# AUTOMATED EXTRACTION OF BUILDING GEOMETRIC FEATURES FROM RAW LIDAR DATA

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## 1. INTRODUCTION

Nowadays LiDAR (Light Detection And Ranging) sensors and data has been widely used from the domain of research and development into the general marketplace primarily as a means of rapidly generating dense, accurate, digital models of the topography and vertical structure of a target surface. LiDAR sensors are usually employed for mass production of high accuracy digital elevation models (DEMs), digital terrain models (DTMs) and triangulated irregular networks (TINs). LiDAR elevation data is ideally suited for mapping extensive areas where very high accuracy elevation data is required rapidly, especially in urban regions [1][2].

3D Building information is extremely important for many applications such as urban planning, car navigation, or environment monitoring etc. In this paper, we define an efficient geometric feature descriptor based on the theory of discrete differential geometry and present an automatic approach for extracting building geometric features from airborne LIDAR data.

## 2. METHODOLOGY

The proposed approach for extracting building geometric features consists of three processes: generating Digital Surface Model (DSM), describing geometric features (as illuminated in Figure 1), and extracting building features (as illuminated in Figure 2).

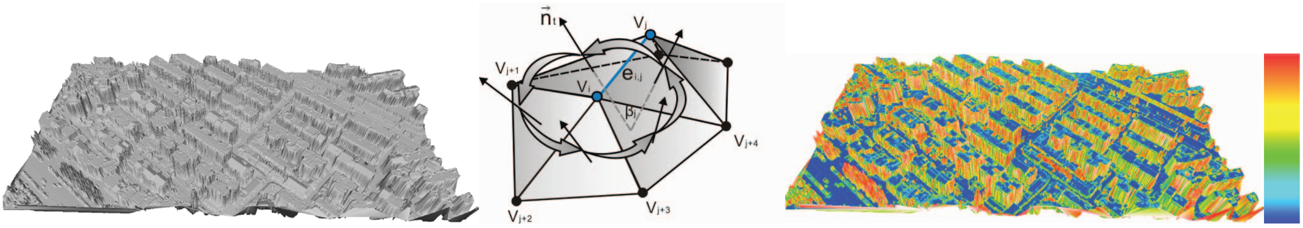
1) Firstly, as shown in Figure 1(a), DSM is generated from raw LIDAR data. This processing step generates a TIN surface of high quality based on the raw LIDAR point clouds. During the triangulation, a 2D-Delaunay Triangulation is applied, which is a common procedure to approximate a real surface that is irregularly sampled by points.

2) Multi-spectral imagery may be useful to distinguish feature vertices from zero-feature vertices according to their difference in gray gradient. However, in this paper, based on the theory of discrete differential geometry [3][4], we define an efficient geometric feature descriptor, to separate vertices according to their geometric shape characteristics because ridges, valleys and flat planes have significantly difference in their geometric shapes. Differential geometry is geometry done using differential calculus, in other words, shape description through derivatives. We use the underlying equation as the geometric feature descriptor of vertices to indicate whether they are feature vertices or zero-feature vertices.

$$F(v_i) = \beta_{\max} \, \| e_{i,\max} \| \tag{1}$$

where $n$ is the number of adjacent triangles of $v_i$, $\beta_{\max}$ is the max dihedral angle between each two triangles that adjacent to vertex $v_i$, and $\| e_{i,\max} \|$ is the corresponding length of edge $e_{i,\max}$ (as illuminated in Figure 1(b)). This means that the vertex, which has bigger dihedral angle between adjacent triangles and longer distance from adjacent vertices, is to be regarded as a salient feature point.

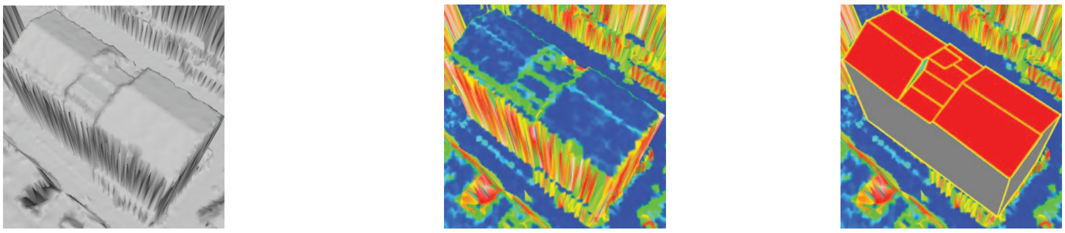
Let the geometric feature map $F$ (as illuminated in Figure 1(c)) define a mapping from each vertex of a DSM (Figure 2(a)) to its geometric feature, i.e. let $F(v_i)$ denote the feature of vertex $v_i$ .Figure 2(b) shows the result of detection of geometric features, such as ridge, valley and boundary features using the geometric feature descriptor. We use pseudo-colors to show the geometric features according to the value of geometric feature descriptor: warmer colors (reds and yellows) show salient features, cooler colors (greens) show general features, and blues show zero-feature. Then we link the feature points to generate closed contour lines on building surface. In next procedure, we guide region growing segmentation by using this normalized feature map $F$ .




(a) (b) (c)

Fig. 1. (a) DSM from raw LiDAR point clouds. (b) calculation of geometric feature descriptor. (c) pseudo-colors showing the features according to the geometric feature descriptor: warmer colors (reds and yellows) show salient features, cooler colors (greens) show general features, and blues show zero-feature.

3) This processing step can be summarized as a region growing segmentation algorithm that uses random seeds, geometric constraint (e.g. in this paper, closed contour lines) and growing criteria (according to the value of geometric feature descriptor). The processing of region growing generates the roof segmentations and wall planes, which consist of points with the same classified features, in the scope of closed contour lines. As shown in Figure 2(c), the experiment shows a very promising result with a good performance in terms of rapid running time.



(a) (b) (c)

Fig. 3. Detecting and extracting geometric features. (a) original DSM. (b) pseudo-colors showing its feature distribution.(c) results of region growing segmentation.

## 3. CONCLUSION

In this paper, we have presented a method to extract building geometric features from raw LiDAR point clouds automatically. Experiments were performed with raw LiDAR data from the city of Shashi and we demonstrated good results with respect to human perception. Further studies will be conducted in quantitative evaluation and a comparison with existing methods. 3D building reconstruction and fusion with high-resolution orthograph images will also be explored in our future work.

## 4. REFERENCES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