COMBINING LIDAR DATA AND GEOREFERENCED MULTISPECTRAL IMAGE FOR VEGTATION CLASSIFICATION IN POWER LINE CORRIDORS

Zhengrong Li [1,2], Yuee Liu [1], Rodney Walker [2], Ross Hayward [1]

[1] School of IT, Queensland University of Technology
[2] Australian Research Centre for Aerospace Automation (ARCAA)

1. INTRODUCTION

Vegetation management activities in power line corridors including tree trimming and vegetation control is a significant cost component of maintenance of the electrical infrastructure. Currently, most vegetation management programs for distribution systems are calendar-based ground patrol [1]. Unfortunately, calendar-based tree trimming cycles are expensive. It also results in some zones being trimmed more frequently than needed and others not cut often enough. Moreover, it is seldom practicable to measure all the plants by field methods. Satellites and aerial vehicles can pass over more regularly and automatically than the ground patrol. Therefore, remotely sensed data have great potential in assisting vegetation management in power line corridors.

As a relatively new member of remote sensing instruments, Light Detection and Ranging (LiDAR) is an effective sensor for 3D information acquisition and has great potential to assist vegetation management in power line corridors. Several approaches of LiDAR based vegetation extraction have been achieved during the past a few years [2, 3]. However, due to the variations of point density and lack of spectral information, it is often hard to achieve robust tree detection results if solely use LiDAR data. Distinct spectral signatures in red and near-infrared bands have been successfully used to discriminate vegetation and non-vegetation [4]. However, grass, low vegetation is hard to be discriminated from trees as they present very similar colors and even textures. A better solution is to combine multispectral images and LiDAR data. In this paper, we developed a vegetation classification method by combining LiDAR data and georeferenced multispectral images.

2. METHODOLOGY

The framework of the proposed tree crown detection method is described in figure 1.

Initial Segmentation from Multi-spectral Image

Optical remote sensors collect and store data about the spectral reflectance of natural features and objects. Different types of land covers can be identified by using the spectral features of certain surface materials. The dominant method for interpreting vegetation biophysical properties from optical remote sensing data is through spectral vegetation indices. NDVI is one of the most well-known and used vegetation indices. In this paper, we use a classic Otsu segmentation algorithm on NDVI image for the initial detection of vegetation and followed by morphological filtering in the post-processing stage to remove the noise and fill the 'hole' [5]. After segmentation, vegetated region are obtained and each connected region is labeled with a particular color and then used for the fusion with LiDAR data. The initial segmentation from multi-spectral image can separate vegetation and non-vegetation, but fails to discriminate low vegetation (e.g. grass area) and the decomposition of tree clusters is occasionally poor. As only trees can pose risks to power lines, other low vegetation is not interested in power line corridor management, we need to remove low vegetation and try to decompose of tree clusters.

Region-level Fusion of LiDAR Data and Georeferenced Image

LiDAR data can be considered as an additional image layer given the multi-spectral image is georeferenced. In this paper, we map the LiDAR data to the initial vegetated regions, and only process the points which are mapped to a region to discomposed connected tree crowns. It is implemented by calculating the corresponding pixel coordinates of the LiDAR points in the segments, and then assigning the points with a region label by checking whether these pixel coordinates belong to a region.

Individual Tree Delineation

In order to remove low vegetation points, a thresholding process is conducted on the object points. It is observed that the mean height of a region which contains ground and low vegetation points is much lower than a region which contains trees. The region mean height histogram is calculated to visualize the height difference among regions. In this paper, we manually select a threshold to remove the regions with relatively low mean height. The height variations of adjacent trees also make it much easier to segment individual trees from the 2.5D LiDAR depth image rather than from 2D multi-spectral image. The 2.5D depth image is obtained by putting a uniform fix-sized grid over the points and within each grid keeping only the point with the lowest Z coordinate. Grid spacing is 0.5 unit, so each pixel of the depth image corresponds to a 0.5x0.5 cm^2 grid. After that a watershed-based segmentation [6] is employed to the 2.5D depth image for the decomposition of tree clusters.

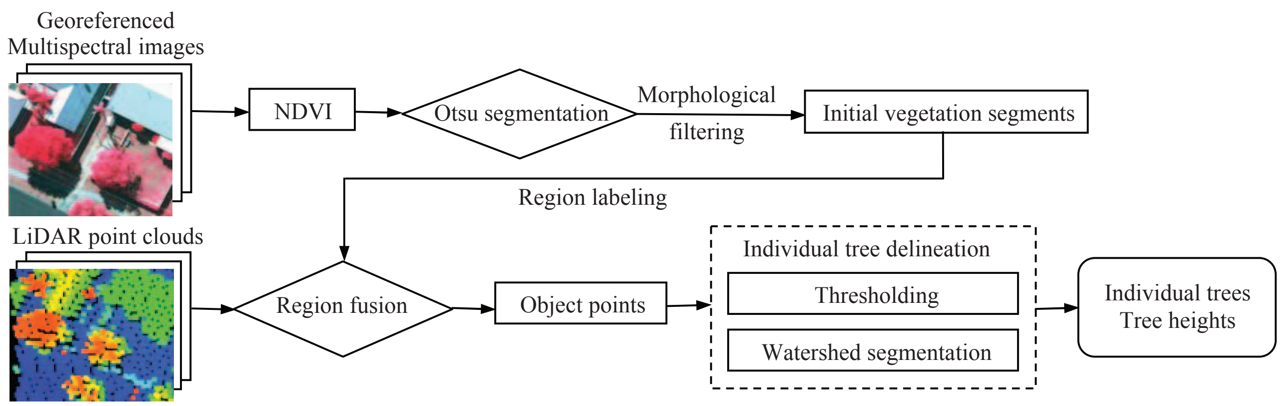
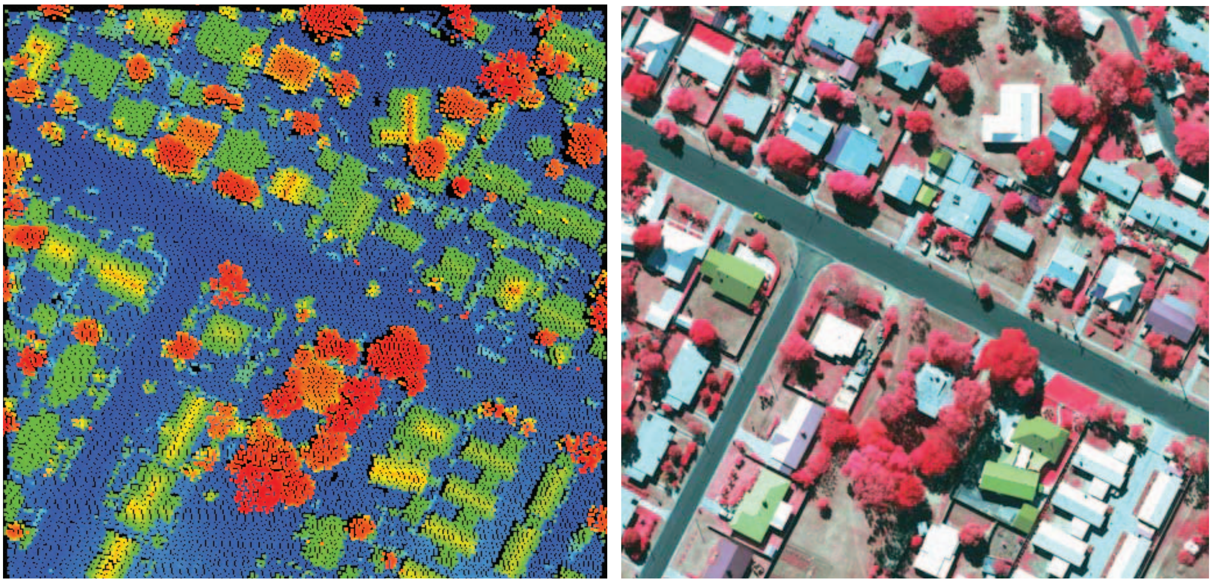


Figure 1 Framework of the proposed vegetation classification

3. EXPERIMENTAL RESULTS

Data Collection: The LiDAR data and georeferenced multispectral image used in this study were obtained from flights organised by Cooperative Research Centre for Spatial Information (CRC-SI) project 6.07 for vegetation management in power line corridors. The flights collected data around Bundaberg of Queensland on the 16th of June 2009 using a Cessna 404 VH-WGS platform and conducted by an aerial mapping company: Fugro Spatial Solutions Pty Ltd. The flight height is approximately 1000m AGL. The main sensors onboard the aircraft include: 1) Leica ALS50-IIM airborne laser scanner, and 2) Leica ADS 40 airborne digital sensor (5 bands: panchromatic, red, green, blue and near-infrared). Figure 2 shows an example LiDAR data and multi-spectral image.



(a) LiDAR point clouds data (b) multi-spectral image

Figure 2 Example of the collected LiDAR data and multi-spectral image in the same area

Experimental Results: We use four pairs of LiDAR data and georeferenced images in the experiment. Figure 4 shows one of our experimental results which is based on the LiDAR data and multi-spectral image in Figure 2. As we can see from Figure 4 (a) and (b), the segmentation algorithm on multi-spectral image successfully detected the vegetated region, but grass area and also detected and under-segmentation of tree clusters exists. Figure 3 shows the region mean height histogram which is generated after the fusion process which is used to find a threshold to discriminate low vegetation region. After low vegetation removal and watershed segmentation on 2.5D object image, the final result is shown in Figure 4(d).

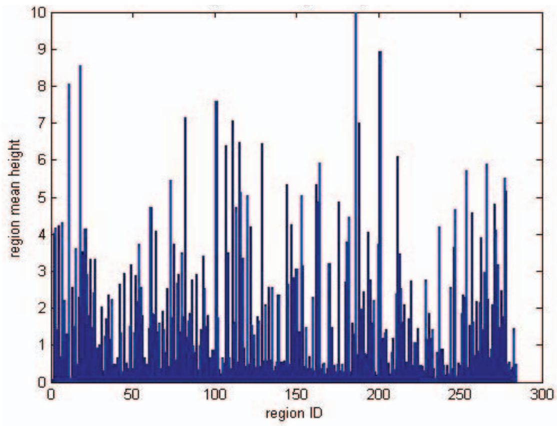


Figure 3 Region mean height histogram

4. CONCLUSION

Aiming at vegetation management in power line corridors, this paper proposed a vegetation classification algorithm by combining LiDAR point cloud data and georeferenced multi-spectral image. The experimental results demonstrate the effectiveness of the proposed algorithm.

5. REFERENCES

[1] B. D. Russell, C. L. Benner, J. Wischkaemper, W. Jewell, and J. McCalley, "Reliability Based Vegetation Management Through Intelligent System Monitoring," Texas A&M University, Texas 2007.

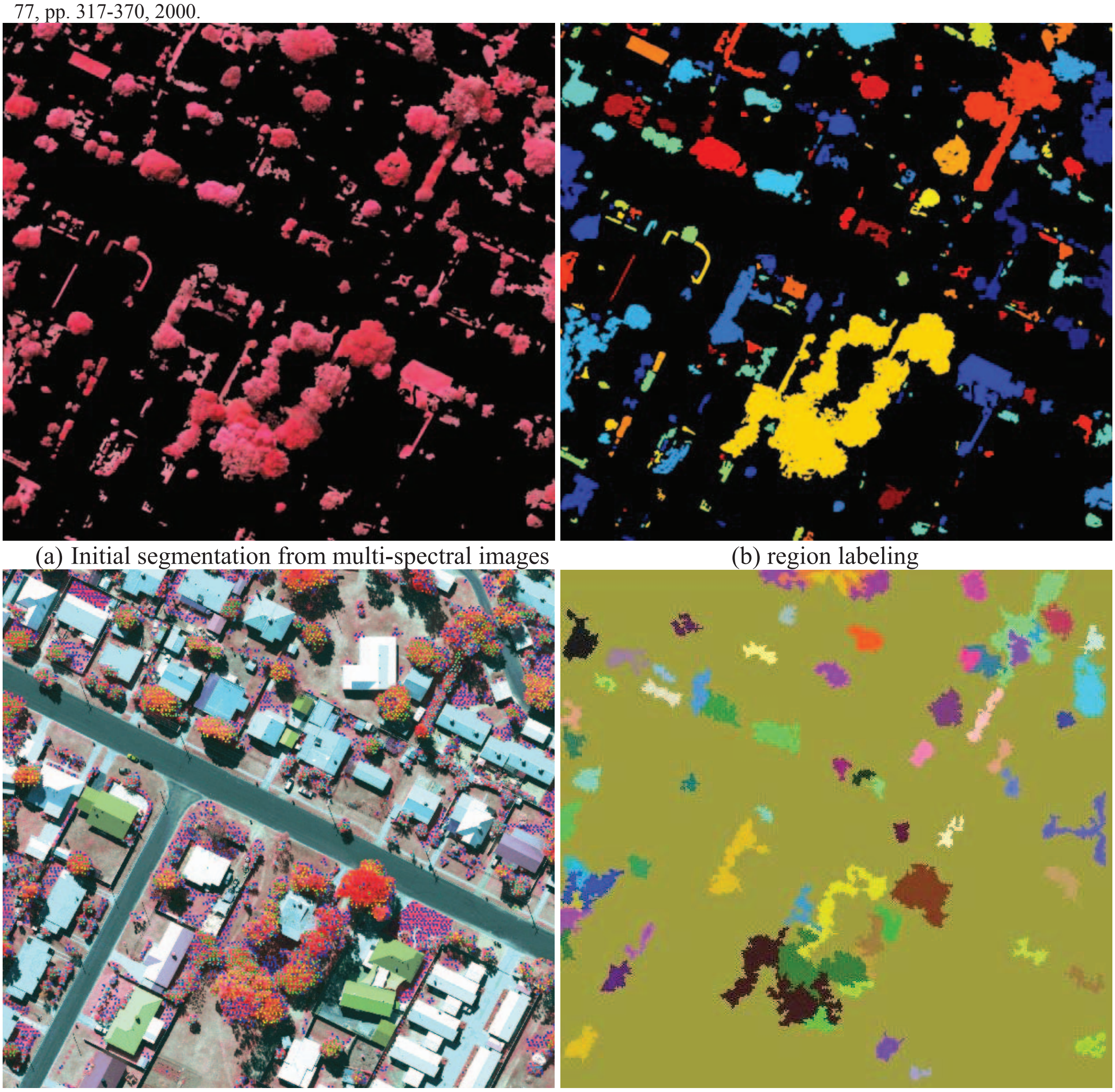
[2] T. Brandtberga, T. A. Warnera, R. E. Landenbergerb, and J. B. McGraw, "Detection and analysis of individual leaf-off tree crowns in small footprint, high sampling density lidar data from the eastern deciduous forest in North America," *Remote Sensing of Environment,* vol. 85, pp. 290-303, 2003.

[3] B. Koch, U. Heyder, and H. Weinacker, "Detection of individual tree crowns in airborne lidar data," *Photogrammetric Engineering & Remote Sensing,* vol. 72, pp. 357-363, 2006.

[4] Z. Li, R. Hayward, J. Zhang, Y. Liu, and R. Walker, "Towards Automatic Tree Crown Detection and Delineation in Spectral Feature Space Using PCNN and Morphological Reconstruction," in *IEEE International Conference on Image Processing* Cairo, Egypt, 2009.

[5] N. Otsu, "A Threshold Selection Method from Gray-Level Histograms," *IEEE Transactions on Systems, Man, and Cybernetics,* vol. 9, pp. 62-66, 1979.

[6] A. e. Bleau and L. J. Leon, "Watershed-Based Segmentation and Region Merging," *Computer Vision and Image Understanding,* vol. 77, pp. 317-370, 2000.



(a) Initial segmentation from multi-spectral images (b) region labeling

(c) Region-level fusion of LiDAR points and image (d) individual tree delineation result

Figure 4 Experimental results