3D Modeling of Urban Tree Crown Volumes Using Multispectral LiDAR Data

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SUMMARY

Urban trees play an important role in urban climate modification, energy conservation, and environmental sustainability in various ways. Urban trees contribute the largest proportion of carbon storage that reduces climate warming and urban heat island effects by sequestering carbon dioxide and storing carbon in biomass. This paper presents our recent development of the method and software tools for 3D modeling of urban tree crown volumes. Our method consists of three main steps: multispectral LiDAR data processing, vegetation isolation, and estimation of dendrometric parameters. First, the raw multispectral LiDAR point cloud data is intensity-rectified and filtered to generate a normalized Digital Surface Model (nDSM). Second, vegetation covers are isolated by the support vector machine (SVM) classifier using multispectral LiDAR intensity information at wavelengths of 532 nm (Green), 1064 nm (Near-infrared, NIR), and 1550 nm (Shortwave Infrared, SWIR), respectively, and nDSM, in which total six classes including two vegetation classes (grass and tree) are classified. Individual tree crown is delineated by local maxima filtering and marker-controlled watershed segmentation. Third, tree height and crown width are derived from the crown segments and compared with field measurements. The multiple linear regression model is then developed to predict field-measured diameter at breast height (DBH) using LiDAR-derived tree height and crown width and assessed by cross validation. A total of 40 trees are sampled in the field that four attributes: height, crown width, DBH, and biomass are recorded for each single tree.

The results show that the land cover classification with multispectral LiDAR intensity images and nDSM achieves above 90% overall accuracy. The result of local maxima filtering is improved by using both multispectral LiDAR intensity and nDSM as input data. The LiDAR-derived tree height has a root mean square error (RMSE) of 1.21 m (relative RMSE = 6.8%) and the LiDAR-derived crown width has a RMSE of 1.47 m (relative RMSE = 16.4%). The prediction performance of the

ALS-DBH model achieves R^2 over 0.80 with a RMSE of 4.6 cm. Our results suggest that the LiDAR-based dendrometric parameter estimation can yield consistent performance and accurate estimation.