Preprocessing Algorithms for Filtering Airborne LiDAR Data

Xian-quan HAN1,*, Hui ZHANG1, Yu JIANG2 and Fang-fang ZHOU1

1Changjiang River Scientific Research Institute, Wuhan, 430010, China
2Tianjin Institute of Geotechnical Investigation Surveying, Tianjin, 300191, China

*Corresponding author

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Abstract. Filter of airborne LiDAR data is a primary step of data processing. This paper reviews the literatures of filter algorithms from aspects of theory and performance. The moving plane fitting algorithm is introduced and improved especially. In addition, the Experiments show the method is effective and lays a foundation for the subsequent regularization of complex building boundaries.

Introduction

The airborne LiDAR (Light Detection and Ranging) is a kind of new promising technique in obtaining instantly 3D accurate information of the earth surface and objects. Airborne LiDAR point cloud data include not only the points of buildings, but also the points of trees, cars and other information [1]. The calculation of Digital Elevation Model (DEM) is the process to eliminate these non ground points, which is often called "filtering". Filter of airborne LiDAR data is a primary step of data processing. How to separate the ground points from the airborne LiDAR data is the main content of LiDAR filtering algorithms [2].

Analysis and Improvement of Filtering Algorithms

Many scholars have been working on the filter of airborne LiDAR data. Currently, five approaches have been widely utilized to obtain the ground information [3-5]:

(1) Linear Interpolation Algorithm

It is a classic algorithm with widely used at present. The core idea is to filter and insert encrypted DEM from the alternate data points through a starting DEM to achieve the purpose of classification [1]. A number of studies have been carried out by some scholars, and the algorithm has been extended with the combination of the concept of the Hierarchical Pyramid in image processing. In the interpolation process, refinement of DEM is achieved by continuously shortening the interpolated pitch. The algorithm has been implemented in some commercial software packages (SCOP++), which is more suitable for extracting DTM in forest areas. However, there are still some problems in the extraction accuracy of DTM in areas with relatively steep terrain changes.

(2) The Encryption Filtering Algorithm Based on TIN models

It is a gradual encryption process of TIN models. The basic principle of the algorithm is that the lowest point in the local area must be the ground point. The angle and distance are used as the threshold parameters in iterative operation through the calculating TIN models with the ground points. But the algorithm needs to adjust the threshold parameters frequently, and it is easy to cause the loss of terrain details [6].

(3) Mathematical Morphology Method

It is an image filtering algorithm in fact, which apply the idea of mathematical morphology to LiDAR data processing. There are two basic operations: open operation and close operation. The window size of these two operations need to be adjust frequently in the iteration implementation. In the reference[7], a filtering method based on mathematical morphology is proposed. It not only needs fewer parameters, but also has better filtering effect than the 8 typical filtering algorithms provided by ISPRS.
(4) Gradient Method
The gradient filtering algorithm is improved on the method of mathematical morphology. The information of elevation, distance and gradient between adjacent points are the primary parameters. But the setting of threshold is difficult and the adaptability is poor[8].

(5) Moving Plane Fitting Method
As well known, the moving curved surface fitting algorithm is proposed by Liu Jingnan and Zhang Xiaohong[9], the main idea is the region growing algorithm. Because the rigidity of plane surface, the bad classification results do not occur often. In this paper, the classical algorithm is extended, which the curved surface is instead of moving plane surface. The overall flowchart is demonstrated in Fig 1. In the massive unstructured point clouds, the proposed algorithm can eliminate the gross error without resampling.

Figure 1. The flowchart of Moving Plane Fitting Method.
Experiment and Analysis

The experiment data used in this paper are the airborne LIDAR data with 500000 point clouds as shown in Figure 2. Based on the primary methods described above, the Linear Interpolation Algorithm, the TIN Filtering Algorithm, the Gradient Method, the Moving Plane Fitting Method are sequentially applied to filter the point cloud data in test. The results illustrated in the Figure 3~Figure 6.

It can be seen that, the better classification results from different filter methods can be get in the flat area with some trees or buildings. However, if there are large forests in the test area, whose terrain is relatively large, the above algorithms have great limitations. On the other hand, from the calculation efficiency of processing, the method of the Moving Plane Fitting Method takes about 10 seconds, while the other algorithms are basically more than 3 minutes.
At the same time, the improved method of Moving Planar Fitting filter algorithm is used to test the standard LIDAR data provided by IRPRS. There are 486800 scattered points in the LIDAR point cloud data, as shown in Figure 7. According to the experimental results, for the urban areas, whose terrain is relatively small, the better separation results between ground and non-ground points can be obtained.

Conclusion
The filtering of airborne LIDAR data is the basis of segmentation of complex building boundaries. In this paper, several LIDAR filtering classification algorithms are discussed and compared, and the moving plane surface method is analyzed and improved. Experiments show that our extended algorithm is effective and lays a foundation for the subsequent regularization of complex building boundaries.

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