THE INVERSION OF CROP HEIGHT BASED ON SMALL-FOOTPRINT WAVEFORM AIRBORNE LIDAR

Mengwei Zhou[1, 2], Qinhuo Liu[1], Qiang Liu[1], Qing Xiao[1], Bo Zhong[1]

（1 State Key Laboratory of Remote Sensing Science, Jointly Sponsored by the Institute of Remote Sensing Applications of Chinese Academy of Sciences and Beijing Normal University, Beijing, 100101, China; 2 Graduate School of the Chinese Academy of Sciences, Beijing, 100039, China）

1. INTRODUCTION

Light Detection and Ranging (LIDAR) can acquire high-resolution three-dimensional (3D) spatial data by scanning laser beams, which provides an efficient means of measuring the height of vegetation. Mass data storage capacity and high processing speed available today has made it possible to digitally sample and store the entire reflected waveform of small-footprint airborne LIDAR. It is able to describe the detailed perpendicular vegetation structure through the analysis of waveform. Earlier algorithm of decomposition is simply used maximum and centre of gravity, or the threshold approach provided by equipment vendor. These methods both show lack of high accuracy. And then detection approaches based on the non-linear least square method [1, 2] and expectation-maximization (EM) algorithm [3] were presented, which deal with tall trees effectively. However they need to be initialized with start values and easily fall into the local optimal solution. Due to limited vertical resolution, the waveform of low vegetation such as crops will superpose on soil waveform. Therefore, application of full-waveform LIDAR data is mainly limited in forestry, with almost no research in agriculture. In this research, we present a new approach to analysis LIDAR waveform and emphasis on the procedure to retrieve crop canopy height.

2. METHODOLOGY

Firstly, in order to separate the vegetation and soil waveform, we propose a Gaussian fitting algorithm based on the Gaussian character of transmit pulse and receive soil energy, and obtain the real soil waveform using optimization methods. Secondly, key points of the waveforms (Fig. 1) and the corresponding time, including the onset and termination of entire waveform, the onset and peak of soil waveform, are identified. Thirdly, height of first return signal could be calculated as the distance between the onset of the entire and soil waveform.

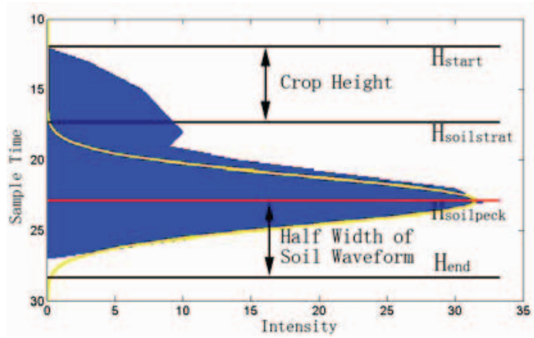

Fig.1 Key points of LIDAR waveform

3. APPLICATION DEMONSTRATION

The study area for this validation is an 8000m^2 cropland within Yingke Oasis, Gansu Province, China. This field composes of four corn plots, where the height of 60 corns in the field was measured in June 21, 2008. High-density LIDAR data were acquired over the study area with a LiteMapper 5600 system which is produced by RIEGL Company mounted on 'Y-12' aircraft in June 20, 2008. In this flight 8th, 9th and 10th trajectories covered the filed. In view of the fact that the smaller scanning angle leads to a higher inversed accuracy [4], we select the data of 9th trajectory whose average scan angle is the smallest to analysis. Cornfield with remarkable row structure is at the middle grown stage in June. In order to overcome the impact of row structure, we divide each plot into 7m^2 sub-areas, and regard the height of the maximum first return signal within each sub-area as the crop height of this sub-area. Finally, the crop canopy height of the plot is calculated as the average of all the crop height of sub-areas within the plot. Fig. 2 shows inversed crop height images of the experiment site on June 20, 2008. The comparison result indicates that this decomposition algorithm and inversion method is basically consistent with the field measurement with a reasonable accuracy (Table 1).

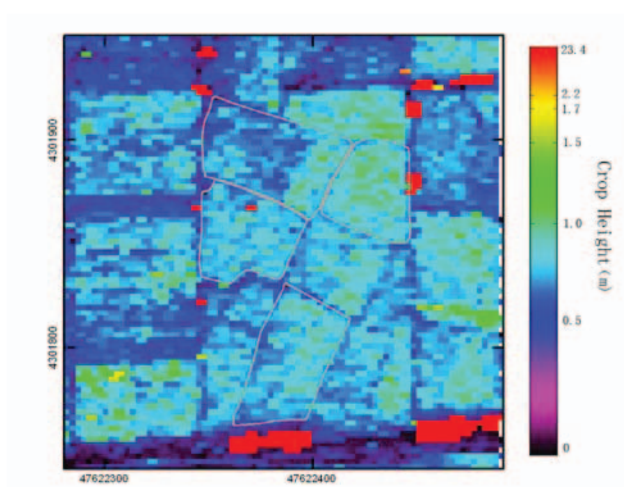

Fig. 2 Image of inversed crop height

Table 1 Comparison of field measured and inversed crop height

Plot	In-situ(m)		Retrieval(m)		t	Relative error (%)	Absolute error (m)
	Avg.	Var.	Avg.	Var.			
No.1	1.060	0.099	1.091	0.083	1.32	2.91	0.03
No.2	0.995	0.103	0.974	0.108	0.70	2.20	0.02
No.3	0.864	0.166	0.909	0.139	1.27	5.13	0.04
No.4	1.013	0.092	0.974	0.081	1.87	3.89	0.04

4. CONCLUTION

In this paper, a waveform decomposition algorithm based on small-footprint waveform Airborne LIDAR is proposed for retrieving crop height and the validation indicates the proposed algorithm perform very well.

5. REFERENCES

[1] W. Wagner, A. Ullrich, V. Ducic, T. Melzer and N. Studnicka, "Gaussian decomposition and calibration of a novel small-footprint full-waveform digitizing airborne laser scanner", *ISPRS journal of Photogrammetry and Remote Sensing*, vol. 60, no.2, pp. 100-112, 2006.

[2] M. A. Hofton, J. B. Blair and J. Minster. "Decomposition of laser altimeter waveforms". *IEEE Transactions on Geoscience and Remote Sensing*, vol. 38, no. 4, pp. 1989-1996, 2000.

[3] Q. Li. "Decomposition of airborne laser scanning waveform data based on EM algorithm". *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.* Beijing. Vol. XXXVII. Part B1, pp. 211-218, 2008.

[4] J. Holmgren, M. Nilsson and H. Olsson. "Simulating the effects of LiDAR scanning angle for estimation of mean tree height and canopy closure". *Canadian Journal of Remote Sensing*, vol. 29, no. 5, pp: 623-632, 2003.