DEVELOPMENT OF THE MICROSTATION-BASED LIDAR DATA PROCESSING SOFTWARE

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ABSTRACT:

LIDAR data filtering and classification are the most important steps of the LIDAR data processing, which requires efficient data processing software. This paper introduces a new LIDAR data processing software named TopLidar. TopLidar was developed to be used on MicroStation. It makes full use of the excellent secondary development capability and efficient large amount of data management, interactive editing and dynamic 3D display of MicroStation system. In data classification, the software provides extended mathematical morphology algorithm and robust estimation algorithm and has some adaptive capability. Our testing shows that the software could be efficiently used in different terrain condition.

1. INTRODUCTION OF AIRBORNE LIDAR DATA PROCESSING

In the past 20 years, the airborne LIDAR has been extensively used as a tool for accurate and fast acquisition of ground 3D data. An airborne LIDAR system is consisted of High-Precision Position & Orientation System (POS), laser scanner, digital camera and center control unit. The POS is a key component of airborne laser detecting and measuring system. It uses Dynamic Difference Global Positioning System (DGPS) technology and Inertial Measurement Unit (IMU) to determine the position and attitude of sensor in the aerial flight. Laser Scanner is core of the LIDAR and usually consists of laser transmitter, receiver, time interval measurement device, gearing device, and a micro-processor. Digital camera is used to receive the image information of an object. The center control controls and coordinates the other hardware to ensure high levels of synchronization of all instruments (Ackerman F, 1999).

The data processing of Airborne LIDAR generally includes several steps as follow (Xiaohong Zhang, 2007):

a) Determine flight track by joint analysis of the differences of data from the ground GPS reference station and the airborne GPS data.

b) Calculate the 3D space coordinates of laser points. The software provided by equipment maker processes the GPS flight track data, airplane attitude data, ranging data measured by laser and swing angle data of laser scanning mirror and then gained 3D coordinates (X, Y, Z) data of objects called Point Cloud.

c) Filter and classify point cloud. Because of various reasons, there are some noises in the point cloud, and they must be removed by filtering. At present, most Airborne LIDAR data filtering methods are based on the height break of pin point, such as morphological filtering method (Lindenberger J, 1993), mobile windows method (Petzold B, 1999), iterative linear least squares interpolation method (Pfeifer N, 1999) and terrain slope based filtering (Vosselman G, 2000). The aim of filtering and classification is to improve the accuracy and applicability of point cloud as well as accurately distinguish information of other objects.

d) Point cloud switching: For data collection of a large area, airplane must fly multiple routes due to the limit of flight height and scanning field angle. A certain degree of overlap must be maintained and the system error should be removed as much as possible.

e) Coordinates transmission: The coordinates should be transmitted according to user's requirement.

f) Generate the digital elevation models (DEMs) and digital terrain models (DTMs) from the ground points gained after classification.

Orienteering and mosaic image data: The high-resolution images gained from digital camera are processed by aerial triangulation measurement method with internal and external orientation elements. Then the data is oriented and mosaic with the DTM data based LIDAR and form digital orthophoto maps (DOM).

2. CURRENT STATUS OF AIRBORNE LIDAR APPLICATION AND ITS DATA PROCESSING SOFTWARES

Along with technology development, LIDAR have been broadly applied. The low-altitude airborne system for shallow sea terrain measurement has been developed by the United States, Canada, Australia and Sweden. It uses airborne ranging equipment, globe positioning system and gyro stabilized platform. Its flight height is 500 to 600 m. By ranging and positioning, it finally gains the shallow sea terrain (or DEM). The United States NASA has sent Shuttle Laser Altimeter (SLA)-based space shuttle twice in 1994 and 1997 which aimed to establish database of global control points based on SLA. Then NASA proposed Geoscience Laser Altimeter System (GLAS) plan, and has launched the Cloud and Land Elevation Satellite (CESAT). The satellite has laser ranging system, GPS receiver and star tracking attitude determination system. The next step of

NASA is that the precision of laser ranging will reach dm-level or even cm-level.

LIDAR has gained equally widely attention in China. Presently, several companies have bought commercial LIDAR equipments from different foreign vendors, and have acquired a mass of original point cloud and image data. The technology has been imported in power line selection, topographic mapping, and other areas by companied including Shanxi Yatai Inc., Guangxi Guineng Information Inc. and Beijing EarthData Pacific Inc. Valuable experiences have been gained in these areas.

Contrast to the hardware, data processing software system is almost a blank in China. The current universal airborne LIDAR data processing softwares include TerraSolid, TopPIT and REALM etc. These systems are provided along with the hardware devices and their arithmetic source codes keeps secret. Thus, their utilizations are limited. Currently, there is a National 863 project to develop the data processing software, but it will take times. Therefore, the airborne LIDAR data processing software is currently a major limitation in the development of airborne LIDAR technology in China.

3. TOPLIDAR INTRODUCTION

TopLidar system is a MicroStation-based LIDAR point cloud data processing software. It uses some functions of MDL language to improve system efficiency and C++ language for interface and some operations. At present the main functions of TopLidar are point cloud reading, saving, filtering, classifying and interactive editing etc.

3.1Introduction of MicroStation

MicroStation was developed by the Bentley System of the United States. It is a general Multi-Platform Computer Aided Design (CAD) software system. It is a professional software system originated from minicomputer, but offers many advantages over other PC CAD software systems:

a) MicroStation is better in software function, structure and performance efficiency

b) MicroStation supports multi-hardware and operation systems. It is compatible in different operative systems and the function and structure are totally the same in these.

c) MicroStation has led the technology advancement in the area for a long time.

d) MicroStation provides five programming languages that could be used by different programmers. Development of TopLidar is used MDL language.

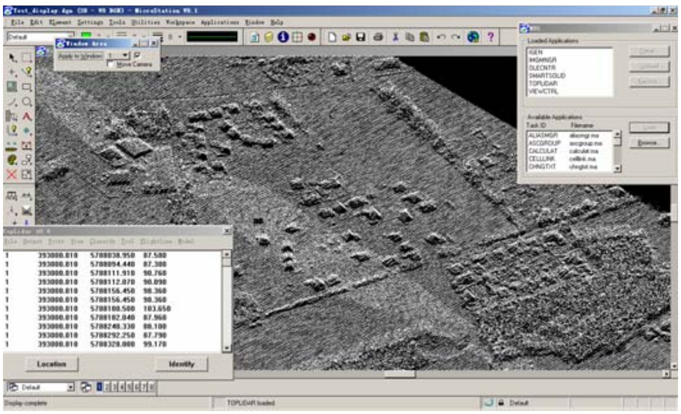


Figure 1: The interface of MicroStation with TopLidar

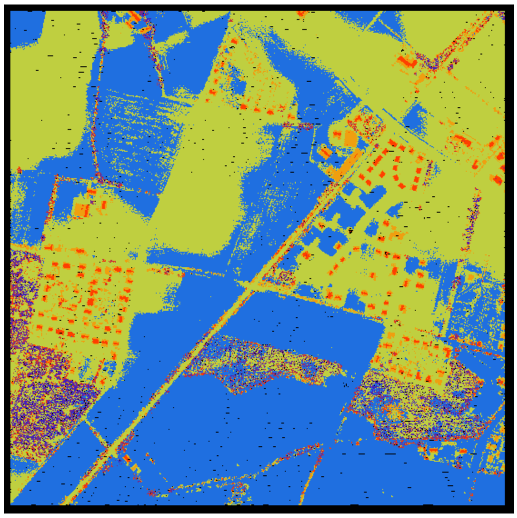
3.2TopLidar System

TopLidar could be run after opening the MicroStation and creating a new 3D workspace. The main interface is shown by selecting TopLidar.ma in MDL Application menu of MicroStation and is divided into menu area and data display area (Figure 1). The data display area is for data display and point positioning processing. View of the MicroStation displays the read of point cloud. The right child window is MDL Application window.

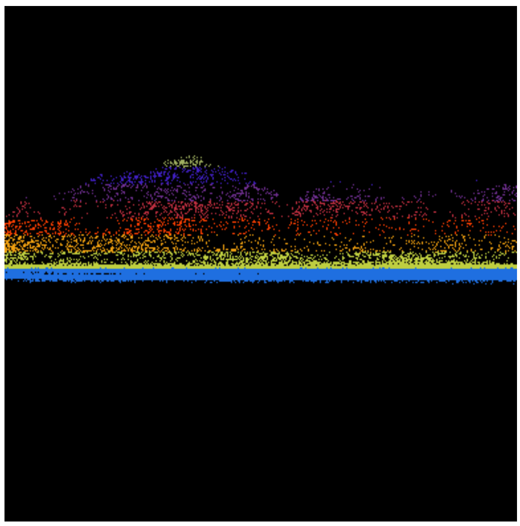
3.3Point cloud Read and Display

For the large amount data of LIDAR, TopLidar employs the data format provided by MDL language. Therefore the embedded formats can be processed better and multifarious operations can be performed by MicroStation.

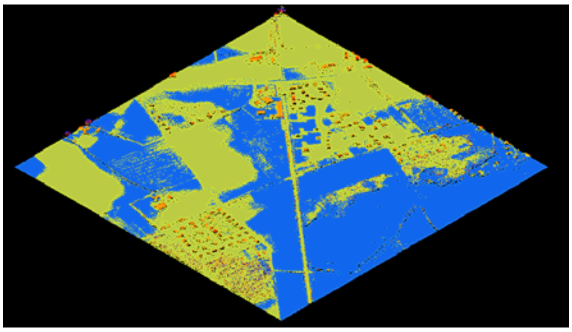
In the aspect of data format, TopLidar currently supports input and output of ASCII and LAS format files. The system automatically gives the points default color and centrally displays in MicrsoStation View. The system provides several display modes, including the modes based on height (Figure 2), intensity and class.



(a) Top visual angle view.



(b) Local front visual angle view.



(c) Isometric visual angle view.

Figure 2: Height based point cloud display (with self-definition colors)

3.4Point Cloud Filtering and Classification

Filtering and classification are the important steps of point cloud processing. TopLidar provides mathematical morphology filtering method, Delaunay triangle method and section analysis method for filtering. Based on the reference setting, filter can also be regard as classification. The paper focuses on mathematical morphology filtering method.

Mathematical morphology is a new image analysis disciplines, and its basic theories and methods have been successful used in the visual detection, robot vision, medical image analysis, and other areas. It can be used to solve the noise suppression, feature extraction, the edge detection, image segmentation, shape recognition, texture analysis, image restoration and reconstruction, image compression and other image processings. It is also successfully used in the discrete data processing. The basic idea of mathematical morphology is to use structure elements with certain morphology to extract the corresponding shape in data and achieves the data analysis and identification purposes. Mathematical morphology is composed by a group of algebra arithmetic operators, including dilation, erosion, opening and closing. Opening and closing are quadratic operations. The opening means erosion after dilation and it has good filtering ability. Mathematical morphology filtering can also be used for the purpose of ground classification.

The following are brief steps of mathematical morphology filtering:

a) Input and sort point cloud by certain rules. The sorting is to comparison numbers of the follow-up steps.

b) Carry out erosion operation on sorted point cloud according to its height. That means replacing the height value of each point by the smallest height value of the all points inside the window which is centered by a specific point with assigned size. Then go through all the points with this operation and store the results in a new array named AR1.

c) Carry out dilation operation on the points in the new array of the step B to its height. That means replacing the height value of each point by the biggest height value of the all points inside the window which is centered by a specific point with assigned size. Then go through all the points with this operation and store the results in a new array named AR2.

d) Compare the height values of each point in AR1 and AR2. If the absolute value of height difference is bigger than a certain threshold value, the point is considered a non-ground point, otherwise a ground point.

The following chart is a simple flowchart of mathematical morphology filtering (Figure 3):

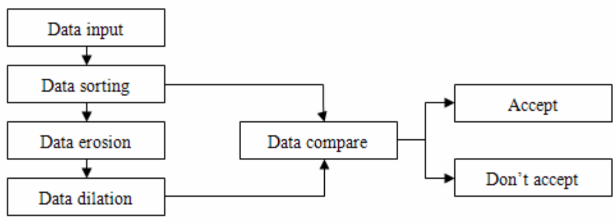
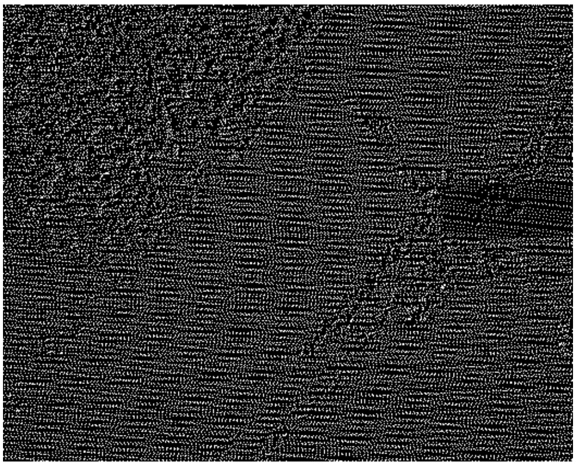
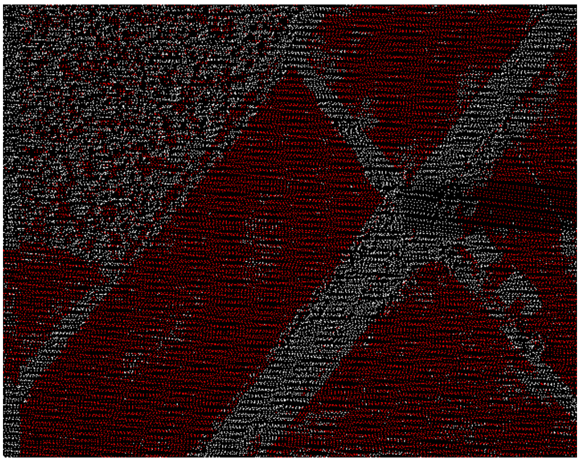


Figure 3: Flowchart of mathematical morphology filtering

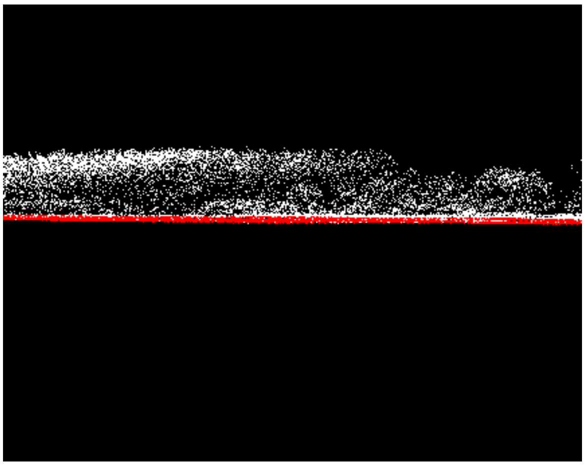
The following charts are the results of the mathematical morphology filtering (Figure 4).



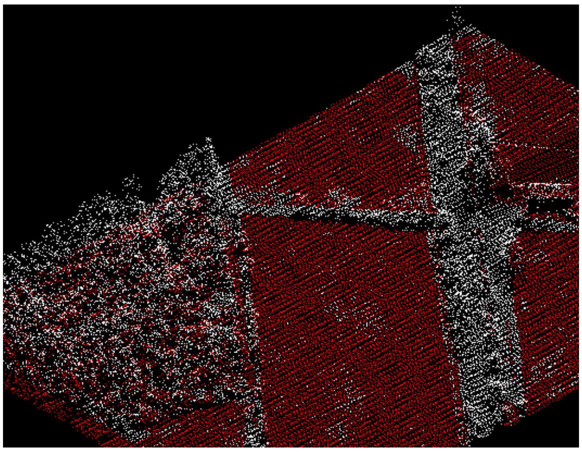
(a) Top visual angle view, original points.



(b) Top visual angle view, points after classification.



(c) Front visual angle view.



(d) Free visual angle view.

Figure 4: The point cloud view after filtering based mathematical morphology (The white points are non-ground points, and the red points are ground points)

3.5Point Cloud Interactive Editing

Terrain is a complex surface. Most of the point cloud automatic classification can be processed by current software, but the accuracy is not dependable due to the randomicity of point cloud. As a result, manual interactive editing is still needed for discrete ground objects especially for scarp, building, vegetable and water.

Interactive editing is mainly used to modify two classification errors in automatic classification. One is that some ground points are classified to non-ground points, and the second one is that some non-ground points are classified to ground points. The interactive editing function of TopLidar can be divided into three categories: point editing, line editing and face editing. Point editing is used to edit single point by changing the point from one class to other class. Line editing can be called section editing; it is used to process the points within one side of a defined line. Face editing is used to process the points within the shape defined by a user. The interactive editing functions mainly use the MDL function, which can be efficiently processed by MicroStation.

4. CONCLUSION

Airborne LIDAR technology has broad applications in many fields, but its applications in China are still lagging behind many developed countries. In order to make the technology more effectively serving the Chinese development, studying the application of Airborne LIDAR technology and data processing method has very important theoretical value and practical significance. TopLidar system partly filled the blank in development of airborne LIDAR data processing. Once TopLidar is completed, it will promote the airborne LIDAR technology in China.

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