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High-resolution Pixel-based Remote Sensing for Forest Functionality and Diversity

Xia Cheng*

Department of Key Laboratory of Intelligent Infrared Perception, Shanghai Institute of Technical Physics, Chinese Academy of Sciences, Shanghai 200083, China

Introduction

Research on plant ecology and biodiversity has increasingly used trait-based methods and remote sensing. Remote sensing permits assessing functional qualities over vast contiguous areas, in contrast to traditional field survey (which often samples individual trees), but assigns trait values to biological units like as Using pixel-based techniques is challenging for both species and individuals. We compared a pixel-based method with a technique based on aerial LiDAR-delineated Individual Tree Crowns (ITCs) for evaluating functional features from remote sensing data in a subtropical forest setting in China. As pixel size and extent varied, we examined the trait distributions, trait-trait correlations, and functional diversity metrics produced using the ITC- and pixel-based techniques. We discovered that physiological differences between ITC- and pixel-based techniques were overshadowed by variations in morphological features determined from airborne laser scanning.

Research on plant ecology and biodiversity increasingly uses trait-based methods that concentrate on the functional traits of vascular plants within a community Remote sensing makes it possible to quantify functional qualities over vast, contiguous areas in comparison to traditional field survey, which often samples individual trees. However, pixel-based methodologies make it challenging to attribute trait values to biological units like species and individuals. In order to evaluate functional features using remote sensing data, we compared an approach based on LiDAR-delineated Individual Tree Crowns (ITCs) with a pixel-based approach using a subtropical forest landscape in China. In order to compare the two techniques' results at altering granularity and extent, we analysed trait distributions, trait-trait connections, and functional diversity indicators. We discovered that the differences between morphological characteristics obtained from airborne laser scanning were greater.

We discovered that physiological traits calculated using airborne Pushbroom Hyperspectral Imager-3 (PHI-3) hyperspectral data showed less variation than morphological attributes collected from airborne laser scanning. Similar results were obtained using pixel sizes that approximated average tree crowns, however in comparison to ITC-based values, 95th quantile height, foliage height variety, and leaf area index tended to be overestimated. The disparities to ITC-based trait values grew bigger and less trait variance was captured as pixel size increased, indicating information loss. As pixel sizes increased, the consistency of ITC- and pixel-based functional richness likewise dropped and changed in accordance with the extent that was found for functional diversity monitoring. We come to the conclusion that high-resolution ITC-based techniques allow for the partitioning of variance between individuals, genotypes, and species [1].

In October 2013, a Yun-5 turboprop aircraft equipped with a Leica ALS70-HP system was used to collect the LiDAR data during the leaf-on season. Using a 0.15 mrad laser, the aircraft soared about 1800 metres above the earth. Resulting from beam divergence, the footprint had a diameter of around 0.27 m. The mean point density in the studied region was 9.05 points per square metre, and the maximum scan angle was 17 degrees from the nadir. As LAS 1.3 format files with noise filtering and point cloud categorization, multiple echo recordings (1–5 returns) were provided. In order to determine the morphological characteristics of ITCs and pixels, the elevation of the point clouds was normalised based on the DEM [2].

***Address for Correspondence:** Xia Cheng, Department of Key Laboratory of Intelligent Infrared Perception, Shanghai Institute of Technical Physics, Chinese Academy of Sciences, Shanghai 200083, China; E-mail: cheng.xia00991@uqu.edu.sa*

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Description

We estimated the Coefficients of Variation (CVs) of each trait over the research region and compared the between-unit variance of traits at increasing pixel sizes to determine how grain size influences the variability of functional traits (3-300 m). Because of the difference between units, the between-unit trait variability can be characterised as one-dimensional functional diversity or the degree of trait dissimilarity. We also combined changes to grain and extent to test the correlation between pixel-based functional richness and ITC at a particular neighbourhood extent when using high- to medium-resolution satellite images (3-30 m). We evaluated functional richness for ITC- and pixel-based features at various spatial extents to guarantee a constant sample size for all scales. Within the study region (300 m inward buffer), 1000 points were produced at random, and the ones in non-forested areas were deleted. There were three different pixel sizes: 3, 5, 10, 15, 20, and 30 m. For the purpose of calculating functional richness, a circle had to have at least 9 pixels inside it and a minimum radius of 9-294 m with a step of 7.5 m. In order to assess the consistency of ITC- and pixel-based functional richness, Pearson correlation coefficients were used [3].

Pixel-based functional traits

When compared to the spatially continuous pixel-based trait maps, the ITC-based morphological and physiological traits showed more between-crown gaps. The ITC- and 3-m pixel-based H95, LAI, and FHD had Pearson correlation coefficients for morphological characteristics of 0.95, 0.65, and 0.62, respectively. The median values of pixel-based H95 and FHD (13.54 m and 0.95) were higher than the ITC-based values (13.25 m and 0.82), While the median value of pixel-based LAI (2.60) was lower than the ITC-based LAI (2.96) according to the histograms of traits across the entire study area. Additionally, the histograms showed various shapes for morphological features dependent on ITC and pixels [4].

In order to determine how well ITC-based traits matched pixel-based traits at a resolution corresponding to the size of tree crowns, we performed linear correlations (3 m side length). We matched each ITC with the pixel that was the closest to the location of the treetop since ITC polygons were not always contained within one pixel. To further examine the distribution differences between ITC- and pixel-based features, we examined the frequency histograms of each (with the same bin width and anchor locations). The centre and spread of the trait distribution were specifically described using the median and Interquartile Range (IQR) values. In order to determine whether trait-trait connections consistently persist between ITC- and pixel-based estimations, we additionally evaluated trait-to-trait associations by generating Pearson correlation coefficients with two-tailed p-values [5].

Conclusion

The scale dependence of functional diversity and the spatial pattern of community assembly were examined by looking at the correlations between functional richness and area. For these sample locations, we estimated functional richness based on the observed and null-model situations. The locations of all ITCs and pixels within the research region were shuffled at random (randperm, Matlab) in order to create the null models. We examined whether these two methods produced the same community assembly patterns for ITCs and 3-m pixels by comparing the observed and null functional richness-area connections (i.e. trait convergence or divergence). We might gain insight into the relationships and distinctions between species-level and community-level functional trait assessments through our comparison of the ITC- and pixel-based approaches. Insights into upscale functional features could potentially be obtained from data aggregation to ITCs and pixels. In many nations, aerial data are currently typically accessible at regional scales to supplement ground surveys. By giving more model training data and aggregating to the grain size matching with satellite imagery, they can capture fine-scale trait variation and then combine with satellite data to scale-up functional diversity assessments. It would be beneficial to use intermediate-scale airborne data to fill the gap between local ground plots and regional or global spaceborne data because spatial aggregation of high-resolution airborne data could increase the representativeness of trait heterogeneity over larger areas.

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