ISSN 2320-5407 International Journal of Advanced Research (2014), Volume 2, Issue 11, 361-367

ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Processing of LiDAR Data using Morphological Filter

Wael M. Sayed
Faculty of Engineering, Cairo University

Manuscript Info

Manuscript History:

Received: 25 September 2014
Final Accepted: 29 October 2014
Published Online: November 2014

Key words:
Building Detection, LIDAR Processing, Digital Terrain Model, Digital Surface Model.

***Corresponding Author**

Wael M. Sayed

Abstract

Light Detection and Ranging (LIDAR) technology has become an effective way to generate digital terrain models (DTMs) and detect buildings with high resolutions for many usages. Scientists have done more efforts every day; to use the data from LIDAR for 3-D mapping and detecting of buildings. Morphological filtering is one of the methods used to filter LIDAR data from noise. In this work, a stepped morphological filtering and its parametric performance in removing unwanted LIDAR measurements are studied. Numerical experiments show that the stepped morphological filter is more effective than the traditional morphological filter.

Introduction

The detection of buildings from remotely sensed data has a number of practical applications such as urban planning, homeland security and disaster (flood or bush-fire) management. Consequently, scientists have worked on a number of automated building detection techniques over the last few decades.

We can divide them into three major groups [5]. At first, there are many algorithms which deal with 2D or 3D information from photogrammetric imagery [3]. At Second, there have been several attempts to detect building regions from LIDAR data. The last, since LIDAR and imagery each have particular advantages and disadvantages in horizontal and vertical positioning resolution and accuracy, several authors have promoted an integration of LIDAR data and imagery.

Detecting of buildings using LIADAR data and using the concept of morphology is the aim of this study. Morphological filter has the ability to extract urban features from LIDAR data for many applications [1]. Till that moment, LIDAR data can only be utilized and processed by highly expensive commercial software, and it is not a simple task. In this study, a progressive morphological filtering code based on Matlab [6] has been developed to remove unwanted LIDAR measurements and a parametric study is conducted to understand the effects of filter parameters. By selecting appropriate parameters, the measurements of unwanted objects were removed, while wanted measurements could be preserved.

1. Data and programming:

The set of data used in this section was downloaded for a school in turn bull, Washington, with 520, 839 measurement points [4]. The area is indicated in Figure (1) From Google Map [2]. MATLAB programming is used in this study to develop for filtering, and for gridding data, and for using the morphological filtering code to remove unwanted LIDAR measurements.

2. Morphological filter:

Simply morphology has been defined as a theory of the analysis of spatial structures, and it provides for an objective, quantitative analysis of the geometric structure within an image. Images based on shapes are processed using morphology operations. A filtering window is applied to an input image, and the same size output images are created. In morphological operations, a comparison of corresponding point in the input image with its neighbors done to get the value of each point in the output image.

Dilation and erosion are the two fundamental morphological operations, that are widely employed to make an extension (erode) in the size of feature. Dilation adds points belong to the object boundaries in image; in contrast erosion removes points that do not belong to it.

The used structure element (window) in the processing determines the numbers of points added or removed from the objects. The structure element is defined as a set of coordinate points that determine the precise effect of the operation.

Equation (1) & (2) shows the defining of the dilation and erosion, respectively

$A \oplus B = \{z / B_z \cap A \neq \emptyset\}$ . . . . (1),

$A.B = \{z / B_z \subseteq A\}$ . . . . *(2).*

Which B_z *is the translation of B by the vector Z namely.*

$B = \{b + z / b \in B\}$, $\forall \in E$

When B which is the structure element has a centre, and the center locate on the origin of E, then the erosion of A by B is the locus of points reached by the center of b when it moves inside A. dilation is the opposite of what had written.

To know the state of any given point in the output image, a specified rule is applied to the corresponding point, and its neighbors in the input image. Erosion was used to determine the minimum elevation values, and dilation to obtain maximum elevation values at any set of LIDAR measurements p(x, y, and z)

$d_p = \max_{x,y \in \omega}(z_p)$

$d_p = \min_{x,y \in \omega}(z_p)$ ……………………………………. (3)

In general, the combined function of erosion and dilation are used to implement the operations of image processing.

As given below in figure 2, first implementing erosion has done then dilation of the dataset for the morphological opening, at the used same widow size in both two. For the closing morphological is the reverse.

In the past, there were two ways available to increase the window size.

One is to increase window size linearly as shown in equation (4):

$w_k = 2*k*b + 1$ …………. (4)

The other way is to increase window size exponentially as shown in equation (5):

$w_k = 2* b^k + 1$ …… (5)

In eq. (4) and eq. (5), b is the base value and k donates the number of iterations with k=1, 2 … and so on.

In this study anew way to increase window size is used as shown in equation (6):

$W_k = b*k^2/2$ …… (6)

In this way the window size change in between of the tow ways before, then we can detect non buildings to remove. Beside the window size, other parameters should be set in consideration in order to implement the algorithm i.e. the initial elevation difference threshold, the maximum elevation difference and the terrain slope.

3. Filtering Data:

Researchers have proved that filtering due to the ground is effective and critical to remove non-building objects [7], [10]. In this research the first and the last return are used to limit points from ground and non ground filtering algorithm on the gridded LIDAR data.

Gridded data:

The raw LIDAR data of the first and last returns are irregularly distributed point clouds, so the cell size is limited to the average point density of the raw LIDAR data. The principle of setting the cell size is to map as many points of set V remain as possible as we can in to the grids in the given data. To get the regularly distributed data we get the cell, size from the given data and the points in the area studied as follow: $C = \sqrt{A / N}$ (7), which A denotes for the total processed area, and N denotes for the total number of points.

4. Results and analysis:

Fig.1.Google map aerial photo of Cheney High school where the LIDAR data was taken (Not in the same time period).

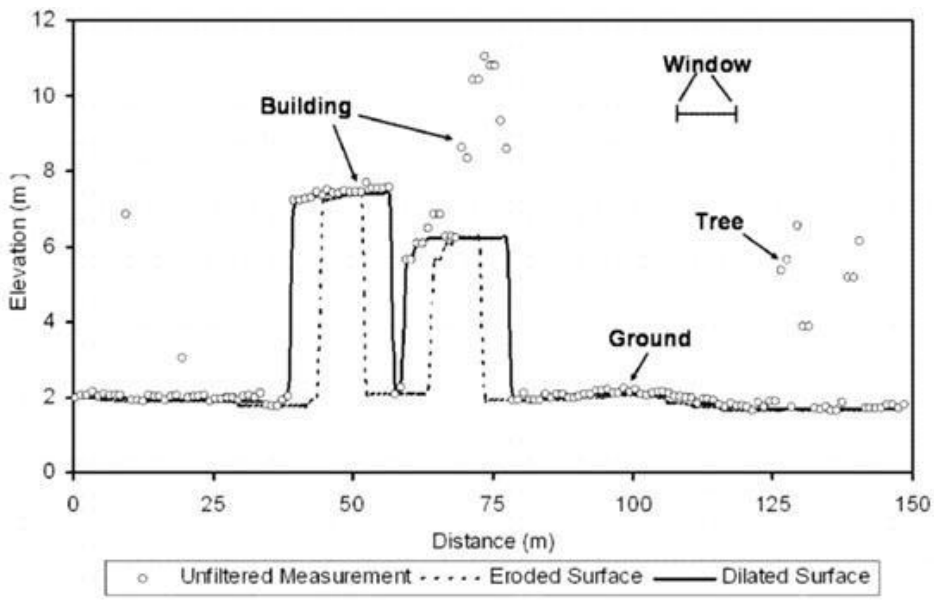

Fig.2. Illustration of opening operation of morphological filtering.

The way with introduce to change window size change it gradually and smoothly, as for each step and new window size we used an opening morphological filter that if first erode things and then dilate.
In this test, the window size is set to increase linearly based on eq. (6). This is because the difference between two successive iterations is smaller than the others, which will be easier for manipulation and comparison, and the base value b is set to be (b=2) and no. of iterations is set to be (k=4).
As shown in table (1), the change for each way. The small change in window size enables to detect non building objects and remove without change in building size.

Table.1.Change in window size

K / way	1	2	3	4
(4)	5	9	13	17
(5)	5	9	17	33
(6)	1	4	9	16

From Fig. 3(a) to Fig. 3(d), a distinct effect of the opening morphological filter was demonstrated. It could be seen in 4(a) that all the unwanted objects for (k=1) and a small window size appear to remove high elevation objects with small area.
However, a few wanted parts (building segment)were filtered (such as the small parts on the top of building) in Fig. 3(d); because of those parts' width may similar to the unwanted objects.
By Visually comparing below illustrate the difference betwwen the unfiltered and filtered data, this method was used to verify that unwanted features such as trees were eliminated entirely and wanted features were remained. Then, the quantitative method were used to examine the correctness of the filtered measurements at the point level from a random sample. The raw data and filtered measurements would be used to help identifying filtering errors. The unfiltered and filtered data are shown in fig.(4)& fig.(5) for illustration. The results are produced from LIDAR data direct mapping without any distortion [9].

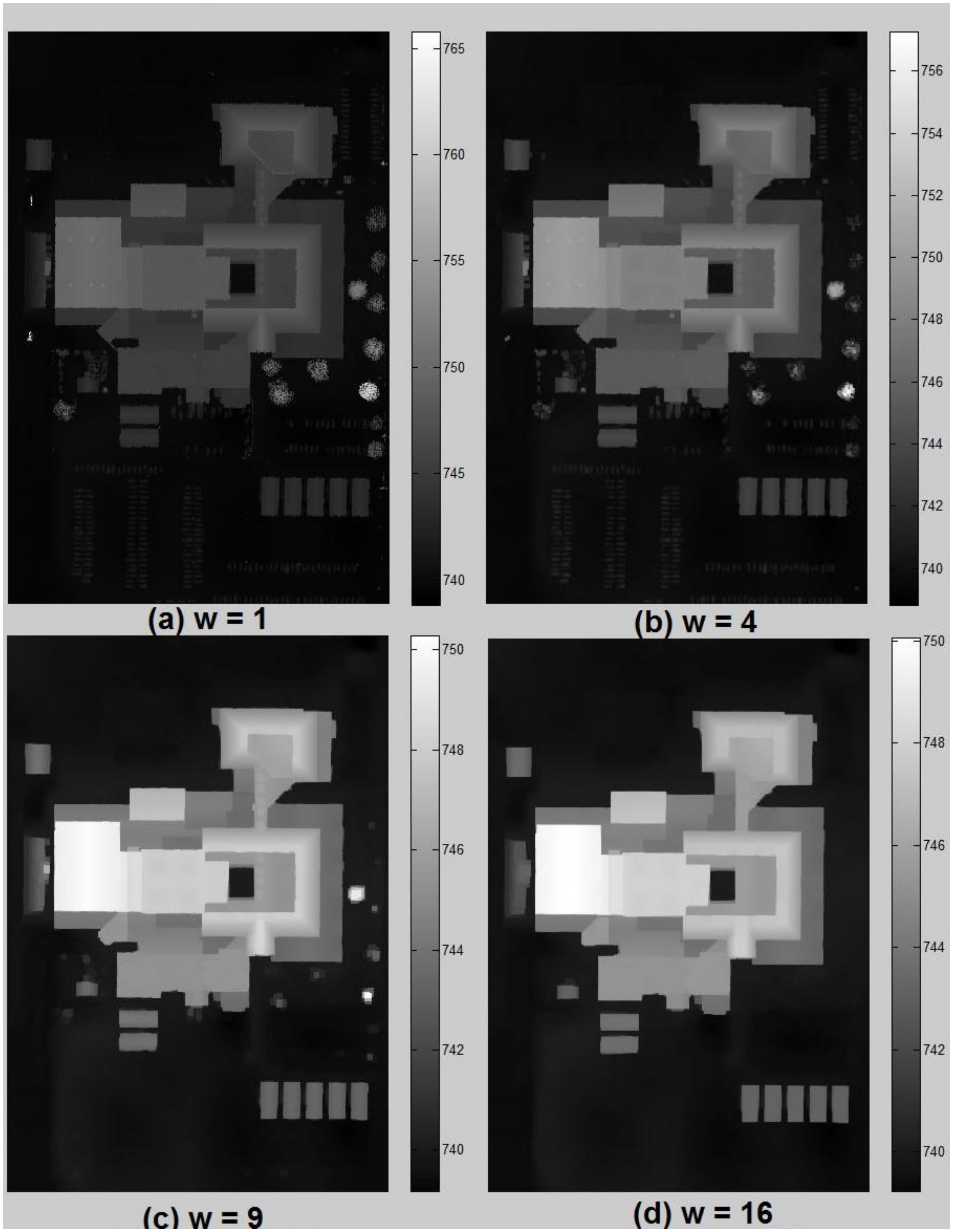

Fig.3. results of opening morphological filter (k=1, 2, 3, 4)

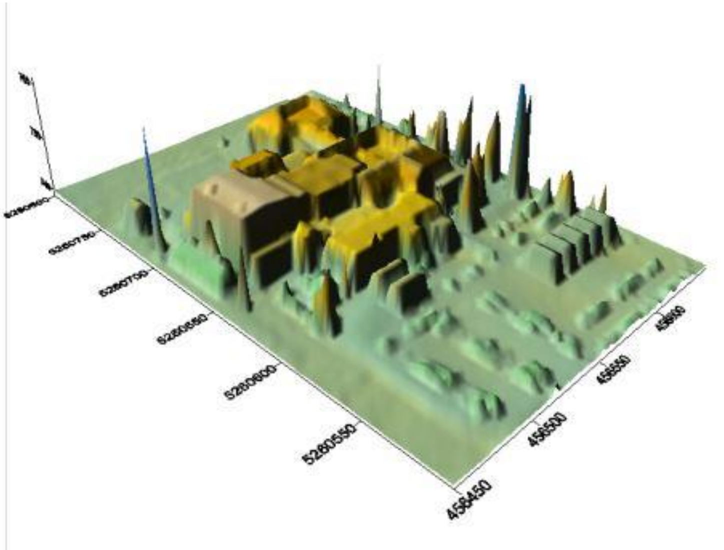

Fig.4. Raw LiDAR Data

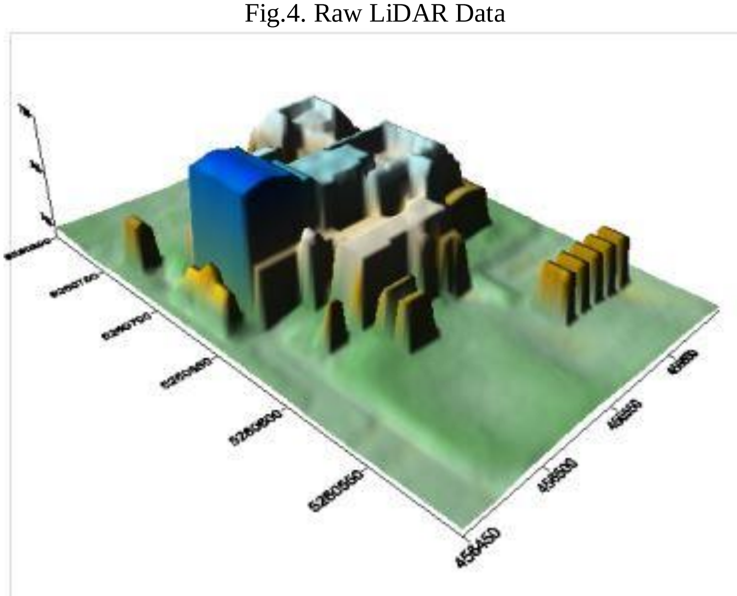

Fig.5. Filtered Data.

5. Conclusion:

The need for generating high resolution DTM, LIDAR measurements from unwanted objects was separated and removed. In this report, unwanted objects were separated and removed. The pre-processing was introduced first to sample those irregular spacing raw data. Three interpolation methods were included; in order to filter this raw data and gridded it in to regularly spaced points. After that, morphological filter was built to remove unwanted LIDAR measurements using the new way of window size. In order to perform the success of filtering method, selections of the filtering parameters did a great impact on the removal of unwanted objects. Appropriate parameters could be found based on analyzing wanted and unwanted measurements in the study area. The filtering process was automated and requires little human interference, which was desirable when processing voluminous LIDAR measurements.

6. References:

1. G. Prisetnall. J. Jaafar, and A. Duncan, “Extracting urban features from LIDAR digital surface models,” Computers, Environment and Urban Systems, vol. 24, no. 2, pp. 65-78, March 2000.
2. Google Map. [Online] AvailableHuang, X., L. Zhang , and W. Gong, 2011. Information fusion of aerial images and LIDAR data in urban areas: vector stacking, re-classification, and post-processing approaches, International Journal of Remote Sensing, 32 (1): 69–84.
3. LIDAR data for TurnBull county.[online] available:
4. Lee, D., Lee, K., Lee, S., 2008. Fusion of LIDAR and imagery for reliable building extraction.
5. Math Works - MATLAB and Simulink for Technical Computing. [Online] Available:
6. Morgan, M., & Tempfli, K., 2000. Automatic building extraction from airborne laser scanning data, In Proc. 19th ISPRS Congr., Amsterdam-The Netherlands, book 3B, pp. 616-623.
7. Photogrammetric Engineering & Remote Sensing 74 (2), 215_226.
8. X. Wang, K. J. Zhou, J. Yang, and Y. L. Lu, “MATLAB tools for LIDAR data conversion, visualization, and processing,” Proc. SPIE, vol. 8286, pp. 82860M1-8, October 2011.
9. Zhang, K., Yan, J., & Chen, S., 2006. Automatic construction of building footprints from airborne LIDAR data, IEEE Transactions on Geoscience and Remote Sensing, 44 (9): 2523-2533.