

A GUI Based LIDAR Data Processing System for Model Generation and Mapping

¹Zheng Cui, ²Keqi Zhang, ³Chengcui Zhang, ⁴Jianhua Yan, ¹Shu-Ching Chen

¹School of Computing and Information Sciences, Florida International University, USA

²Department of Earth and Environment, Florida International University, USA

³Department of Computer and Information Sciences, The University of Alabama at Birmingham, USA

⁴Amazon.com, Inc. USA

^{1,2}{cuiz, zhangk, chens}@fiu.edu

³zhang@cis.uab.edu

⁴yjhsjtu@gmail.com

ABSTRACT

This paper presents a Graphical User Interface (GUI) system to process huge volume geospatial data acquired from LIDAR survey. This GUI system provides friendly user interface to display, edit and process LIDAR data. It also offers useful geospatial tool kits to process area of interest from a big data set. The processing results would be used for high quality digital elevation model (DEM) generation and mapping.

Categories and Subject Descriptors

I.3.5 [Computer Graphics]: Computational Geometry and Object Modeling—Geometric algorithms; Surface and solid representations; D.1.7 [Visual Programming]

General Terms

Design.

Keywords

LIDAR, Digital elevation model (DEM), data filtering, geospatial data analytics

1. INTRODUCTION

As LIDAR (Light Detection and Ranging) has become a widely used technology in surveying and industrial measurement applications in recent years, many filtering methods have been developed to separate ground and non-ground features. High quality digital elevation model (DEM) and map can be generated from good processing results according to different applications. These DEMs and mapping results are indispensable for many applications such as urban management, emergency event planning, and mapping tools. Since LIDAR data contains huge volume of data points even in a small surveyed area, it is necessary to have a practical GUI system for the users to process the data according to their application requirements.

Developing the tools to process LIDAR data is a challenging task because of the unique characteristics of LIDAR data [1][2]. Huge

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MapInteract'13, November 05 – 08, 2013, Orlando, FL, USA.

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<http://dx.doi.org/10.1145/2534931.2534934>

volume of irregularly spaced points in the LIDAR data is difficult to display, edit and analyze in many commercial GIS and remote sensing software which are designed to handle vector and raster images. Therefore, the dedicated processing system of LIDAR data for varied application needs is necessary. From the scientific research perspective, this kind of tool is also very useful for researcher to test their algorithm and compare the performance of different methods. The advantage of this tool is not only free to use at no cost compared to commercial software, but provides a framework to embed all the research achievements into the system for testing, processing and research purposes. The high quality processing results would provide the commercial software appropriate input for viewing, editing and analyzing.

2. SYSTEM ARCHITECTURE

The proposed GUI system provides a whole workflow to process the LIDAR data. The general processing of LIDAR data consists of several major components, which include interpolation of data, filtering of data, identification of objects, and creation of object models. The proposed GUI system offers a generalized batch processing interface for users to select different methods to process input data files. In the meanwhile, it offers a GUI to let users display, edit and process the data on the fly interactively.



Figure 1. Schematic procedures for LIDAR data processing

The schematic procedure for LIDAR data processing was shown in Figure 1. High volume LIDAR data in a surveyed area would be partitioned into tiles with predefined size. Some project data need to be split into strips in *Strip Boundary & Merge* procedure before being partitioned into tiles. This *Data Partition* procedure would split a huge data set into small pieces for better storage and processing. In the *Data Preprocessing* procedure, the outlier points such as extremely low points would be removed. Also the interpolation of empty parts in the data set could be carried out in this procedure. The *Filtering* procedure will separate the ground and non-ground features according to the application needs. Multiple filtering methods have been implemented in the *Filtering* module. The separated ground and non-ground points will be processed in the *Features Classification* procedure to further extract the desired terrain or non-terrain features according to the application purposes. Finally, the extracted features would be used

to generate digital terrain model (DTM) or digital elevation model (DEM). These processing modules have been implemented in a generalized multi-task batch processing GUI. Users can use the same interface to select the processing input/output files, methods, and parameters.

The proposed system offers GUI for users to interactively view the three-dimensional LIDAR data which would be displayed in different colors according to their elevations. The legend can be modified to satisfy different display purposes. The data set's information such as 3D boundary information would be shown in the GUI. Users can also retrieve a single LIDAR point's location information by pointing the cursor to it. The view can be zoomed in and out. Multiple views of display and processing results are cached for undo and redo operations. Users can switch the data views back and forth easily in this way. These viewing functionalities are very helpful for users to study the spatial detail of the data set and compare the processing results.

The GUI offers the editing and processing operations through polygon shape selection in the data view. These functionalities are necessary for users to edit and process a complex data set, especially when the users need to visually select various areas of interest in a big data set to carry out different operations. These operations include exporting data, removing data, filtering data, objects detection, and objects classification in the selected regions. By using these functionalities, users can visually choose the study area in the data set and carry out their processing methods repeatedly. The processing results will be displayed on the fly and can be retrieved from cache by undo/redo operations.

These features of the system are very useful for processing and analyzing large complex data sets which have difficulty for single filtering method to separate ground and non-ground features. With the interactive features, users are able to select any part of the data set by using polygon, and process it with different methods and parameters according to the applications. It offers users much flexibility to handle different kinds of terrain with various configurations.

3. DEMONSTRATION

The proposed system will be demonstrated by a personal computer program on the Windows platform. A sample LIDAR data set will be used for the viewing, editing and processing functionalities. The functionalities presented to the users are described as follows.

The main GUI is shown in Figure 2, which uses Document/View architecture for Visual C++ project. The data points can be shown in the view with different colors defined in the legend bar. The legend bar's settings dialog is shown in Figure 3, multiple parameters can be modified by users. The elevation display settings use relative elevation values to the benchmark value. Users can set the benchmark value to define the origin of vertical axis. All the elevation levels can be defined relative to the benchmark value in a list. Different elevation ranges would be displayed by user-defined colors. Users can change the color as they need, the interval between each elevation level can be modified by setting *Interval* value. The legend settings offer users a good way to display the data. Users can use mouse to select any rectangle region to zoom in the selected area. Multiple views would be cached for users to retrieve.

The interactive processing interface is shown in Figure 4. The figure shows that users can select any polygon shape area to carry out related processing operations, such as export, deletion, and

other filtering related operations. The polygon shape is adjustable; users can resize the polygon shape by dragging its vertices. After the polygon region is selected, users can do all the related operations by right-clicking the polygon, the operation menu will be prompted for users to choose the operations. For example, if the user chooses a filtering operation such as *Morph Filter*, a parameters form will pop up. User can fill in the parameters of the method shown in Figure 5, and then the processing will start after the user click OK button. The operation result is shown in Figure 6. To process the same polygon size of data in different area of data set, user can drag the polygon shape to different part of the data set and choose the appropriate operation for that area. Figure 7 shows the result of another operation on different part of data set with the same polygon shape. This operation extracts the non-ground features of the data set, while the non-ground features were removed in the previous polygon shape area. Users can select different operation methods to satisfy their own data retrieval needs. The processing result in each polygon shape can be exported into file for further analysis and processing. This GUI based interface provides a framework for testing and comparing different methods. All the related LIDAR processing methods can be embedded into this GUI interface. This would benefit researchers to test and compare various methods on different areas of each data set, because users can easily switch between different processing results view through *Undo* and *Redo* buttons. Another operation result is shown in Figure 8. It extracts the points of buildings in the data set. This can be further used to retrieve the boundaries of these buildings. Figure 9 shows the result of the boundaries identified from the extracted buildings. With this information, the buildings' boundaries can be easily displayed in the commercial software such as ArcGIS, and overlapped on the online map system, such as Google Map. It also provides important information for 3D model generation.

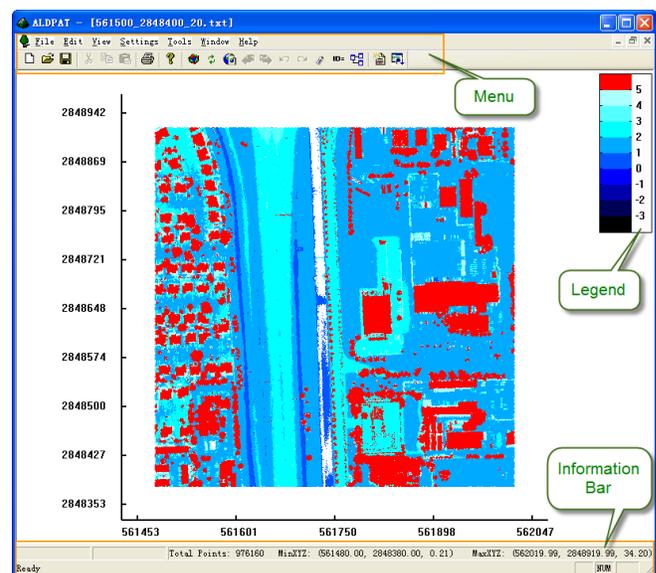


Figure 2. GUI view of LIDAR data

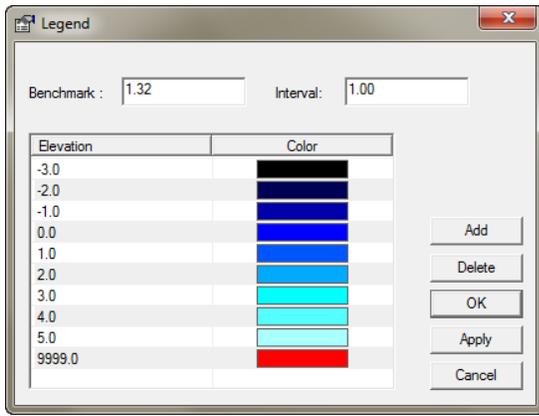


Figure 3. Legend bar settings

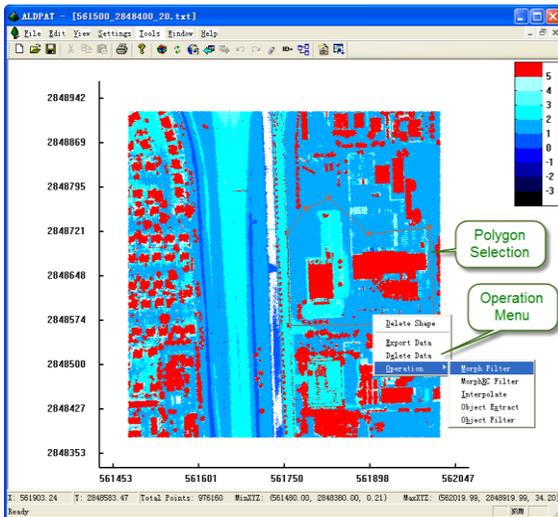


Figure 4. Operations on selected polygon region

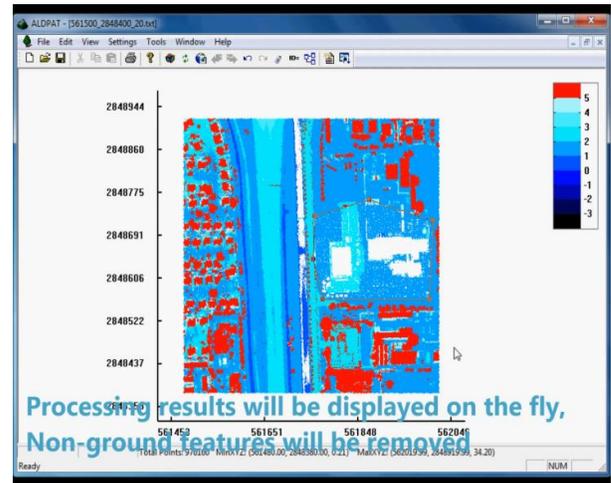


Figure 6. GUI operation result

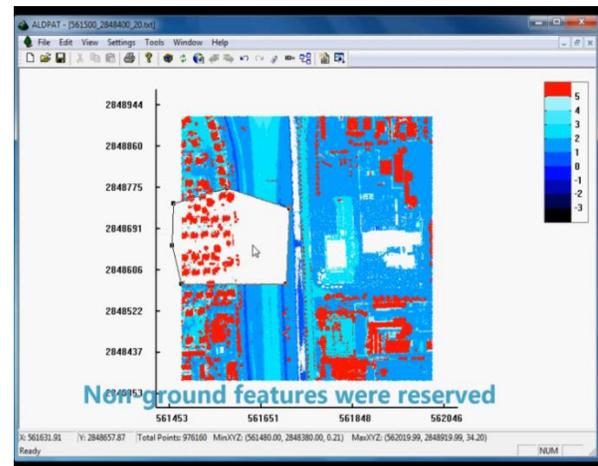


Figure 7. Another operation result on different part of data set with the same polygon shape

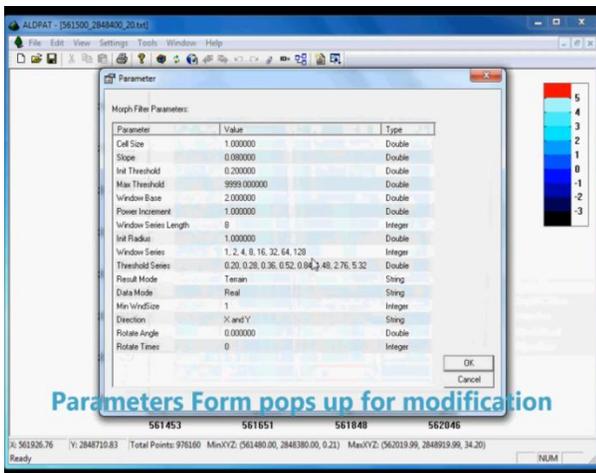


Figure 5. Parameters form of the operation

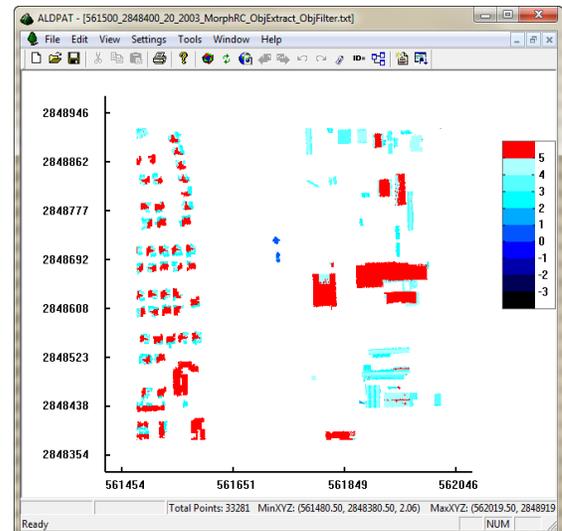


Figure 8. Building extraction

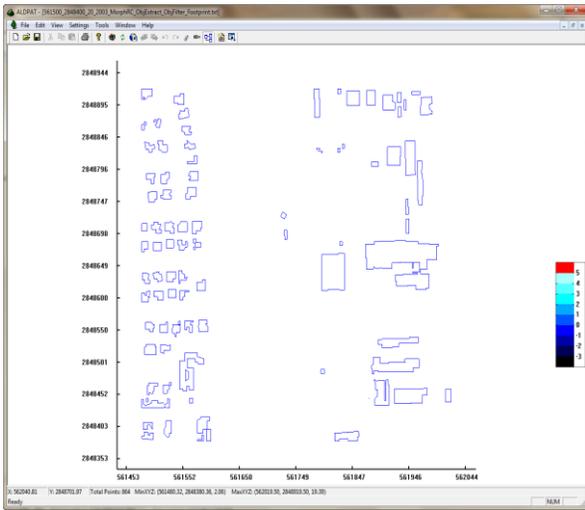


Figure 9. Non-ground objects' boundaries detection

The batch processing interface is shown in Figure 10. Users can choose from a list of implemented methods [1][2][3][4], set the parameters for each method, and add it into the processing task list. The processing input and output file can be selected and set through the general batch processing form. The processing method can be selected from the methods list. Before the processing job is added to the task list, a parameters form (shown in Figure 11) will pop up for users to fill in all the parameters of the method. Multiple jobs can be added into the task list, they will be processed sequentially. The processing time and job status (shown in Figure 12) will be displayed for each job. Users can stop the processing job anytime. These features are very helpful for comparing methods' performance, especially for large data sets which need long processing time. The detailed batch processing features are explained in [2].

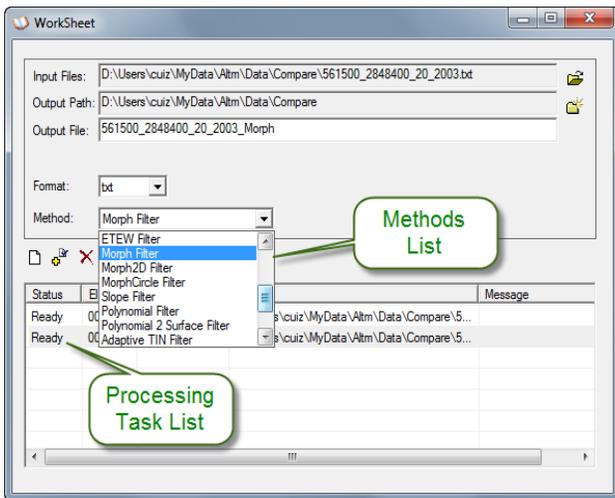


Figure 10. Batch processing interface

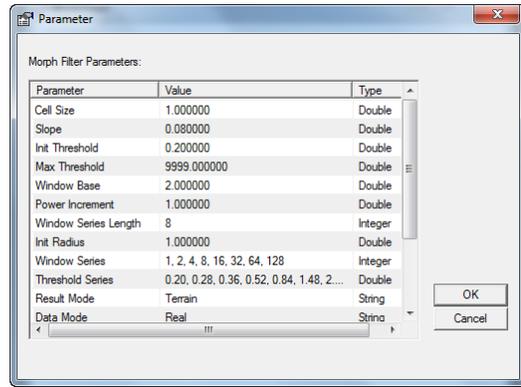


Figure 11. Parameter form of the selected method

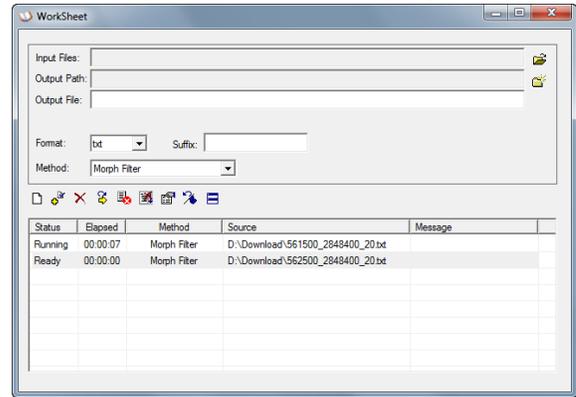


Figure 12. Processing jobs' status are shown in task list pane

4. ACKNOWLEDGMENTS

We would like to thank NCALM and NOAA Florida Hurricane Alliance Research Program for providing the necessary financial support for this project. Dr. Quin Robertson at Coastal Planning & Engineering Inc. and Ms. Patricia Houle at Florida International University tested the software and provided valuable feedback.

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