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Improvement the Accuracy of Digital Elevation Model (DEM) with Reduction Pit and Flat Errors (without field work)

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Abstract

Many geo-morphometric parameters such as DEM, Slope, and Slope aspect related with elevation. Some errors are created in calculated parameters, due to lack of height information in topographic maps (medium and small scales), which are often hidden from the investigator's view and has effect on the future calculations., Some research and practical projects, surveying and field work are expensive, but it is possible to produce automatic program, which can extract more information from the topographic maps and lead to more accurate calculation from DEM. Also, removing pit and flat errors (two common errors in DEM) should be considered for DEM generation. In this research by using ArcView software and object oriented programming language (avenue) a model has developed that can be done quickly and save money. Elevation points of the river are calculated with desired intervals from contour line. The result of the program can be used as height point layer for Dem generation. The statistical results show the importance of evaluation point.

Key word: Digital Elevation Model; Avenue; Object Oriented Programming; Flat error; GIS programming; Pit error.

1. Introduction

Although topographic-based elevation points and high phenomenon can be used to increase accurately geo-morphometric parameters such as slope, aspect and curvature [2], it may not occasionally occur due to lack of elevation data in topographic maps, which caused by some limitation association with cost/time and physically obstacles, particularly in plain landforms [4]. Therefore, topographic-based digital data and existing Digital Elevation Model (DEM), as well as extracted information from such data have no adequate accuracy. Today several methods have developed to modify the existing DEM. Ferdi Hellweger (1997) represented an algorithm, which generate a new DEM-based stream network by reduction height in the stream network of basin [3]. Hannah (1981) designed an algorithm to assess the DEM accuracy [2]. This algorithm based on comparison between the value of elevation-points and the values obtained from their neighbour (using the interpolation method). O'Callaghan and Mark (1984) applied spatial filters to correct the systematic and random errors [4]. The height value of each cell is calculated by the average height of eight cells neighboring the central cell. Luzio, Srinivasan and Arnold (2001) used, also, SWAT[1] model to decrease

[1] Soil Water Assessment Tool

the height of DEM in a drainage network, so water flow matched with the flow direction pattern, and the automatic generation of hydrological catchment is possible [1]. Quoi Anh and Trung (2004) extracted DEM from ASTER satellite images by using ground control points (GCPs) in Geographical Information Systems (GIS). Their results showed errors in a flat area are much more than mountainous area, with RMS error 30m [7]. Westen and Farifteh (1997) represented a method to modify DEM based on peaks and closed contour lines [8]. According to this method, peak-points extracted from topographic maps, in addition to, contour lines contributed to interpolate the elevation-points as a driver of raster layer [8]. In this method, there is no approach to extract elevation-points and these points must be already generated. Furthermore, there are several methods, which are based on neighbourhood operations, to identify the DEM errors; particularly in the flat areas and pit. Thomas (1996) and Razavi (2002) defined the special data such as Poly line and Poly Line M which are particularly significant to analysis the vector data. The dataset, Feature Line and/or Feature Line M, defined as Poly Line and Poly Line M, which each line has single or multi- point with 'X', 'Y' and 'M'. 'X' and 'Y' are geographical coordinates and 'M' is the numerical value [5 and 6]. Accordingly, the literature review on this topic indicates the necessity of reform DEM after generation. Therefore, the main objective of this research is produce the new model to increase the accuracy of DEM generation using high frequency of elevation-points derived from original dataset.

2. Study area

In this research, topographic maps on a scale of 1:500 (by field surveying) and a scale of 1:50000 by National Geographical Organization (Iran) showing Seyed Abad, Vasmagh and Razgan rivers which are 2 to 4 in length (kilometres) and three geomorphologic feature types which include plain area, Semi-mountainous and (mountainous) are used. These features are located in Markazi province, Saveh city, Seyed abad village between latitude 35 15 53 to 34 24 09 north and longitude 49 54 02 12 50 to 50 12 08 (Figure 1). Arc View software and avenue object-oriented programming language'' have used to developed a new algorithm model.

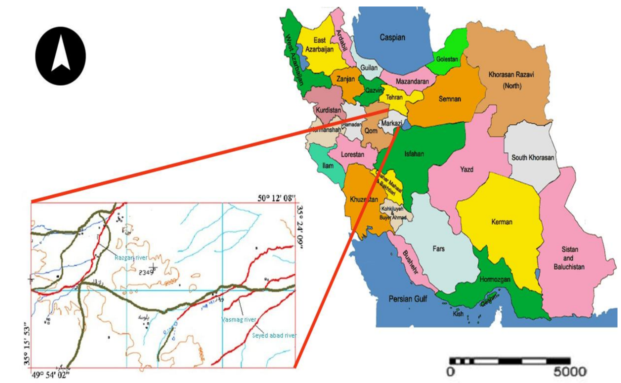

Fig.1. Position of Seyed Abad, Vasmagh and Razgan rivers in Zarand plain in Iran

3. Material and Methods

At first, three digital river layers from Polyline structure converted to Poly Line M, then vertices are produced according to the user's request and favourite distance. At this stage, it should be noted that the numerical value to every few vertices is assumed null (Figure 2)

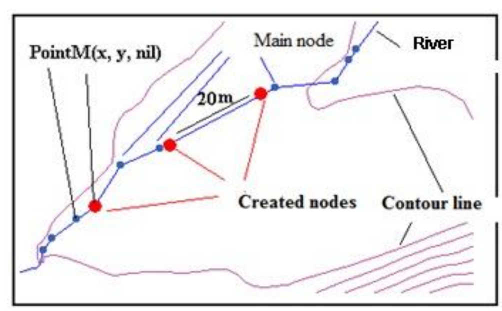

Fig.2. Points M verticals in new Poly Line M structure Main drainage network vertices (.) New vertices with 20 meters intervals (.)

Since the presence of node on line feature is not necessary, therefore, it must be used from other points, which are intersect with the contour lines, The height of these points indicates the elevation of contour lines. Elevation of all points with null value has calculated by the known elevation, points (Figure 3).

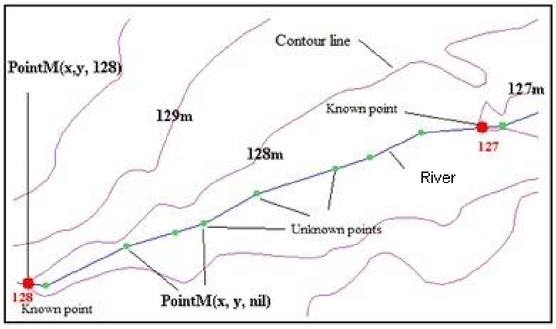

Fig.3. Generating points in location of contour lines

In the next step, by using Interpolate NilM located at Poly line M feature Class, the elevation of unknown points was calculated based on distance from known points (Linear interpolation). Important note: all calculations are vector base. (Figure 4).

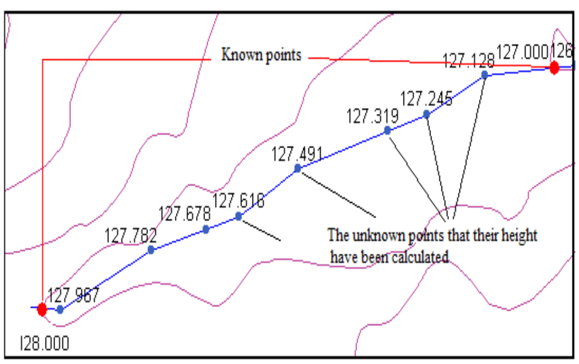

Fig. 4 Height has calculated in unknown points

It is clear that, from these points, the accurate DEM can produce. Finally, to evaluate the effect of auxiliary elevation points for generation corrective Dem, the height of control point in vertical river profiles (Seyed Abad, Vasmagh, Razghan rivers) with the corresponding points (X, Y coordinate system, Z(elevation) in corrective Dem and normal Dem used.(The Student's t- test)

Statistical test (Eq.1).

$$t = \frac{\bar{d} - do}{\frac{sd}{\sqrt{n}}} \quad (1)$$

Where:

$\bar{d}$: The height difference means for pairs of elevation points

Sd : Standard deviation: the number of compared point

In order to investigate the effect of the number of decimal of elevation values in DEM, Two DEM with 0.1 until 0,001 decimal accuracy for three regions(Razghan, Vasmgh, Seyed Abad) were generated(because of errors in flat areas (Flat), digital Pit). Then Pit and Flat's errors in DEM identified and compared with them by GIS functions.

4. Results and Discussion

An auxiliary elevation point's model in the stream network of the watershed has designed using Object-oriented programming language Avenue in Arc View 3.2. The results of auxiliary elevation point's analysis showed they had a significant role in increasing the accuracy of the Dem in three regions (Razghan, Vasmgh, Seyed Abad). Student's T-test analysis shows significant differences between the height of control points and corresponding in the normal DEM of three rivers, while in the corrective Dem with a confidence level of 1% and 5%. There in not significant differences between the height of control points and corresponding points (Table 1 and 2).

Table1: Control points and corresponding points in corrective and normal DEM

Elevation of control points from surveying (Z)m	Elevation of corresponding points in normal DEM(A)m	Elevation of corresponding points in the corrective DEM (B)m	Height difference between control points and corresponding points in the Normal DEM Di=(Z-A)m	Height difference between control points and corresponding points in the corrective DEM Dii=(Z-B)m
Z1	A1	B1	Di 1	Dii1
..	..	..	..	..
Zn	An	Bn	Din	Diin

Table 2: The results of Student's t-test of Razghan, Vasmgh and Seyed Abad River

Statistic Parameters		
Sayed Abad River	Corresponding points in normal DEM	Corresponding points in the corrective DEM
Number of Point	231	231
T test	-17.8	-0.78
Vasmgh River	Corresponding points in normal DEM	Corresponding points in the corrective DEM
Number of Point	232	232
T test	-16.6	-1.9
Razghan River	Corresponding points in normal DEM	Corresponding points in the corrective DEM
Number of Point	133	133
T test	-10.18	-0.5
t domain: Level 1(2.567%) and level 5 (1.96 %)		

To increase accuracy of digital elevation model by adding the number of decimal elevation values (at least three decimal) has a remarkable effect on reducing the errors of flat area (Flat) and Pits (Fig 5 (a, b) and 6 (a, b)).

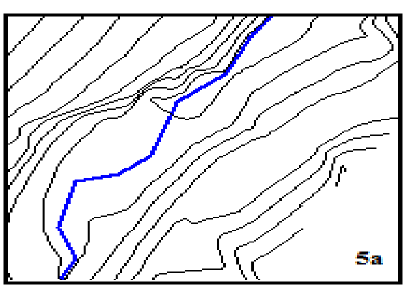

Fig.5a. The flat errors from DEM (accuracy 0.001 decimal)

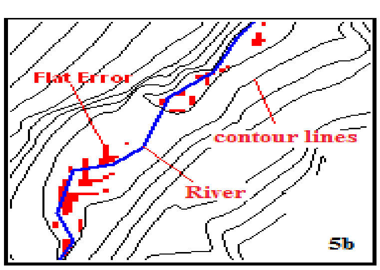

Fig.5b. The flat errors from DEM (accuracy 0.1 decimal)

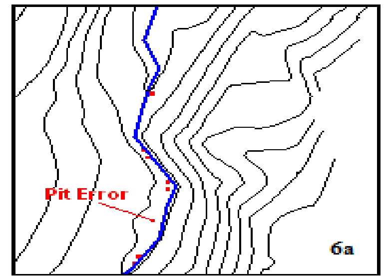

Fig.6a. Pit errors from DEM (accuracy 0.001 decimal)

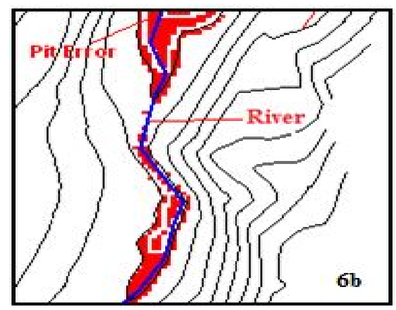

Fig.6b. Pit errors from DEM (accuracy 0.1 decimal)

5. Conclusion

The results of this research indicated that the elevation points, which have obtained from innovative models, are accurate as their own source topographic maps. Moreover, reapplying the elevation points plays an important role for Dem production. Therefore, the others maps have derived from Dem such as slope, slope aspect, vertical slope. Since in most situations, collecting elevation points in field studies is not possible, due to cost and time. Therefore, this model can produce the auxiliary elevation points with much time saved and cost reduced. P value (statistics) comparison based on the student's T-test in the path of the three rivers, Razghan (mountainous area), Vasmgh (Semi-mountainous area), Seyed Abad (Plain area). It can be concluded that the auxiliary elevation points has the greatest impact on flat and low slope areas. The results indicate that due to the lack of height information in low slope area, the Dem has low accuracy in these areas. Therefore, slope, slope aspect, and vertical profile could contain the errors which are typically hidden from the investigator's view.

To consider surface models production such as digital elevation model, sufficient information on topographic maps plays an important role in increasing the accuracy of the models. In the most situations, this is not possible due to limitations of the software. It becomes necessary to develop GIS systems via programming. Applied programs will be able to solve these problems. The COM[2] technology which is the new technologies for construction (production) and development in geographic information systems software. By Arc Objects, it can be possible to develop the existing software or construct (produce) independent GIS software.

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