Investigating the Effects of Changing the IDW Power on the Quality of the Generated Digital Elevation Models

Fahmy F. F. Asal
Civil Engineering
Dept., Faculty of Engineering,
Menoufia University,
Shebin El-Kom, Egypt

Abstract: *Digital elevation data is utilized in generating Digital Elevation Model (DEM), which is involved in different Engineering and Environmental applications. Different techniques such as ground surveying, RTK GPS, analytical/digital photogrammetry, in addition to airborne laser scanning based on LiDAR technology are the main sources of digital elevation data. Digital elevation data form discrete point support files making it necessary to utilize an interpolation approach for the creation of a continuous surface forming a DEM. The research applies quality investigation on DEMs obtained from IDW interpolator of different powers in order to examine the effects of the variation of the power on the quality of the generated DEM. Real elevation data has been collected from field using a total station instrument in mountainous terrain. DEMs have been generated from the discrete data at a unified grid cell size using IDW interpolator with varying powers starting from a power of one and ending by a power of ten. Qualitative analysis is carried out on DEMs using visual analysis of 2D and 3D views of the DEM, in addition to statistical analysis of the DEMs. Visual analysis has shown that smoothing of the DEM is decreasing with the increase in the power till the power of four; however, increasing the power more than four does not leave noticeable changes on the 2D and 3D views of the DEM. These results are supported by the statistical analysis of the DEM where the value of the Standard Deviation (SD) of the DEM increases with increasing the power of the IDW. Changing the power from one to two causes 36% of the total increase (the increase due to changing from power of one to ten) in SD while changing to power of three from the power of one produces 60% of the total increase in SD and with power of four this percentage becomes about 75%, which refers to decrease of smoothing in the DEM with the increase in the power of the IDW algorithm.*

Keywords: *DEM/DTM/DSM, Ground Surveying, IDW, Interpolation, Digital Mapping, Spatial Analysis.*

1. INTRODUCTION

1.1 Digital Elevation Model

A Digital Elevation Model (DEM) is a continuous surface forms an array of a set of earth's surface points of X (Easting), Y (Northing) and Z (height). DEM data can be collected or generated using GPS or conventional surveying techniques; analog/analytical/digital Photogrammetry and non imaging airborne techniques including Airborne Laser Scanning (ALS) and Airborne Synthetic Aperture Radar (SAR). The size and location of the project decides on the technique to be used for collecting DEM data. As an example, if a project site is smaller than 100 acres, which is covered by tall trees and/or it constitutes urban landscape, the conventional surveying techniques; total station and spirit leveling, are optimal for such a project

1.2 Digital Elevation Model Quality

Prior to the use of DEMs in various applications it is important to identify their qualities in order to determine the suitability of a certain DEM to the quality standards necessary for a specific

[1], [2]. The concept of DEM can be used for digital representation of any single-valued surface such as a terrain relief model namely; Digital Terrain Model (DTM), or representing the top surface of an urban or rural area forming a Digital Surface Model (DSM). The concept also, can be used in other disciplines; such as in demography to represent the variations of population density over a certain region. DEMs are widely used in remote sensing and Geographical Information Systems (GIS) as they are mainly used for ortho-rectification of images, topographic mapping and engineering design and modeling. Furthermore, DEMs are used in numerous disciplines, ranging from geo-information to Civil Engineering. In various applications DEM serves as inputs for decision making, as examples they are employed in flood hazard analysis [3].

application [4]. The quality of a DEM is subjected to some factors such as the density of the sampling points, the spatial distribution of the sampling points, the method of interpolation used, the propagated errors from the source data in addition to other factors [5], [6]. Asal and

Hassouna, (2007) studied the effect of the interpolation techniques on the quality of the obtained DEM [7]. The outcome of the research indicated that IDW provides better quality DEM than that is given by the Spline method, which smoothes the surface and generates quite noise DEM. The research did not answer the question, which value of the power to be used with the IDW for providing a DEM of specific quality. For that reason it has been suggested that it would be useful to examine IDW of different powers against the quality of the obtained DEM.

2. CREATION OF DEM FROM DISCRETE SPOT ELEVATION SURVEYING MEASUREMENTS

2.1 Interpolation Operation

Elevation interpolation is a complicated operation that can be defined as a process of predicting a value of attribute z at unsampled site from measurements carried out at neighbouring sites within given neighborhoods. The process aims at creation of a continuous surface from observations at sparsely located points or for resampled grid to different density or orientation as in remote sensing images [3]. Elevation interpolation could be considered as a spatial filtering process where the input data are not necessarily located at on a continuous grid. Interpolation operations can be expressed in a mathematical command language, however most users will encounter specialist packages so that standard terminology can be used. It may be useful to mention that predicting an elevation value outside the site area from the point data is known as extrapolation [8]. The main purpose of an interpolation operation is the conversion of point data files into continuous fields so that the spatial patterns of these measurements can be compared with the spatial patterns of other entities [9]. Interpolation operation is applied when the discretised surface has different levels of resolution from the required surface. It may also be applied when the continuous surface is represented by different models. Moreover, interpolation operation is performed when the data available does not cover the domain of the area of interest [10].

Interpolation methods may be divided into two main groups, global interpolation and local interpolation techniques. Global interpolation uses all available data to provide prediction of the whole area of interest. On the other hand, local interpolators operate within a small zone around the point being interpolated to ensure that the estimates are made only with data from locations in the immediate neighbourhood and fitting as good as possible. As examples of global interpolation methods, classification using external information, trend surface on geometric coordinates, regression models on surrogate attributes and the methods of spectral analysis. However, local interpolation techniques encompass thiessen polygons and pycnophyactic methods, linear and inverse distance weighting and thin plate Splines. Global interpolations in most cases are not used for direct interpolation, but for examining the effect of global variations and sometimes removal of this effect that may be caused by major trends. As soon as the effect of global variations in the data is removed the data can be interpolated using local interpolators in different types of gentle and corrugated terrains. All global and local interpolation methods are relatively straightforward as they require only understanding of simple statistical methods. Commercial GIS packages usually include these methods. Geo-statistical interpolation using methods of spatial autocorrelation is known as kriging as they require understanding of the principles of statistical spatial autocorrelation. These methods are used when the variation in elevations is so irregular and the density of the sample is such where simple interpolation methods may not give reliable predictions [8].

2.2 DEM Interpolation Using Inverse Distance Weighting (IDW) Technique

The ideas of proximity adopted by thiessen polygons is combined with the gradual change of the trend surface by the Inverse Distance Weighting (IDW) technique. It is assumed that the value of an attribute z at unvisited point is a distance weighting average of data points occurring within a neighbourhood or window surrounding the unsampled point. The original data points may be located on a regular grid as well as they can be distributed irregularly over an area where interpolation is performed to locations on a denser regular grid in order to produce a map. The weighted moving approach computes the interpolated elevation as [8]:

$$z = \sum_{i=1}^{n} \lambda_i z(x_i) \quad \text{and} \quad \sum_{i=1}^{n} \lambda_i = 1 \qquad (1)$$

Where:

λi = the weights, which are functions of the position of the point i, Thus,

$$\lambda_i = \varphi \ (d(x, x_i))$$

The value of $\varphi(d)$ tends to the measured value as d tends to zero, which is given by the exponential function e^{-d} and e^{-d^2}. The most common form of $\varphi(d)$ is the inverse distance weighting predictor whose form is [8]:

$$z(x_j) = \sum_{i=1}^{n} z(x_i) d_{ij}^{-r} \Big/ \sum_{i=1}^{n} d_{ij}^{-r} \qquad (2)$$

Where,

x_j = the points where the surface is to be interpolated,

x_i = the data points.
r = the formula power, which can be *1, 2, ., ...n*

As in equation (2) φ(d) tends to infinity as d tends to zero, the value of the interpolated point that coincides with a data point must be copied over. The simplest form of this interpolation is called linear interpolator, in, which the weights are computed from a linear function of distances between sets of data points and the points to be predicted. It should be noted that the inverse distance weighting is forced to the exact values at the data points. This means that if the input grid coordinates are equal to those of a sampling point, then the interpolated elevation at this location will be copied over by exact elevation value of the sampling point. The quality of the DEM produced from the IDW interpolation may be assessed by using additional observations as the method has no inbuilt technique for the testing the quality of interpolation [8], [10].

3. METHODOLOGY

A test site in hilly corrugated terrain has been established to the east of Cairo, Egypt. Data has been collected from field using conventional surveying methods where a total station instrument has been used for measuring the three dimensional coordinates (x, y, z) of spot points.

The sample data covers an area of about 830 by 660 metres and consists of 2687 spot elevation measurements forming a density of an elevation point for every 203.87 square metres and an average spacing between spot elevations of about 14.28 metres. The maximum elevation in the sample data is 138.27 metres and the minimum elevation is 116.73 metres above the mean sea level giving a range of elevations of 21.84 metres in the tested terrain. The mean elevation of the sample data is 128.76 metres and the median is 129.62 metres while the mode of the sample data records two values of equal frequencies; are 131.96 and 131.07 metres. Additionally, the variance of the sample is 18.68 metre squared and

the standard deviation of the mean is ±4.32 metres which is quite high value referring to highly varied terrain.

DEMs have created from the field data using ESRI spatial analysis and 3D analyst working under ArcView GIS 3.2 commercial software package. All parameters have been kept unchanged except the power of the IDW that has been the only parameter allowed to change for the creation of DEMs using powers ranging from one to ten. Qualitative analysis of the DEMs has been undertaken aiming at viewing differences between DEMs generated from IDW with different powers in representing the earth's surface. Also, statistical analysis is carried out for the purpose of the assessment of changes in the statistical parameters of the DEMs due to changing the power of the IDW technique.

4. RESULT ANALYSIS AND DISCUSSIONS

4.1 Visual Analysis of the Generated Dems

Figures 1 to 10 represent DEMs created from spot elevation data collected from field using a total station instrument. ArcView GIS 3.2 with the spatial analysis and the 3D analyst extensions have been used in creating the DEMs. The IDW technique has been the algorithm exploited in this process. The grid cell size has been 2.0 metres, in order to minimize the effect of grid sampling that arises as DEM smoothing on the produced DEM, and kept unchanged for all the generated DEMs. The number of neighbours used is 12 as the default input of the system and kept unchanged for all the DEMs as well. The only factor allowed to change is the power of the DEM, which is the factor under investigation. Figure 1 is a DEM created using a power value of one while figure 2 is a DEM created using a power of two. Additionally, figure 3 is a DEM produced using a power of three and figure 4 is a DEM obtained using IDW with a power of four. Figure 5 is a DEM produced using a power of five and figure 6 is a DEM developed using a power of six. Moreover, figure 7 is a DEM created using a power of seven and figure 8 is a DEM generated using a power of eight. Finally, figure 9 depicts a DEM interpolated using a power of nine and figure 10 represents a DEM developed using a power of ten. As mentioned above, the only factor subjected to changes is the power of the IDW while all the other factors are kept unchanged. After trying different colour ramps for 2D viewing of the DEMs it has been decided to view the DEMs using a colour ramp named as; Terrain Elevation #1 included in the ArcView 3.2 wallet of colour ramps, which provided the best

visualization of the differences between DEMs. The total range of elevations, about 21.84 metres, contained in the DEM is divided into sixty colour classes, which is a considerable number of classes allowing minor differences between DEMs to be interpretable.
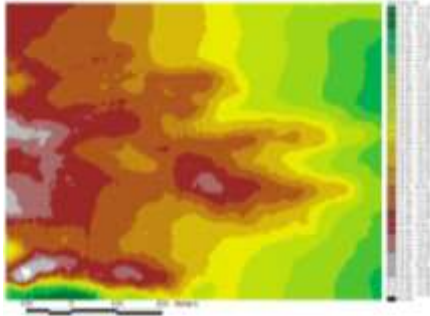

Figure 1. *DEM created using IDW of power of onfrom spot elevation measurements*
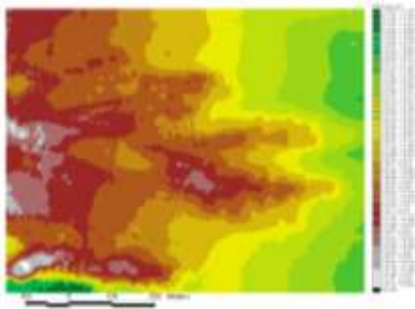

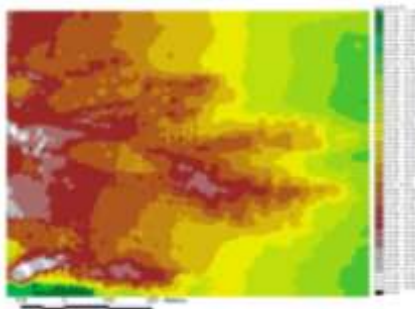**Figure 2.** *DEM created using IDW of power of two from spot elevation measurements.*

Figure 3. *DEM created using IDW of power of three from spot elevation measurements.*

Referring to figure 1, which depicts a DEM created using IDW algorithm with power of one it can be noticed that the view is clear with sharp transition between elevation classes. Also, the view is showing a very limited number of tinny colour patches among colour class areas referring to smoothing and approximation of elevations in the DEM. A different view is obtained in figure 2, which is a representation of DEM generated using the power of two. Different from figure 1, in figure 2 interaction between colour classes is observed with bigger numbers of tinny colour

patches inside big patches of different colour classes. This refers to better interpolation of elevations and less smoothing of the DEM. Additionally, less sharpness between colour classes can be observed in figure 3, which is a DEM created using IDW of power of three. Larger numbers of tinny colour patches are observable reflecting more corrugations in the DEM and better representation of the terrain. Smaller differences between DEMs may be interpretable in figures starting from figure 4 which is a DEM created with the power of four to figure 10, which is a DEM created with the power of ten. This reflects smaller improvement in the interpolation operation due to the increase in the value of the power of the IDW more than four. It may be important to note here that increasing the power of the IDW leads to huge amount of calculations to be performed, which is translated into additional costs of the DEM generation, especially in large areas where DEM production is required. In this case it might be useful to consider the efficiency of the operation of the DEM generation, which refers to determining the power of the IDW algorithm to be applied so that the resulting DEM would be of enough quality that suits a specific application at a reasonable cost.
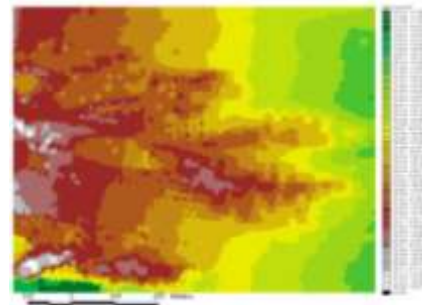

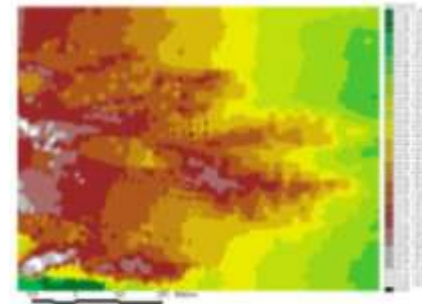**Figure 4.** *DEM created using IDW of power of four from spot elevation measurements.*

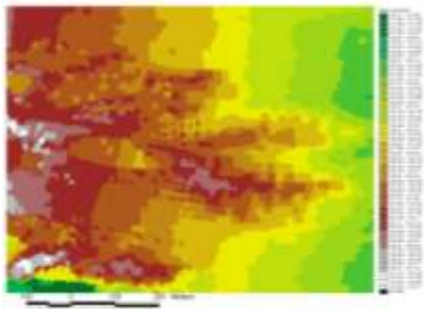**Figure 5.** *DEM created using IDW of power of five from spot elevation measurements.*

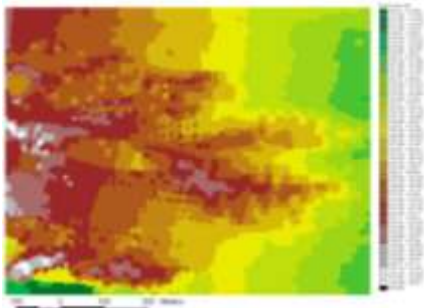**Figure 6**. *DEM created using IDW of power of six from spot elevation measurements.*

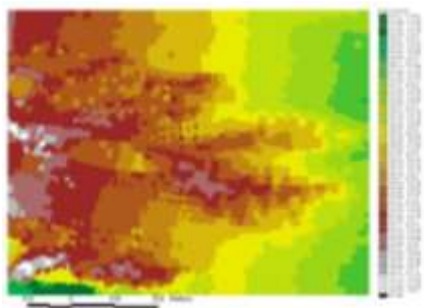**Figure 7.** *DEM created using IDW of power of seven from spot elevation measurements.*

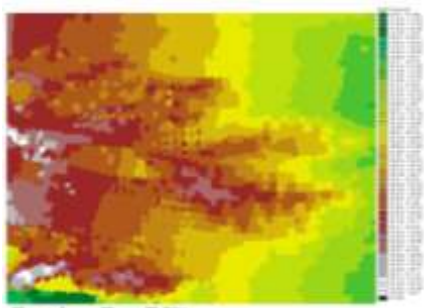**Figure 8.** *DEM created using IDW of power of eight from spot elevation measurements.*

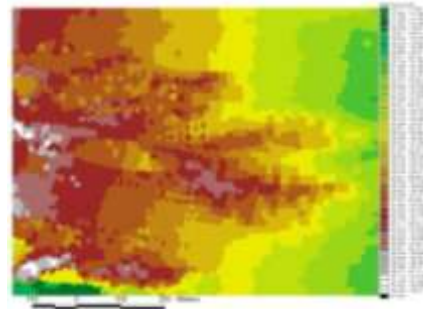**Figure 9.** *DEM created using IDW of power of nine from spot elevation measurements.*

Figure 10. *DEM created using IDW of power of ten from spot elevation measurements.*

4.2 Generation and Analysis of 3D Views of the Created Digital Elevation Models

Figures from 11 to 20 are 3D views generated from digital elevation models created using IDW of different powers, where Figure 11 is a 3D view of DEM generated from IDW of power of one and figure 12 is a 3D view of DEM interpolated from IDW of power of two. In addition, figures 13 and 14 are 3D views of DEMs created using IDW of powers of three and four respectively. Moreover, figures 15 and 16 are 3D views of DEMs interpolated using IDW of powers of five and six respectively. Furthermore, figures 17 and 18 are 3D views obtained from DEMs interpolated using IDW of powers of seven and eight respectively. Finally, figures 19 and 20 are 3D views of DEMs produced using IDW of powers of nine and ten respectively.
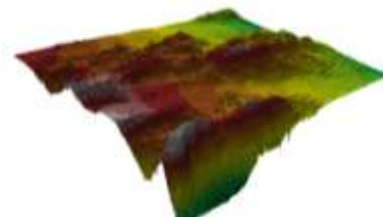

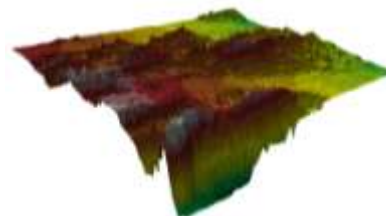**Figure 11.** *3D view of the DEM created using IDW of power of one from spot elevation measurements*

Figure 12. *3D view of the DEM created using IDW of power of two from spot elevation measurements.*
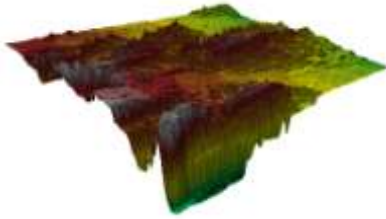
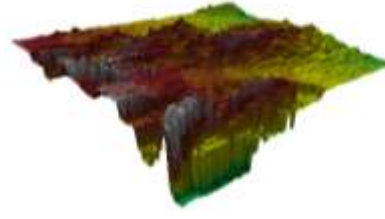**Figure 13.** *3D view of the DEM created using IDW of power of three from spot elevation measurements.*

Figure 14. *3D view of the DEM created using IDW of power of four from spot elevation measurements.*

Figure 15. *3D view of the DEM created using IDW of power of five from spot elevation measurements.*

Figure 16. *3D view of the DEM created using IDW of power of six from spot elevation measurements.*

Figure 17. *3D view of the DEM created using IDW of power of seven from spot elevation measurements.*

Figure 18. *3D view of the DEM created using IDW of power of eight from spot elevation measurements.*

Figure 19. *3D view of the DEM created using IDW of power of nine from spot elevation measurements.*

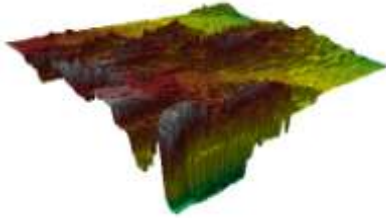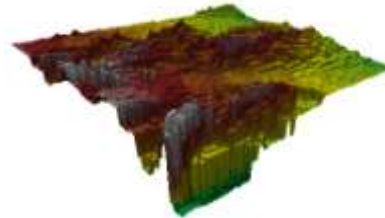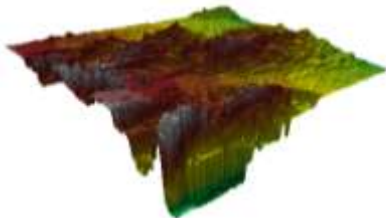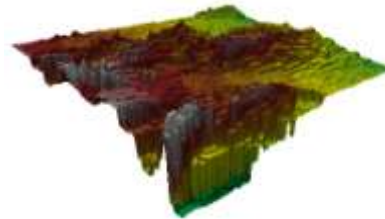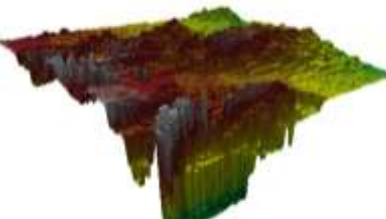**Figure 20.** *3D view of the DEM created using IDW of power of ten from spot elevation measurements.*

3D views in Figures 11 to 20 record differences between DEMs generated using IDW of different powers. Compared to the other 3D views, figure 11 records the minimum amount of corrugations, which supports the outcomes interpreted in the 2D view. This is also translated into smoothing of the surface and higher degree of approximation in estimating the DEM elevations. More corrugated surface is viewed in figure 12, which has been created using the power of two, which leads to better estimation of the surface elevations. With increasing the power of IDW, more corrugated surfaces are noticeable, which, in turn is an indication of improvement in the estimation of the DEM elevations; however, this improvement is much clearer when increasing the power from one to two and becomes noticeable when increasing the power from two to three and from three to four. The corrugations increase with increasing the value of power from four to five and so on, but the changes in the view of the DEM become less with the use of higher values of the IDW power. From the analysis it can be concluded that 3D visualization of the DEM has proven to be a
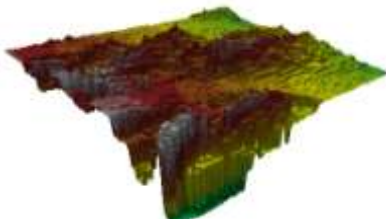
suitable tool for viewing differences in the DEM due to changing the IDW power.

4.3 Statistical Analysis of the DEMs Created Using Different Powers

Referring to values in table 1 and the graph in figure 21 it can be seen that the sum of elevations in the DEM decreases with the increase in the power of the IDW model from one to ten. However, the decrease in the sum of elevations is rapid and sharp until the use of power of four and becomes milder till the use of power of seven while it is very small when using powers more than seven until ten. As a percentage the decrease in the sum of elevations due to changing the power from one to two is about 40% of the total decrease in the sum of elevations that occurs due to changing from the power of one to the power of ten. When using a power of three the percentage of decrease is about 66% and becomes about 80% when using a power of four. Moreover, the percentage of decrease becomes 88% when using a power of five and 93% when using a power of six. Additionally, using the power of seven causes a decrease of 96%. Furthermore, increasing the power of the IDW from seven to ten causes slight changes in the sum of elevations in the DEM, letting improvements in the interpolation operation might be worthless if it is compared against the cost due to the increase in the amount of calculations required.

When examining the maximum elevations in the DEMs, it is noticed that IDW with power of one records slight decrease in the maximum value compared to that of the original data, which increases with the increase in the power value and approaches the value recorded in the original data with the use of a power of three. The opposite can be said for the minimum elevation where IDW of power of one gives higher minimum elevation value than that is recorded in the original data. This value decreases with the increase in the power value approaching the recorded value in the original data with the use of power value of four and remains unchanged due to increasing the power value more than four. The effects of changes in the maximum and minimum elevations are reflected on the range of elevations in the DEM. IDW with power of one records narrower range of elevations, 20.48 metres, compared to that recorded in the original data, 21.84 metres. The range of elevations in the DEM increases with the increase in the power of the IDW until reaching the value of 21.84 metres with the use of power of four and remains unchanged after that.

Table 1. *The statistical properties elevations in the DEMs created using IDW interpolator with different powers.*

Statistical Value	Sum	Max.	Min.	Mean	Median	Mode	Range	Standard Deviation
DEM-P1	17458377	138.270	117.790	128.567	129.400	131.370	20.480	3.926
DEM-P2	17454423	138.550	116.840	128.538	129.320	131.350	21.710	3.969
DEM-P3	17451839	138.570	116.740	128.519	129.260	131.090	21.830	3.998
DEM-P4	17450394	138.570	116.730	128.508	129.230	131.070	21.840	4.015
DEM-P5	17449597	138.570	116.730	128.502	129.200	131.070	21.840	4.026
DEM-P6	17449133	138.570	116.730	128.499	129.180	131.070	21.840	4.032
DEM-P7	17448849	138.570	116.730	128.497	129.170	131.070	21.840	4.037
DEM-P8	17448666	138.570	116.730	128.496	129.170	131.070	21.840	4.040
DEM-P9	17448540	138.570	116.730	128.495	129.160	131.070	21.840	4.043
DEM-P10	17448452	138.570	116.730	128.494	129.160	131.070	21.840	4.045

This means that smoothing of elevations is at its highest with power of one and decreases with the increase in the power of the IDW. Also, when examining the Standard Deviation (SD), with referring to table 1 and figure 22, which depict the effects on SD of the elevations in DEMs due to changes in the IDW power, it is observed that SD increases with the increase in the power of the IDW technique. The increase in SD is sharp till reaching the power of four where about 75% of the total increase is obtained and become smaller

with powers of five, six and seven where about 93% of the total increase is recorded at power of seven. It is important to note here that the increases in SD of elevations in the DEM refer to increases of variations of elevations in the DEM, which is a reflection of decreasing in smoothing of DEMs and consequently better estimation of elevations.
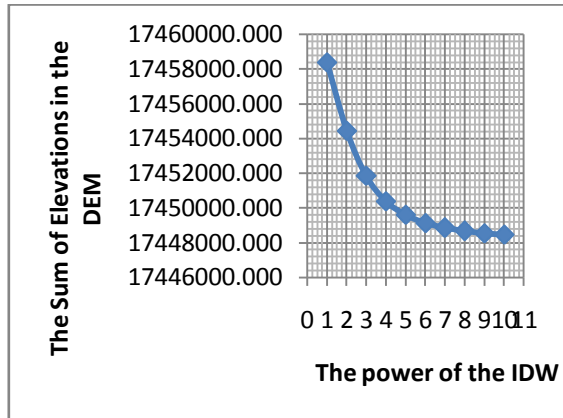

Figure 21. *The effect of changing the power of the IDW on the sum of the elevations in the generated DEM.*
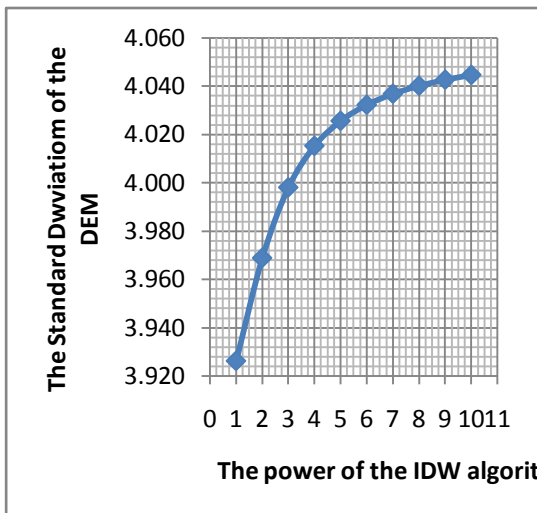

Figure 22. *The effect of changing the power of the IDW on the standard deviation of the elevations in the generated DEM*

4.4 Discussions

DEMs have been created from a point support file containing 2687 discrete spot elevations using IDW interpolation algorithm with different powers starting from power of one to power of ten giving ten different DEMs. All the factors of the IDW algorithm have been kept unchanged except the power factor, the factor under examination. For examination of DEMs regarding quality against the power of the IDW, three tests have been performed so that it can be determined which

power of the IDW algorithm can produce reasonable quality DEM. Visual analysis of the ten DEMs at two dimensional views has been the first test. The DEM created using the power of one has shown clear view with sharp transition between elevation classes and less changes in the tones within the DEM. This reflects smoothing of elevations and less quality in the prediction of elevations throughout the DEM. DEM produced using the power of two is less clearer, less brighter and less sharper than that one created using the power of one where less smoothing and better estimation of elevations could be the case. Also, interaction of color classes increases due to increasing the power of the IDW. Additionally, differences between DEMs are observed when changing the power to three and also, to four, however, DEMs created using powers of five to ten can be similar in views where it is difficult for differences to be distinguishable. Smoothness of the surface is clear in the 3D view, figure 11, which is a 3D view of the DEM created using power of one. Interpolation of elevations has improved when using the power of two where more corrugated surface is observed in the 3D view. With the use of power of three the corrugations increase but at smaller rate compared to the rate of increasing due to changing from power of one to power of two. Additionally, when increasing the power more than four, the changes in the surface become hardly noticeable from the 3D visualization analysis which coincides with the outcomes from the 2D visual analysis of the DEMs.

Visual analysis of DEMs generated from IDW of different powers using 2D and 3D visual analysis has uncovered clear changes in the DEMs due to increasing the value of the power from one to four. With the increase of the power more than four and till seven, the obtained changes are smaller, however, with increasing the power more than seven the changes may hardly be noticeable. For changes in the DEM properties to be sensible it would be more convenient if they are expressed in numbers. The statistical analysis test of the DEM has been carried out so that some of the statistical properties of the generated DEMs can be examined against the use of different powers. Clear differences in the statistical properties of DEMs created using different powers have been obtained where the sum of elevations in the DEM decreases with the increase in the value of the power. Considering the total decrease in the sum of elevations in the DEM due to change in the power of the IDW from one to ten is one hundred

percent, increasing the power from one to two has produced about 40% of the total decrease. Additionally, the use of power three has produced about 66% of the total decrease (i.e. about two thirds of the total decrease). Furthermore, the use of power of four has caused a decrease of about 80% of the total decreases in the values of the sum of elevations in the DEM. In addition to that, the values of the maximum, the minimum, the range, the mode and the median elevations record some changes from their corresponding values in the original data when using powers of; one, two, three and four, however, with the use of powers starting from five the corresponding values of the maximum, minimum, range, mode and median elevations in the original data are retained. The obtained analysis is supported by the standard deviation property of the DEM, where, changing the power from one to two produces an increase in the SD of about 36% of the total increase in SD which has occurred due to changing the power from one to ten. However, with the use of power of three this percentage becomes about 60% where it increases to 75% when using the power of four. On the other hand, increasing the power of the IDW more than four gives increases in the values of the standard deviation but the rate of increasing becomes slighter.

5. CONCLUSIONS

The availability of digital elevation data has been widely increasing motivated by the developments in computing technology. Digital elevation data can be obtained from conventional surveying techniques, conventional photogrammetry and from LiDAR technologies. Generated digital elevation data is usually in discrete point file format where it is usually utilized in creating digital elevation models through the application of an interpolation approach. Different interpolation algorithms exploited in such operation are expected to provide DEMs of varying qualities. Inverse Distance Weighting (IDW) algorithm is one of the interpolation algorithms that is widely used in generating DEMs. IDW can be performed with different values of the power factor with the expectation of giving DEMs of different qualities. Spot elevation data collected from a corrugated hilly terrain test site has been used for the analysis. DEMs have been created from the test data with the changing of the value of the power of the algorithm starting from one to ten. Three tests have been performed on the generated DEMs; the 2D visual analysis, the 3D visual analysis and the statistical analysis of DEMs tests. The analysis has shown the following results:

- IDW with the power of one gives the highest degree of smoothing and approximation of elevations in the DEM. This outcome has been supported by the three tests.
- With the increase in the value of the power more than one the 2D and 3D views of the DEM show increasing in the corrugations of the surface.
- Increasing the IDW power more than four produces little changes in the views of the DEMs. These changes are hardly noticeable at higher powers more than seven.
- The statistical analysis of DEMs generated with different IDW powers shows decrease in the sum of elevations within the DEM with the increase in the power of the IDW. The decrease is at its highest value when increasing the power from one to two, where about 40% of the total decrease is obtained, while increasing the power from one to three results in about 66% of the total value of the decrease. Also, changing the power value from one to four gives about 80% of the total decrease in the sum of elevations due to chancing the power from one to ten.
- Increasing the power of the IDW gives increases in the value of the Standard Deviation of the DEM. This refers to better estimation of the elevations and decrease of smoothing within the DEM.
- Increasing the power of the IDW from one to two provides about 36% of the total increase in SD due to changing the power from one to ten. Also, increasing the power from one to three provides an increase in the SD more than 60% while with the increase from one to four an increase of about 75% of the total increase in the SD is obtained.
- From above it is noticed that the characteristics of the produced DEMs improve with increasing the power of the IDW, however the improvement is very significant with power of four where about 75% percent of the expected improvement can be obtained. With the use of powers of five, six, seven, eight, nine and ten values, the improvements become slighter.
- Increasing the value of the power leads to increasing the required amount of calculations which leads to increasing in the computing time and computing costs especially when performing interpolation of DEMs in wide areas where huge amount of data is to be processed. In this case an optimization operation is necessary.

- More investigations are necessary in order to assess the effect the power of the IDW on the accuracy of the interpolated elevations and on the geomorphological characteristics of the DEM.

REFERENCES

[1] Acharya, B., Fagerman, J. and Wright, C., 2000, "Accuracy Assessment of DTM Data: a Cost Effective Approach or a Large Scale Digital Mapping Project", International Archives of Photogrammetry & Remote Sensing, Vol. XXXIII, Amsterdam, 2000.

[2] Podobnikar, T., 2009, Methods for Visual Quality Assessment of s Digital Terrain Model. Journal of SAPIENS (Surveys and Perspectives Integrating Environment and Society), Vol. 2/n°2 Special issue. http://sapiens.revues.org/index738.html.

[3] Soleimamani, K. and Modallaldoust, S. 2008, Production of Optimized DEM Using IDW Interpolation Method (Case Study; Jam and Riz Basin-Assaloyeh), Journal of applied Sciences 8(1): 104-111, 2008, ISSN 1812-5654, Asian Network for Scientific Information.

[4] Acharya, B. and Chaturvedi, A., 1997, "Digital Terrain Model: Elevation Extraction and Accuracy Assessments", Journal of Surveying Engineering, Vol.123, No.2, May 1997, pp. 71-76.

[5] Zhu, C., Shi, W., Li, Q., Wang, G., Cheung, T. C. K., Dai, E., and Shea, G. Y. K., 2005, "Estimation of Average DEM Accuracy under Linear Interpolation Considering Random Errors at the Nodes of TIN Model" International Journal of Remote Sensing, Volume 26, Number 24,01D2005, pp. 5509-5523(15).

[6] Karl, W., Pfeifer, N. and Briese, C., 2006, "DTM Quality Assessment", Working Group 11/7, 2006.

[7] Asal, F. F. and Hassouna, R., 2007, "Accuracy Assessments of Digital Elevation Models Created Using Different Interpolation Techniques", Al-Azhar University Engineering Journal, JAUES Vol. 2, No. 3, Apr. 2007.

[8] Burrough, P. A. and McDonnell, R. A. 200, "Principles of Geographical Information Systems", Oxford University Press, 2000.

[9] Mayers, E. D., 1994, "Spatial Interpolation: An overview", Geoderma, 62: 17-28, 1994.

[10] Lo, C. P. and Yeung, A. K. W., 2004 "Concepts and Techniques of Geographic Information Systems" Prentice-Hall of India Private Limited, New Delhi – 110 001, 2004.