USING AIRBORNE LIDAR TO RETRIEVE STRUCTURAL PARAMETERS OF THE CROPLAND

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1. INTRODUCTION

Airborne LIDAR (Light Detection and Ranging) is an active remote sensing technique that measures the properties of scattered light to determine the range and intensity information of a distant target. Many researches have been reported on estimating a suite of forest characteristics such as fractional vegetation cover (f_{cover}), leaf area index (LAI) and canopy height using LIDAR data. Such methods are applicable for forest, however, may not be suitable for crops. As crops are so low that almost every pulse has ground hit, it is difficult to separate the crop and soil. In this article, we choose corn field as research object, trying to derive gap fraction using the LIDAR intensity of ground hits, so we can manage to retrieve the f_{cover} , LAI, and the height of crop canopy. Field validation shows that our method can accurately retrieve the structural parameters of crop field.

2. METHODOLOGY

For LIDAR, the received laser power can be expressed in the following Equation [1-3]

$$P_r = \frac{P_t D_r^2 \rho}{4\pi R^4 \beta_t^2} \eta_{sys} \eta_{atm} A_s \qquad (1)$$

where P_r and P_t are the received and transmitted laser energy respectively, R is the distance between sensor and target, β_t is the laser-beam divergence, D_r is the diameter of the receiver aperture, ρ is the reflectivity of the target surface, A_s is the target area, and η_{sys} and η_{atm} are the system and atmospheric transmission factor respectively.

In the crop field, the intensity of ground echo is smaller than that of bare soil, since the crops hold up same energy on the path of laser shot. When the scan angle is smaller than 10°, it can be assumed that P_t, D_r , ρ , R , β_t , η_{sys} and η_{atm} in a given study area are approximate constants during the same flight. LIDAR intensity is the ratio of laser energy received to transmitted [1,4]. For bare soil, let A_{max} be the area of bare soil, P_{max} and I_{max}

represent the received energy and intensity respectively; For crop field, let A_g be the area of ground, P_g and I_g represent the received energy and Intensity of ground echo respectively. We have

$$\frac{I_g}{I_{\max}} = \frac{P_g}{P_{\max}} = \frac{\frac{P_t D_r^2 \rho}{4\pi R^4 \beta_t^2}\eta_{sys}\eta_{atm}}{\frac{P_t D_r^2 \rho}{4\pi R^4 \beta_t^2}\eta_{sys}\eta_{atm}} \square \frac{A_g}{A_{\max}} = \frac{A_g}{A_{\max}} \quad (2)$$

The right side of Eq. (2) is the gap fraction which is also the canopy transmittance (T). If there are not only one ground echo, T can be computed from Eq. (3)

$$T = \frac{1}{n}\sum_{i=1}^{n}\frac{I_{gi}}{I_{\max}} \quad (3)$$

Where *n* is the number of echo, I_{gi} is the intensity of echo *i*.

For crop field, fractional vegetation cover can be computed according to Eq. (4)

$$f_{cover} = 1 - T \quad (4)$$

The probability of photons directly reaching the soil represents the canopy transmittance:

$$T = e^{-\lambda_0 \cdot \frac{G}{\mu} \cdot LAI} \quad (5)$$

where λ_0 is the Nilson parameter considering vegetation clumping effect, G is the mean projection of a unit foliage area into the plane perpendicular to the solar incidence direction, μ is the cosine of solar zenith angle, LAI is the vegetation leaf area index. In a given study area, when the scan angle is smaller than 10°, we assume $\mu = 1$. Ground truth data were collected in a maize field, the same as prior knowledge, $G = 0.6$, $\lambda_0 = 0.6$ in the corn canopy. We have

$$LAI = -\frac{\ln(T)}{0.36} \quad (6)$$

In the crop field, vegetation echoes include a few tree points which are indicated as noise. After removing the noise of trees, we calculate the maximum and minimum value of height ($H_{\max}$, height of the top of canopy and $H_{\min}$, height of the ground) from all the points within a certain grid. Canopy height (CH) is easily computed from Eq. (7)

$$CH = H_{\max} - H_{\min} \quad (7)$$

3. FIELD VALIDATION

The study area is located at Yingke Oasis, Zhangye City, Jiangsu Province, China, (38.75°N~39.12°N, 100.33°E ~100.52°E), where an extensive and well organized ground experiment “WATER” [5] has collected abundant ground measured and remotely sensed data. Airborne LIDAR data were acquired at Jun. 20, 2008 using LiteMapper-5600. Data of one flight path with point density of 0.81 points per square meter was used to retrieve the f_{cover} and LAI. To compute the canopy height, data of additional three flights over the same area were used, for increasing the point density. Using the above methods, fractional cover, LAI and canopy height are calculated. Ground truth data in four samples were collected, which equipped with GPS. We obtained f_{cover} by taking hemispherical photographs, measured LAI using LAI-3000, the canopy height was also measured. Results show that the root-mean-square error (RMSE) of f_{cover}, LAI and canopy height are 0.06, 0.18 and 9.5cm respectively.

4. REFERENCES

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