

# Automatic peaks extraction from Normalized Digital Surface Model (NDSM)

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## ABSTRACT:

Automatically extraction of peaks from 3D Digital models such as Digital Elevation model (DEM), Digital surface model (DSM) and Normalized Digital surface model (NDSM) is as important as image comprehension in Remote Sensing and Photogrammetry. Especially in urban areas, structures are playing a great role and methods have been used for extracting them are very useful for the mapping process of urban programming and Geo-spatial information system. So extraction of peaks from 3D Digital models in order to automatically extraction of objects is an important topic. Considering the importance and usage expansion, this title has been studied in Remote Sensing and Photogrammetry during the last few years. Digital models can be acquired by automatic image matching algorithms applying stereo high-resolution satellite imagery or can be directly captured by airborne laser scanning system. Lately, using Remote Sensing and Photogrammetric methods, we have reached a new horizon and modern methods about extraction of peaks from digital models in order to obtain different goals such as 3D city models ,tele-communication industry, assessment of air pollution in different areas of the city, control analysis, navigation and landscape planning, etc. In this article peaks are automatically extracting from NDSM by means of a morphological surface reconstruction algorithm.

## 1. INTRODUCTION

NDSM is a type of raster GIS layer which represents a regular arrangement of locations and each cell has a value corresponding to its elevation. The peak point in the 3D Digital models is a pixel which have the largest value regard to the value of around pixels. For this purpose, the morphological reconstruction method is used in order to specifying peaks in digital elevation models.

## 2. Preparing DATA include

### DTM, DSM, NDSM

The case study is located near of tehran and in order to generation of digital terrain model (DTM) and digital surface model (DSM), we use digital map in 1:500 ratio scale.

In this map there are two kind of height points, one of them is related to earth topography and another hight points is belong to artificial

elevation features such as buildings .According to this issue, Preparing DTM is based on height points of streets and Preparing DSM is based on sum points of streets and building roofs. Because the NDSM represented the absolute elevation of artificial elevation features regard to the earth, for preparing of NDSM the DTM should be subtracted from DSM.

So we have;

$$NDSM = DSM - DTM \quad (1)$$

Where;

DTM is Digital Terrain Model

DSM is Digital Surface Model

NDSM is Normalized Digital Surface Model calculations of interpolation operations in order to preparing digital models were performed by help of Arcview GIS software that has proper capabilities for these operations.

The method of interpolation to preparing DTM and DSM is based on Inverse distance weighted interpolation.

DTM network,DSM network and NDSM network are shown in figure 1,2,3 respectively.

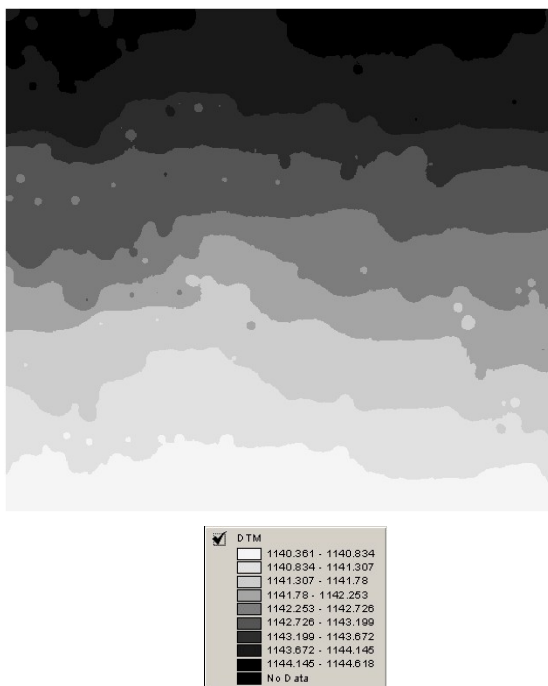


Figure 1. is two dimensional image of DTM network

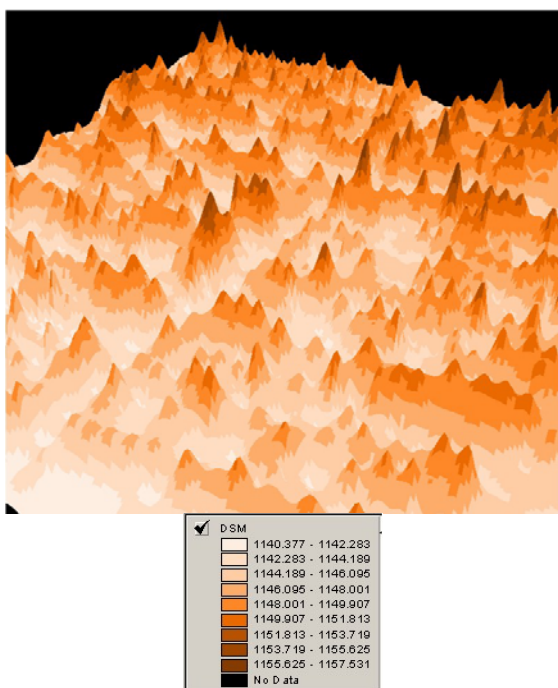


Figure 2. is three dimensional image of DSM network

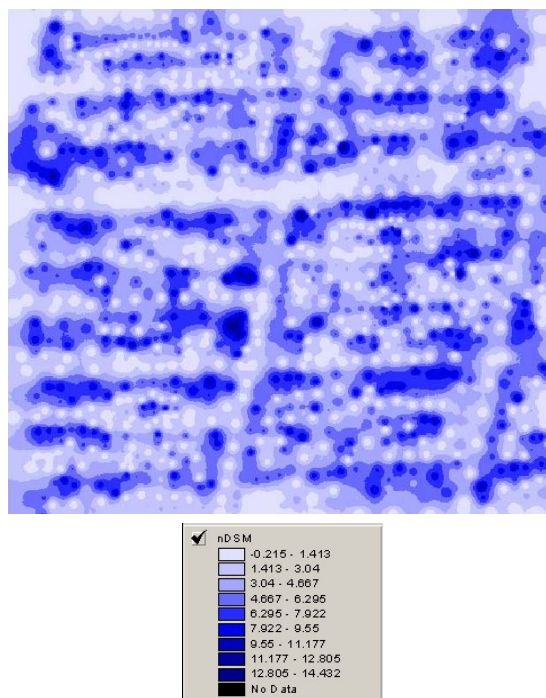


Figure 3. is two dimensional image of NDSM network

### 3. Morphological Reconstruction

Mathematical morphology suggested by Matheron and Serra, first in 1970, this method is used to analyze images and signals and expanded according to series theory.

Also it has developed in digital image processing as image enhancement, edge detection, context analysis and noise removal in images. In addition, it can be useful for extraction of peaks in digital models such as DSM, DTM and NDSM.

One of the efficient operators in mathematical morphology is reconstruction that is based on an algorithm to find peaks in NDSM, so we will explain its conception.

#### 3.1. Surface reconstruction for obtain the demes network

One of the efficient applications of surface reconstruction is providing a demes network. In fact, for performing a reconstruction surface, we need a mask and a marker layer that the marker layer is lower than the mask layer.

In this application, we assume a specified layer such as NDSM as well as a mask layer and then

we generate marker layer with subtract “a constant value = h” from mask layer.  
 now if we do reconstruction operation according to marker layer ,then we will generate the domes network and then the peak points will extracted.this conception is shown in figure 4.

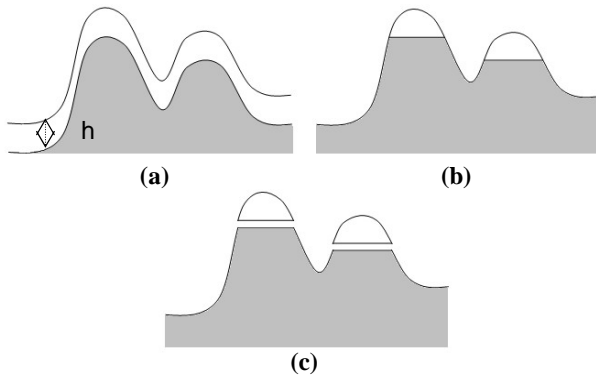


Figure 4. Conception of surface reconstruction

Where ;

a) is shown mask layer ( upper layer) and marker layer ( lower layer).

b) is reconstructed surface as well as j-stability in order to obtain domes network

c) is domes network where;

domes network = mask – reconstructed surface

(j-stability)

also there is no concern about a constant value selection because with increase or decrease of value of it, we achieve more or less peaks.

### 3.2. Peaks extraction Algorithm

The standard algorithm in order to performing reconstruction operation is named parallel reconstruction algorithm.

this algorithm is as bellow :

- Input : mask layer ( such as NDSM)
- Generate the marker layer , where  
 Marker layer = mask layer – a constant value (2)  
 Reconstruction is performed directly on marker layer
- Allocate work image such as k matrix on marker layer

For every pixel in domain of marker layer:

$$k(p) = \max(J(p)) \quad (3)$$

$J(p)$  is refer to community of 8 neighbors with the central pixel in marker layer.

For example if we show neighbors of pixel p as bellow:

$$\begin{matrix} 1 & 2 & 3 \\ 4 & p & 5 \\ 6 & 7 & 8 \end{matrix}$$

We will have:

$$J(p) = \{1,2,3,4,p,5,6,7,8\}$$

- For every pixel in Domain mask layer:  
 - marker layer =  $\min(k(p), \text{mask layer})$  (4)
- Repeat until marker layer reach to stability (In fact no more pixel value in marker layer has been changed):

Thus: this layer is called J stability.

$$J \text{ stability} = \text{reconstructed surface} \quad (5)$$

- Finally;

$$\text{Domes network} = \text{mask layer} - J \text{ stability} \quad (6)$$

## 4. Using model and results

The parallel reconstruction algorithm is performance in programming language of Avenue in Arc view GIS software because it has high capabilities in working with network and raster data. Also the other capabilities of this software are easily extraction of coordinates and obtain height of peaks from NDSM.

All of operations in order to obtain the network of domes is consist of two steps:

- Implementation and performing parallel reconstruction algorithm
- Extraction three dimensional coordinates of peaks

### 4.1. Implementation and performing parallel reconstruction algorithm

As we said, parallel reconstruction algorithm on based mathematical morphology was performed by help of Avenue programming language in Arcview software.

The result of performing this algorithm lead to obtain reconstructed surface ( J-stability) and the domes network which has been generated with subtraction of this layer from mask layer (NDSM). In order to extraction of peak points we should extraction the centers of domes network as well as peak

points. Since the domes network has a raster format, we should convert this raster layer to vector layer and then the centers of each polygon would be extracted as well as peak points. This conception is shown in figure 5.

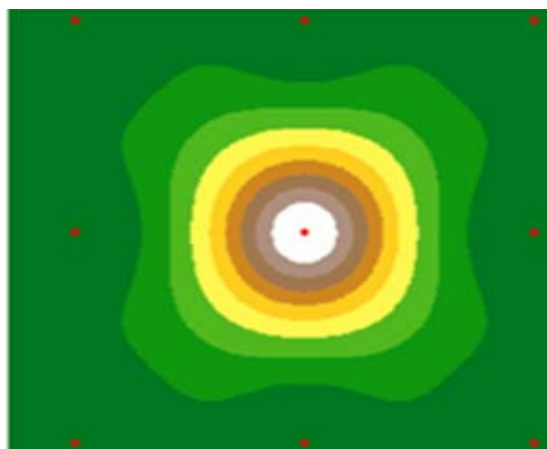
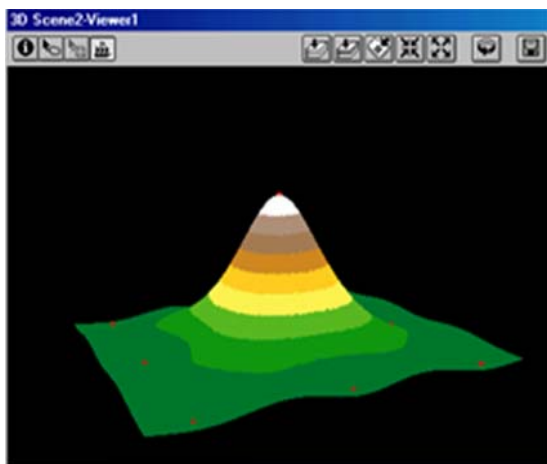


Figure 5. Center of dome is same as a peak point

The result is shown in figure 6 which three dimensional view of domes network is presented and two dimensional view of domes network is shown in figures 7.

Also we can calculate height of these points according to NDSM. for convert raster to vector model and extraction polygons and its centers; we use functions and present tools in Arcview software. The result of extraction peak points in NDSM is shown in figure 8.

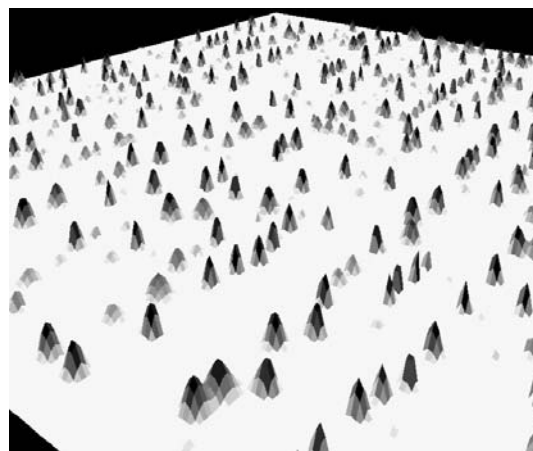


Figure 6. three dimensional view of domes network

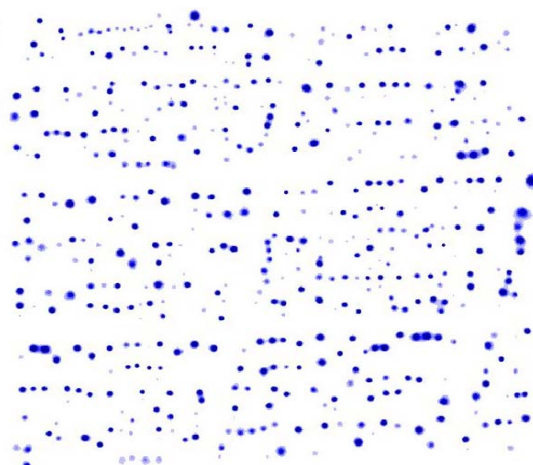


Figure 7. two dimensional view of domes network

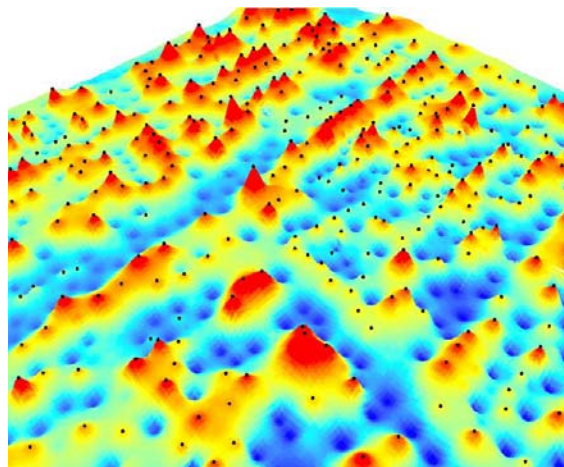


Figure 8. extracted peak points of NDSM

## 5. Conclusions

In generation of marker layer, we assume the amounts of “a constant value = h” in parallel reconstruction algorithm is 0.5m. Selection of



0.5m is according to the variation of elevation (from zero to 15m) in NDSM. With performing this program for various amounts of h we will have small changes in finally result. Infact, if we select large amounts of h, we will lose some peaks of NDSM and if we select small amounts of h we will have answers with high noise (unnecessary peaks). With the extraction of peak points we can use of them in many applications in order to obtain different goals such as providing 3D city models, tele communication industry, control analysis, navigation and landscape planning.

For example after extracting of peak points, we can create a 3D city model in urban regions. For this purpose, the peaks can transformed on satellite imagery such as IKONOS, QUICKBIRD, CARTOSAT, est. and the elevation regions are obtain on satellite images, also the height of these regions is extracted from NDSM and so the 3D city model will be provided. The result in implementation of the proposed method has shown its capability in solving the problem of artificial elevation features extraction.

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