Accuracy Assessment of Digital Terrain Model Data: A Cost Effective and Analytical Approach

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Key words:

SUMMARY

Digital Terrain Model is the most critical and cumbersome element of any large-scale mapping projects. Accuracy assessment of DTM data is an intricate but vital process. Over the years DTM data are collected utilizing either global positioning system (GPS) surveying techniques, photogrammetric (digital or analytical) or non-imaging airborne techniques. With the invention of differential GPS, more accurate height information of any topography can be acquired.

In this paper, Global Positioning System (GPS) surveying techniques is used to assess DTM data produced from contour lines digitized from topographic sheet covering a study site (a mixed urban and sparsely vegetated area). Using various interpolation methods, quality accuracy of datasets was assessed with the aid of different established stations with known X, Y and Z values. The result revealed interpolation model with better accuracy. Furthermore, this method is quite economical when compared with other quality control tests for DTMs.

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1. INTRODUCTION

A model is used to conceptualize certain aspects of reality. Digital terrain model is a numerical representation of terrain features in terms of elevation and planimetric measurements obtained by sampling a topographic surface. In other words, it is a numerical representation of both planimetric details and height information that provides a continuous description of the terrain surface.

Computer manipulation of elevation data opens up great possibilities for studying the geometry of land surfaces in relation to physical factors such as climate, vegetation, soil and geology. Therefore, understanding of the relationships between land surface geometry and these physical factors will help us to make more informed land use decisions.

The Digital Terrain Model has become a central storage carrier for height information. Automatic generation of DTMs is a subject of research, since the 1980s when the first experiment with intensity based matching have been carried out. However, software modules exist at photogrammetry software workstation which processes aerial image pairs (stereo pairs) and produce high quality DTMs.

With the use of three-line linear CCD (Charged Couple Devices) arrays (by SPOTS, MOMS02, etc) for direct digital data acquisition, direct DTM production from satellite imageries with standard techniques and algorithms are now possible (W. Korms, 1995).

DTM, besides its many exciting uses also serves as a veritable source for a clearer exploration and better understanding of the relationships of all these physical factors.

2. DATA ACQUISITION

Data acquisition for DTM is an integral part of daily workflow for any Remote Sensing and GIS research oriented institution (Nasser El-Sheimy, 1999). Digital Terrain Model (DTM) is a set of X (Easting), Y (Northing) and Z (height) points on the surface of the earth. These points are usually used to generate topographical contour maps, surface modeling, volume computation and engineering design work. To achieve and maintain the accuracy of the Z component of these points is a challenging and strenuous job.

3. STUDY AREA

The study area, Lat. 6° 32' – 6° 55 North, Long. 4°13' – 4° 35'East, is located west of Yaba, Lagos state. The morphology of the area is slightly undulating. The climate condition is slightly hot for most part of the year.

4. METHODOLOGY

Data set used for this study is a digital contour data digitized from a topographic map at a scale of 1:50000 with contour interval of 50m. The digitized contour is then undergone through a process called interpolation. Interpolation is the determination of an intermediate unknown value between fixed known values or rate of surface change (Wolf, 1987). This mathematical procedure is carried out in order to derive a continuous surface of the study area. However, a number of computer programs have been developed using various algorithms in order to develop surface interpolation. Below is an example of an interpolation model.

$$Z_i = a_0 + a1X + a_2Y + a_3XY \qquad \text{----------------} \ (1)$$

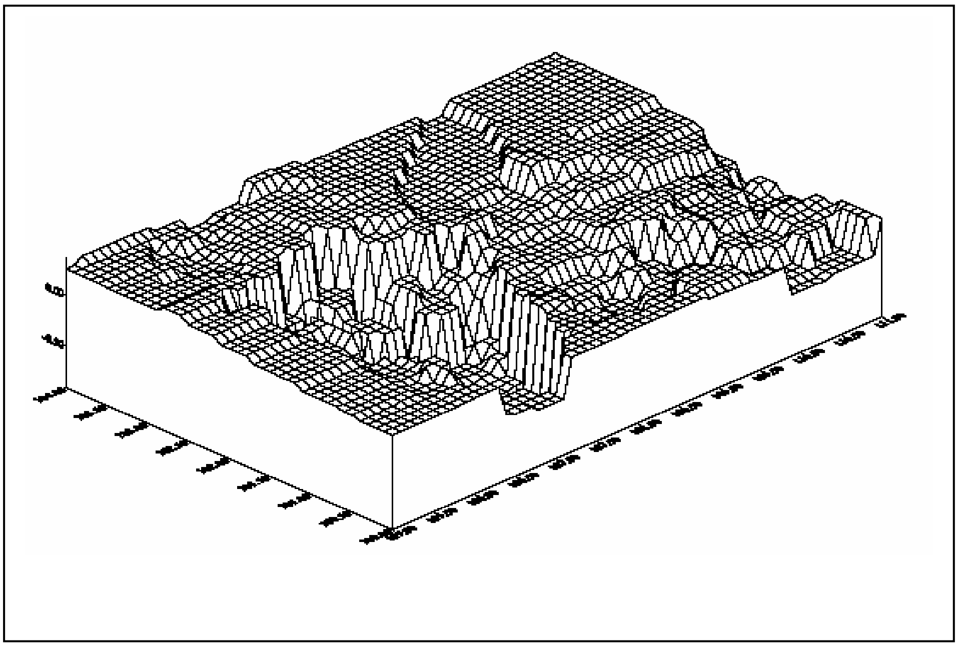
AYENI O.O (2002)

Where

Z_i = height value of ith location

a's = coefficients or parameters of the polynomial

XY = rectangular coordinates of ith point



5. TEST RESULTS AND DISCUSSION

In order to achieve the objective this paper, five different interpolation models were used to verify the accuracy and quality of heights data. Five control points was identified. This control points are different height data obtained from different established stations which falls within the study area. The resultant height data derived after interpolation are compared with height data obtained from different established stations and are shown below.

Table 1: Showing height data for different stations and heights obtained for different models

Station	Existing height data	Dataset 1 (Linear Inter.)	Dataset 2 (Polynomial)	Dataset 3 (Kriging)	Dataset 4 (Nearest Neighbor)	Dataset 5 (Shepard's Method)
	h(m)	h_1(m)	h_2(m)	h_3(m)	h_4(m)	h_5(m)
A	6.375	6.373	6.378	6.368	6.370	6.372
B	7.442	7.455	7.441	7.438	7.408	7.400
C	6.997	6.982	6.994	6.903	6.999	6.971
D	6.269	6.263	6.268	6.265	6.267	6.261
E	5.534	5.531	5.531	5.542	5.501	5.547

Table 2: Showing height error data for different datasets

Station	Dataset 1 (Linear Inter.)	Dataset 2 (Polynomial)	Dataset 3 (Kriging)	Dataset 4 (Nearest Neighbor)	Dataset 5 (Shepard's Method)
	$\triangle h_1$(m)	$\triangle h_2$(m)	$\triangle h_3$(m)	$\triangle h_4$(m)	$\triangle h_5$(m)
A	0.002	-0.003	0.007	0.005	0.003
B	-0.013	0.001	0.004	0.034	0.042
C	0.015	0.003	0.094	-0.002	0.026
D	0.006	0.001	0.004	0.002	0.008
E	0.003	0.003	-0.008	0.033	-0.013
R.M.S.E	0.02105	0.00539	0.09477	0.04773	0.05179

Table 1 shows height data obtained for different stations after interpolating the contour map. The result shows that Linear Interpolation model has closest value to the height data obtain on ground for station A while Kriging has the least. However, for station D the result shows that Polynomial Interpolation model has the closest value while Shepard's method has the least value. Individual station responds differently to different interpolation models as shown in Table1. Table 2 further shows error recorded for each station using five different interpolation models. In order to obtain the root mean square error value every error recorded for each station was taken into consideration. The graphical result is thus shown below.

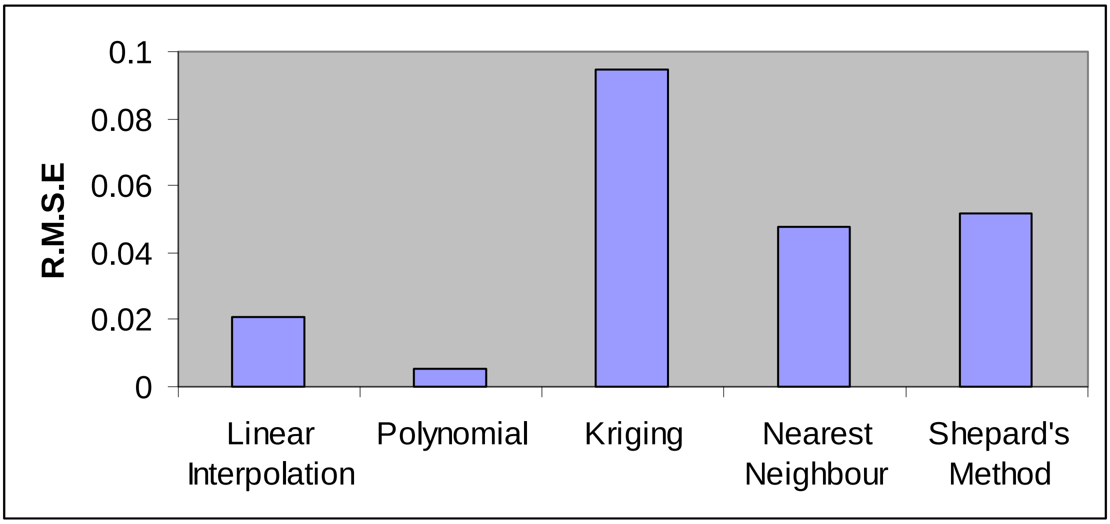


Figure 2: Showing Accuracy Analysis graph for different datasets

6. CONCLUSION

This study has been able to deduce that, after using different interpolation methods, polynomial interpolation method produce more accurate DTM data when compared with existing established data. Furthermore, the technique described in this paper for quality test may cost only a fraction of the cost for performing similar test using photogrammetric or analytical technique.

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