Evaluation of Forest Canopy and Understory Gap Fraction Derived from Terrestrial Laser Scanning

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ABSTRACT:
The quantification of forest carbon sequestration is helpful to understand the carbon storage on the Earth. The estimation of forest carbon sequestration can be achieved by the use of leaf area index (LAI), which is derived from forest gap fraction. The hemispherical image-based technique is the most popular non-destructive means for obtaining such information. However, only the gap fraction of the top canopy is derived due to the limitation of imaging technique. The gap fraction information of understory is thus neglected. In this study, we evaluate the use of a terrestrial laser scanner (TLS) to obtain the forest canopy and understory gap fraction. The forest TLS data were manually classified as the top canopy and understory layers to facilitate the estimation of top canopy and understory gap fraction, respectively.

1. INTRODUCTION
Past studies have demonstrated the use of Terrestrial Laser Scanning (TLS) to produce fisheye image, which can be used for the estimation of forest canopy gap fraction (Morsdorf et al. 2006, Danson et al. 2007, Zhao and Popescu 2009, Ramirez et al. 2013, Zheng et al. 2016). The gap fraction information can then be further used to derive leaf area index and also forest carbon sequestration.

The purpose of this paper is to classify the TLS point data into three different vertical layers, i.e., canopy layer, understory layer, and forest floor layer. The TLS points of canopy layer and understory layer were then, respectively, processed to produce fisheye images for the computation of gap fraction.

2. DATA
A study area of 15 m \(\times\) 15 m, located at upstream of Tseng-Wen River in Chiayi County, Taiwan, was scanned in April and August 2014 with a Z+F IMAGER\textsuperscript{®} 5010 unit. The dominate trees in the study area are Cinnamomum camphora, Vernicia fordii, and Bischofia javanica. Four wood benchmarks were installed in the field to guide the TLS scan location. So, the scan stations were the same for two different months. Figure 1 shows the location of the study area and the arrangement of the TLS scans, overlaid on an orthophoto with a resolution of 20 cm.

The Z+F IMAGER\textsuperscript{®} 5010 TLS has a beam divergence of 0.3 mrad, detectable range of 0.3 m to 187 m, and a field of view of 320° \(\times\) 360°.

3. METHODOLOGY
3.1 Manual Classification of TLS Point Data
The TLS points belonging to single trees were manually classified as tree class by iteratively identifying the cylinder-shaped tree trunk feature (Figure 2(A)) and region growing, based on visual inspection, toward the upward or downward directions of the tree trunk. The height of tree trunk were also used to further classify the trees as canopy layer or understory layer; where the former and latter are sometimes called the dominate tree and non-dominant tree, respectively (Figure 2(B)).

Because the leaves usually cluster in groups, the TLS points showed clustering pattern were first identified as leaves and then assigned, respectively, to the nearest tree, which belonged to the canopy layer or understory layer (Figure 2(C) and (D))
3.2 Gap fraction

To compute the gap fraction, the synthetic fisheye images were generated using the classified TLS point data follow Morsdorf et al. (2006), Danson et al. (2007), Alberto, et al. (2013). The gap fraction, \( G(\theta_z) \), for the zenith angle of \( \theta_z \) were computed according to

\[
G(\theta_z) = 1 - \frac{x_{\theta_z}}{m_{\theta_z}}
\]

where \( x_{\theta_z} \) = the number of fisheye image pixels with TLS point present at the zenith angle of \( \theta_z \),

\( m_{\theta_z} \) = the total number of fisheye image pixels at the zenith angle of \( \theta_z \).

4. RESULT AND DISCUSSION

Figure 3(A) – 3(C) and 4(A) – 4(C) show the classified TLS point data for April and August 2014, respectively, where the canopy layer are denoted as purple and understory layer are denoted as green. Figure 3(D) – 3(F) show the synthetic fisheye images of canopy layer and understory layer for April 2014 data, respectively. Figure 4(D) – 4(F) show the same results for August 2014 data.

Figure 5(A) and 5(B) show the gap fraction of April and August 2014 data, respectively. The gap fraction derived from combined canopy and understory layer between April and August show significant difference for the zenith angles greater than 50 degree. Different pattern of gap fraction for canopy layer alone and understory alone are also significant between April and August 2014.
Figure 5. The gap fraction for (A) April and (B) August 2014 data.

REFERENCES


