A COMPARATIVE STUDY OF POLARIMETRIC AND NON-POLARIMETRIC LIDAR IN DECIDUOUS-CONIFEROUS TREE CLASSIFICATION

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ABSTRACT:

As an active remote sensing tool, lidar has become more and more popular. One of the applications of lidar is in forest remote sensing, which includes above ground biomass detection, canopy structure detection, tree height measurement, among many others. Recently, there was one particular application that drew wide attention in forest remote sensing, which was to identify tree species at either individual tree level or dominant species level [1]. This research could help us better understand the forest ecosystem and plan a better forest management strategy.

Most research focus on the application of airborne small-footprint laser altimeters. One approach is to look at the reflectance pattern of the tree crowns and classify the pattern based on tree height, crown shape, first and last return, etc. [2]. Many modern laser altimeters also provide the so-called intensity measurement data. Such data reveals the reflectance information of tree canopy. Combined canopy structure data with intensity data, classification of Douglas-fir, western larch, ponderosa pine, and lodgepole pine was achieved [3].

However, with the development of multiwavelength and polarimetric lidar, more information can be used toward tree species identification [4]. For example, multiwavelength capability provides spectral reflectance of tree crown at several different wavelengths; while polarimetric capability provides the polarization state of the backscattered laser. Such data could be used to better characterize the tree under study, and can potentially lead to more accurate classification.

The lidar system used in this study is the Multiwavelength Airborne Polarimetric Lidar (MAPL) developed at the University of Nebraska [5]. The MAPL system employs a Nd:YAG laser at 1064-nm and 532-nm. The two beams are both linearly polarized and are emitted simultaneously. There are four photomultiplier tube (PMT) detectors that detect the backscattered light at both wavelengths along the co-polarized and cross-polarized directions. The entire waveforms at these four detectors are recorded simultaneously. We used ground data collect at various sites in South Dakota in this study. The tree data were collected from ponderosa pine, blue spruce, Austrian pine, maple,

and green ash. In order to compare the performance of a polarimetric lidar and a non-polarimetric lidar at the same capacity, data from a non-polarimetric lidar were simulated using the MAPL data. Specifically, data coming from the co-polarized and cross-polarized detectors are added together to simulate the signal that would come from a non-polarimetric lidar sensor.

The lidar data were analyzed using principle component analysis (PCA). Figure 1 and 2 shows the data distribution for each tree species under the polarimetric and non-polarimetric situation. Then the first and second principle components were passed to an artificial neural network (ANN) which performs classification. In each case, half of the data were used as training data set in order to train the ANN. The other half of the data were used as testing data to check the classification accuracy.

This study clearly demonstrated that under otherwise similar situations, the polarimetric lidar will perform much better than the non-polarimetric lidar for deciduous-coniferous tree classification. Further study requires collecting more field data on more tree species and also a strategy to classify either individual tree or dominate tree species. This technique is particularly useful for a medium to large footprint lidar with low spatial data density, which is expected from a high altitude or satellite lidar system.

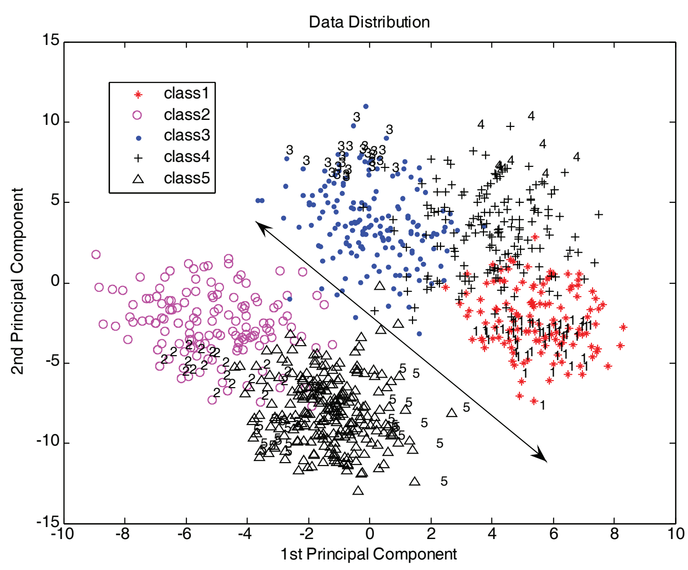

Figure 1. Scattered data plot after PCA analysis for polarimetric lidar data. A clear boundary is observed between the coniferous and deciduous trees (in this figure, class1 represents blue spruce, class 2 represents green ash, class 3 represents ponderosa pine, class 4 represents Austrian pine, and class 5 represents maple.).

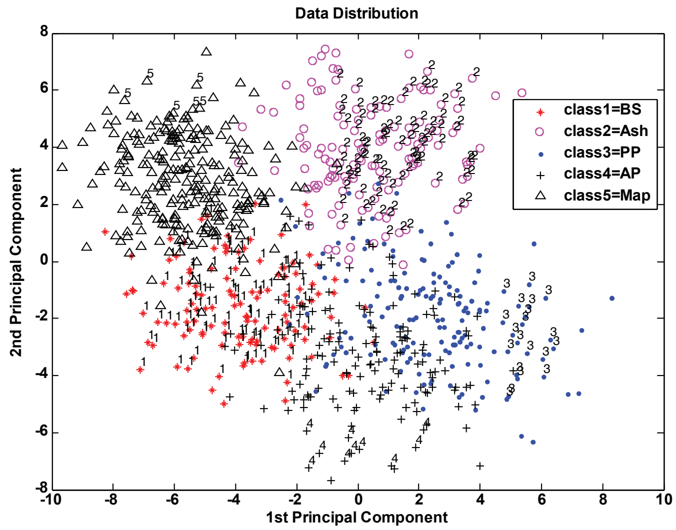

Figure 2. Scattered data plot after PCA analysis for non-polarimetric lidar data. A clear boundary between the coniferous and deciduous trees can not be easily obtained (in the figure, class1 represents blue spruce, class 2 represents green ash, class 3 represents ponderosa pine, class 4 represents Austrian pine, and class 5 represents maple.).

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