Jurnal Teknologi

Full Paper

DEMONSTRATION OF WATERSHED SEGMENTATION ON SIMULATED SURFACE TOPOGRAPHY DATA

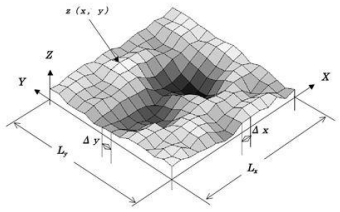
Mohd Fauzi Ismail[a,c*], Nor Hidayawati Mohd Zaini[b], Talib Ria Jaafar[a,c], Nuraini Che Pin[b]

[a]Fakulti Kejuruteraan Mekanikal, Universiti Teknologi MARA, Malaysia
[b]Institute of Graduate Studies, Universiti Teknologi MARA, Malaysia
[c]Automative Research and Testing Center, Universiti Teknologi MARA (Pulau Pinang), Malaysia

Article history
Received
15 February 2015
Received in revised form
30 April 2015
Accepted
31 May 2015

*Corresponding author
mohdfauzi305@ppinang.uitm.edu.my

Graphical abstract



Abstract

Surface texture comprises of many features of interest, which may or may not be essential for surface functional requirements. Features on the surface topography data refers to the peak, pit and the relationship between them; instead of the point on the valleys only. Hence, the objective of this paper is to demonstrate the watershed segmentation on the simulated surface topography data. Watershed segmentation is applied on the selected areal surface texture to determine the regions of the features of the hill and dales. The segmentation of the features is developed by using MATLAB. The developed application is then validated with the simulated topography data. The application's result on the simulated data shows that, the watershed segmentation method works as intended.

Keywords: Surface texture, surface topography, watershed segmentation, hill and dales segmentation

1.0 INTRODUCTION

Surface is a physical boundary between the work piece and the surrounding environment. Surfaces on engineering parts such as precision ball screws, gears, bearings and consumer goods are generated from the machining process. It is important to study those surfaces as they have significant effects on the performance of the component and related products that were mentioned earlier. The geometrical characteristics of any surface refer to the surface texture or surface topography. It consists of a series of peaks and valleys which have a characteristic shape, size and spacing [1].

Surface texture comprises of many features of interest which may or may not be essential for surface functional requirements. Features on the surface topography data refers to the peak, pit and the relationship between them instead of the point on the valleys only. According to the ISO 25178-2, a new parameter named "feature parameter" has been introduced. Feature parameter is defined as a parameter that is calculated on selected topographic features like points, lines or areas which was extracted by watershed segmentation on the surface.

Through the years, the characterization and assessment of surface topographies are demanded to be more detailed and comprehensive, especially with the existence of high-precision and functional performance requirements. Feature parameters calculated after a robust segmentation, are designed for the characterization of such modern surfaces. It can be seen as the elements for

engineers and metrologists that make it possible to define new specification methods and to get a better correlation between parameter values, and the functional requirements [2]. Hence, the objective of this paper is to demonstrate the watershed segmentation on the simulated surface topography data.

1.1 Watershed Segmentation Procedure for Areal Topography Data

All surfaces have some features which may or may not be important for a given technical function. In order to differentiate both the functional and the disfunctional related features automatically, segmentation methods are used. According to ISO 25178-2:2012 and ISO 166610-85:2013, segmentation is defined as a method, which divided a surface into mutually exclusive areas spatially.

In this work, the approach for the assessment on the feature parameter will be on signal data processing only, instead of image processing for the simulated data from the machining tools. Furthermore, the development of the feature extraction will use the areal surface as reference. The reason behind it is because, its capability of diagnosing the functional performance of the surface compare to the profile surface texture. The priority of this study is to characterize hill and dale based on watershed segmentation. Hence, sinusoidal surface is chosen to be analyze later.

1.2 Data Structure

The data structure is a dataset containing of sine wave areal surface data which include two wavelengths; long and short wavelength. The data structure consists of a rectangular matrix of height values (z values) arranged along the rows and columns of a regular x, y grid with constant Δx and Δy. Figure 1 below show the simulated data structure. A three dimensional Cartesian coordinate system, with origin O and axis lines namely X, Y and Z, oriented as shown by the arrows.

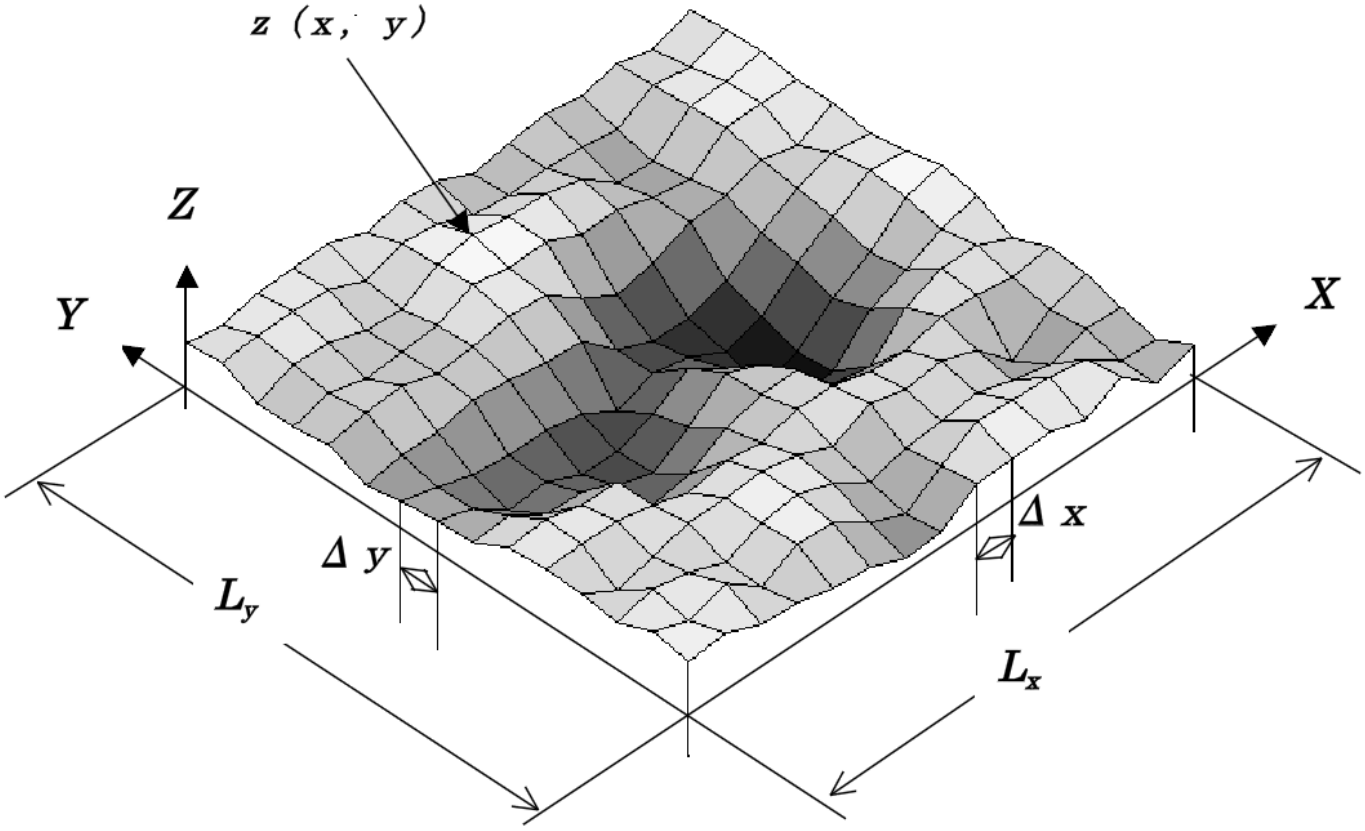


Figure 1 Simulated data structure of the surface texture

1.3 Watershed Segmentation

In this section, watershed segmentation procedures applied are explained. The scope of this method is limited to the areal discrete surface topography data of a limited surface. The data have been sampled in a Cartesian coordinate system with consistent sampling. Figure 2 shows the flow chart of the watershed segmentation process according to the pattern recognition technique by P.J Scott [3]. The main step for watershed segmentation is, to select the type of the texture feature for analysis purposes. Then, areal feature, which consist of hill and dales are chosen in this work. Next, watershed segmentation is applied on the feature to segment the region of the features.

The segmentation method proposes the possibility of fast automatic metrology methods. This method can be developed to most features on a scale-limited surfaces. The idea of the segmentation is to isolate relevant features and discard smaller or less relevant features. Segmentation processes are important for remodeling the areal topography data in terms of features. It is also crucial for further analysis for manufactured pattern and for process functionality.

Watershed analysis over a surface topography in terms of hills and dales, actually originates from the work by Maxwell on geographical analysis [4], and has been extensively applied to the characterization of geographical digital elevation data [5,6] and also has been used on digital images. It is an established and well-known technique for image segmentation [7, 8]. Presently, this technique has been introduced in the field of surface topography segmentation and can be seen in ISO 25178.

Watershed based surface segmentation divides the surface topography into regions classified as the hills (areas from which maximum uphill paths lead to one particular peak) or dales (areas from which maximum downhill paths lead to one particular pit) and the boundaries between the hills is called watercourse lines and the boundaries between dales is called watershed lines. Watershed-based segmentation is the most established and successful method available for segmenting surface texture and it is included in ISO standard for areal surface texture characterization.

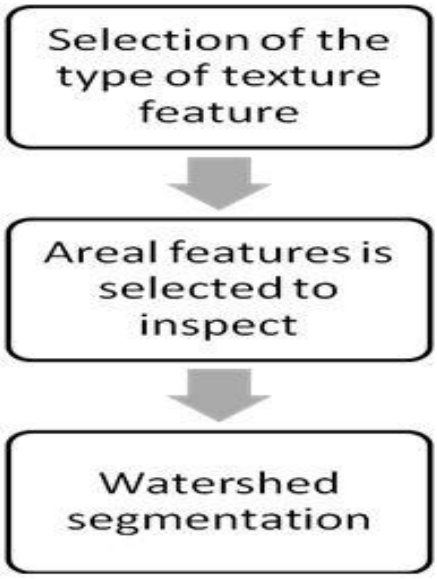


Figure 2 Watershed segmentation process

2.0 RESULTS AND DISCUSSION

Figures 3 shows the results of the watershed segmentation method on the surface texture topography data. The data is in the sine wave surface topography data. For Figure 3 (a) show the original figure before it went for watershed segmentation. The view of x and y grid is from the Cartesian coordinate system. There are 3 main colors used as indicator for the region of the hills and dales before segmentation. The red and yellowish colors represent the hill region while the blue is dale region. For figure 3 (b) and (c) is the areal surface topography after the segmentation. The line between the colors of the region is the line boundaries which separate the feature to their next neighbor which later can be analyzed to determine the parameter required for every feature required.

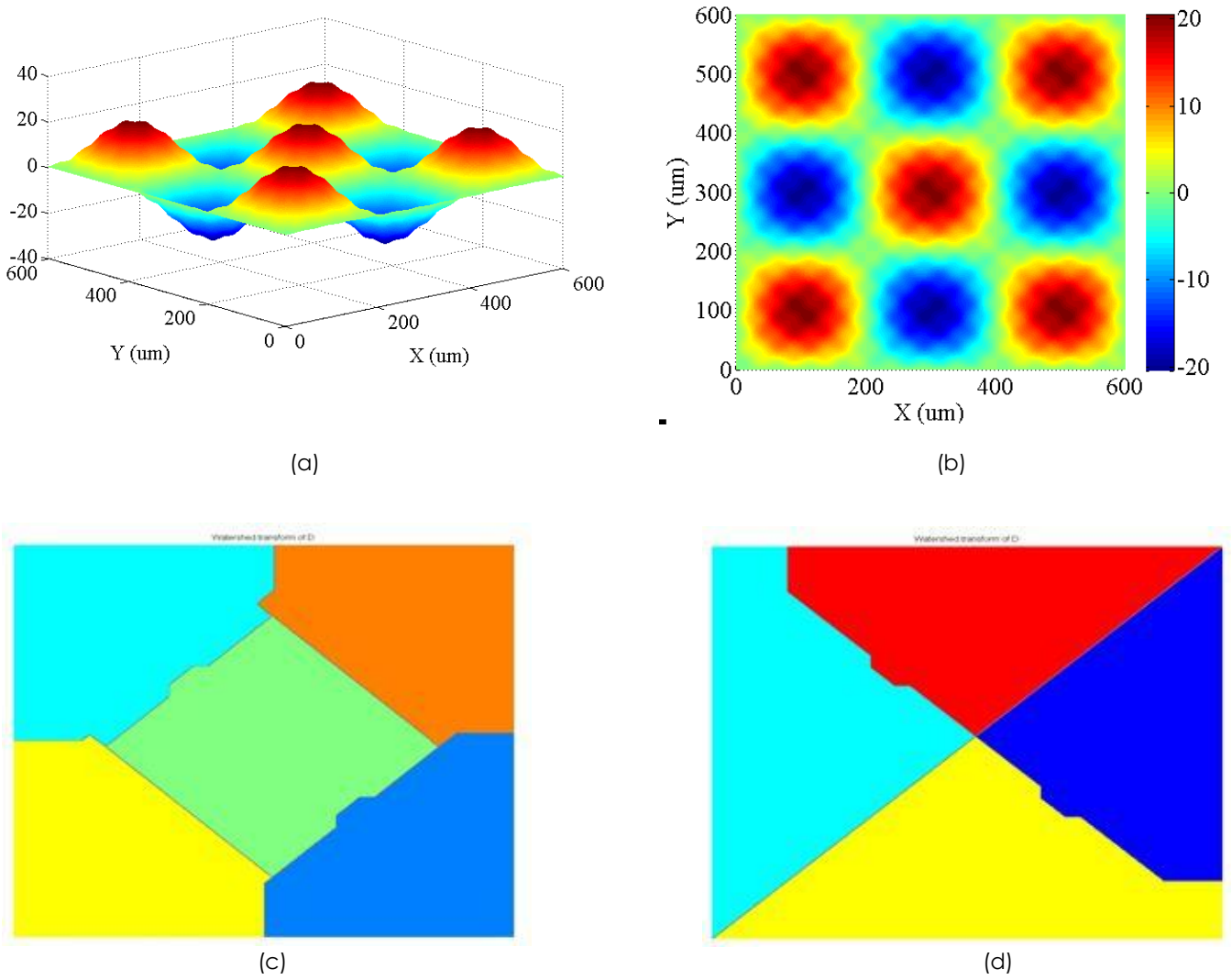


Figure 3 Watershed segmentation method on the surface texture topography data (a) isometric view and (b) top view; original figure before undergo watershed segmentation; after undergo watershed segmentation (c) Hill segmentation; (d) Dale segmentation

3.0 CONCLUSION

In this paper, hill and dales segmentation as defined in ISO 25178-2 has been demonstrated. The results show that, the watershed segmentation algorithm is possible to be used to segment the region of the interested feature on the scale limited surface. However, the most significant challenge for the future task is to determine which feature's parameter and oversegmentation that may overshadow the significant features wanted. A mechanism is required to resolve this problem, so that necessary information can be retained for further improvement in the signal processing data.

References

[1] Liam Blun, 2003. Introduction: The History and Current State of 3D Surface Characterisation. *Advanced Techniques for Assessment Surface Topography. 1-13.*

[2] Blanc J., Grime D. and Blateyron F. 2011. Surface Characterization Based Upon Significant Topographic Features. *Journal of Physics: Conference Series*. 311(1).

[3] Paul J. Scott Taylor. 2009. Feature Parameter. *Wear.* 266(5-6): 548-551.

[4] Bleau, L. J. Leon. 2000. Watershed-Based Segmentation And Region Merging, *Computer Vision Image Understanding*. 77 (2000): 317–370.

[5] Kweon, I. S. and Kanade, T. 1994. Extracting Topographic Terrain Features From Elevation Maps. *CVGIP: Image Understanding. 59 (2): 171– 182.*

[6] Takahashi S., et al.1995. Algorithms For Extracting Correct Critical Points And Constructing Topological Graphs From Discrete Geographical Elevation Data. *Comp. Graphics Forum 14 (3): C181–C192.*

[7] Senin N., Ziliotti M. and Groppetti R. 2007. Three-Dimensional Surface Topography Segmentation Through Clustering. *Wear.* 262: 395–410.