimension of the area was 17 km x 13 km. Location was latitude 19°00' - 19°11' N and longitude 103°21' - 103°30'E, highly undulated. Figure1 shows the Methodology of the study.

3.1 Creation of Elevation Sample points data

Locations of sample points are important for interpolation. Ideally, for mapping, points should be located evenly over the area. However, samples can be regularly or randomly spaced. More the input points and greater their distribution, more reliable of the results can be achieved. In this study, contour map of 100 m interval was used, the source of the data was the National Geography Department of Lao PDR. As one of the objectives of the study was to examine the
performance of interpolation output with suitable data sampling and hence the uniformity of input data need to be controlled. Thus initially, contour data was used to generate elevation surface using TIN model then it was converted to 500 m grid. Subsequently, the grid result with 26 rows and 34 columns were converted to equal mesh points. Total data points were 884. Then the number of points were reduced to 108, 63 and 20 respectively, to examine whether the number of them might affected to interpolation methods. These sets of data were called as “Regular sample”, representing a perfect selection of sample point. The next step was creation of “Stratified Random Sample” i.e. the sample points in between the cases of regular. These sets of data were created by shifting X,Y locations of regular sample points. The last data set was “Random Sample”, it was selected randomly from Stratified Random Sample points. Figure 2 shows the steps adopted in the creation of sampling points.

![Figure 2 Creation of Sample points data sets](image)

### 3.2 Interpolation Techniques

This study was developed in ArcGIS software, which allows many techniques available, three of those difference techniques were selected for this study. Options and parameters pertaining to particular method were depended upon default setting of the software.

- **Inverse Distance Weighting (IDW)**

  IDW assumes that each measured point has a local influence which is inversely proportional to a selected power of the distance&hence the name of the method is Inverse Distance Weighting. The output value for a cell using IDW is limited to the range of the input values used to interpolate. It should be noted that since IDW is a weighted distance average, the average cannot be greater than the values of samples. Therefore, it cannot create ridges or valleys if these extremes have not already been sampled. Also, the output surface will not pass through the sample points.

- **Spline**

  Spline is an interpolation method that estimates values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through
the input points. Theoretically, the sample points are extruded to the height of their magnitude; spline bends a sheet of rubber which passes through the input points while minimizing the total curvature of the surface. It fits a mathematical function to a specified number of nearest input points while passing through the sample points. This method is best for generating gently varying surfaces such as elevation, water table heights, or pollution concentrations.

- **Kriging**

Kriging assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain the variation in the surface. Kriging fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. Kriging is a multistep process; it includes exploratory statistical analysis of the data, variogram modeling, creating the surface, and (optionally) exploring a variance surface. Kriging is most appropriate when we know there is a spatially correlated distance or directional bias in the data. It is often used in soil science and geology.

4. RESULTS AND DISCUSSION

4.1 Visualized surface performance

- **Comparison of interpolations surfaces created from maximum number points (884) and difference interpolation methods.**

*Figure 4* shows surface outputs corresponding to IDW, Spline and Kriging interpolations for the maximum number of regular and stratified data points. It could be seen from *Figure 4* that both regular and stratified random sample points provide similar surfaces for each interpolation technique. According to time of processing used, it was found that Kriging method with 884 points of regular sample and stratified random sample took longest processing time (5 minutes).

![Figure 4 Comparing Maximum number points (884)](image)

- **Comparison of interpolations surfaces created from different number of sample points, sample types and interpolated methods**

Elevation surface models corresponding to different number of sample points, sample type and interpolation methods are illustrated in *figure 5*. These results were compared to *Figure 4* which assumed as complete dataset. Demonstrating the less detail appearance when number of points was reduced. Among different Interpolation methodologies available, Spline and Kriging give a more smooth surface than that given by IDW, which gave more single hills appearance. 63 number of sample points provided a little differences surface compared to 108 sample points. Unlike 20 points returned less and rare detail of surface.
4.2 Graph Statistic Characteristics

- **Comparison of statistics of interpolations surfaces created from maximum number points (884)**

*Figure 6* shows the statistical graph associated with the maximum number of sample points, corresponding to *Figure 4*, Statistics values; minimum, mean and maximum of regular sample surface were almost same with regular sample input points, and stratified random sample point were small difference at minimum value, which was from spline methodology.

- **Comparison of interpolations surfaces created from different number of sample points, sample types and interpolated methods**

*Figure 7, 8 and 9* show graphs of statistics of interpolations surfaces created from different number of sample points; 108, 63 and 20, for each type of sample; regular, stratified random and random as well as difference interpolation methods; IDW, Spline and Kriging.

In terms of number of sample points, it is realized the fact that more number of points and more regular sample points would generate new values which are comparative to input data points (original data). However, this trend reduces with random sample point type using Spline method, which generate minus values. Regular and Stratified random sample points generated stable and moderately stable surfaces respectively. Random sample points produced more artificial values on all three sample set points, *Figure 9*.

- **Preliminary testing for the accuracy of a surface**

The best way to test the quality of surface is to generate the removed sample point against the remaining sample and examine the interpolated surface whether it could predict the missing sample (ESRI). For this study, due to time limitation, those steps were not prepared. However, preliminary testing of the accuracy of a surface, provided some significant results. *Figure 10* depicts graph bars of the testing surface obtained for different interpolation methods using 63 points random sample, the set that most probably similar to real sampling collection, against the 884 points stratified random sample which was the initial sample data. It could be seen that the IDW method generates the most statistic values close to the full data points, i.e. 884 stratified random sample points. Therefore, it could be assessed that IDW would be the best method for this random sample 63 points dataset.

5. CONCLUSION

In the context of GIS, interpolation is a functional method to create surface with inadequate sample data. The more input sample data and the more distribution and regular samples created, higher the reliability of results.

Spline method produced smoothest surface, enabling good visualization and contour line conversion. However, the method returns the synthetic results because of its curvature and smooth processing, while IDW and Kriging, generated more preservative statistic values of original sample points.

Based on statistics, IDW method would be the best method for this study area with 63 random sample points. Testing of the accuracy of surface, however, require more exhaustive process. Future work on this study would consider output surface, model and option testing.
Figure 5 Comparing of different number points, sample types and interpolated methods
Figure 10 depicts graph bars of the testing surface of difference interpolation methods using random sample 63 points against to stratified random sample 884 points.
REFERENCES


