LiDAR Point Cloud Analysis using 3D Shape Descriptors with Zernike Moments

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Introduction

This poster presents a method for tree classification using only shape information. Using a Zernike moment shape descriptor and a decision forest classifier we obtain an accuracy of up to 82%.

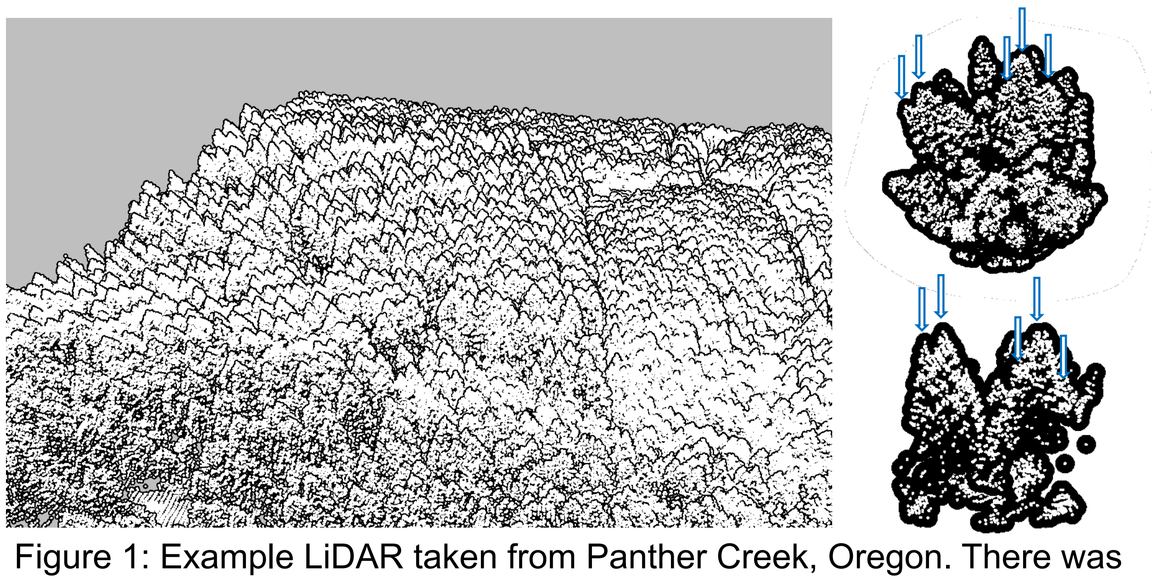


Figure 1: Example LiDAR taken from Panther Creek, Oregon. There was no color data available.

Methods

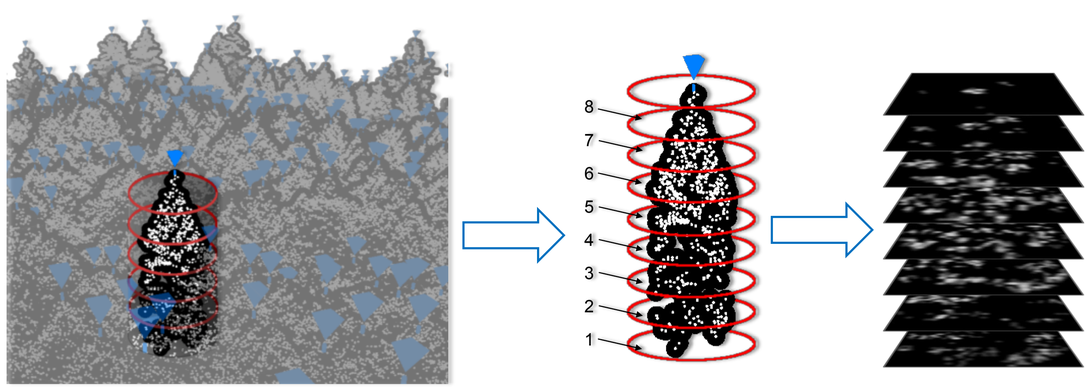


Figure 2: When building a model shape descriptors are centered on trees using ground truth. Height bins are created, which are then projected down into 2D images.

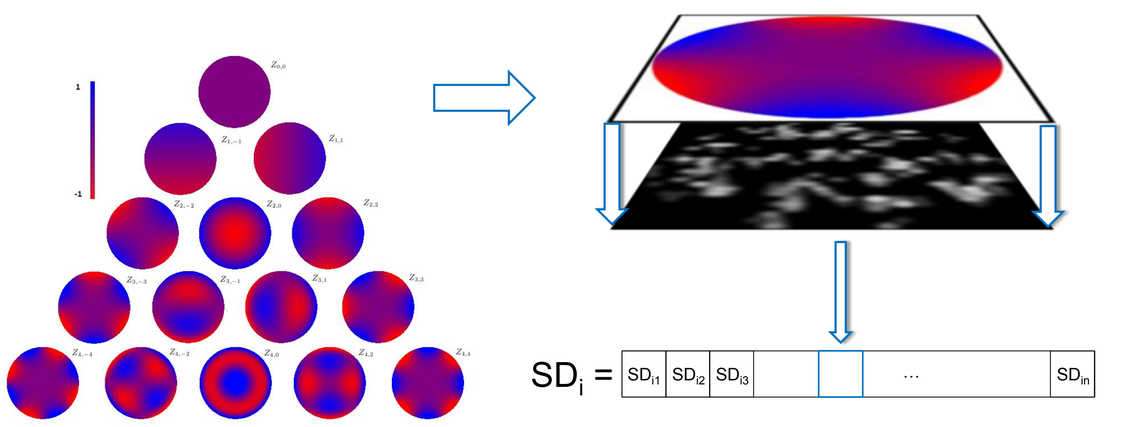
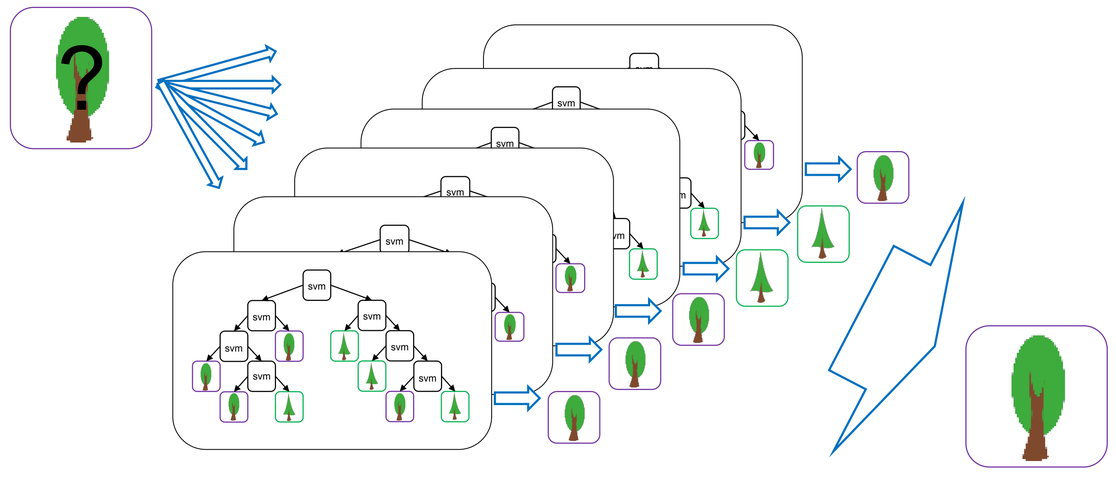


Figure 3: Zernike Polynomials can decompose a 2D image into a series of complex numbers called Zernike Moments, like a Fourier Transform decomposes a signal. Zernike moments are rotationally invariant, but not scale or translation invariant. Our shape descriptor is a vector of 240 Zernike Moments.

$$R_{n,m}(\rho) = \sum_{s=0}^{n-|m|/2} \frac{(-1)^s (n-s)! \rho^{n-2s}}{s!(\frac{n+|m|}{2}-s)!(\frac{n-|m|}{2}-s)!}$$

$$Z_{n,m}(\rho,\theta) = R_{n,m}(\rho) exp(im\theta)$$

Figure 4: Zernike polynomials are only defined for the unit circle. n, m are the order and repetition respectively and are determined by the pattern in Figure 3.



We used a forest of random decision trees. Each decision tree was trained on a randomized subset of the test data using a randomly chosen subset of features. The ratio of positive and negative examples was enforced for each decision tree.

Results

75% of trees in the ground truth were Douglas Fir, which lead to a large imbalance between class sizes. We also experienced much better performance when only dealing with binary classifiers.

Test	Accuracy	F-measure	Precision	Recall
Coniferous vs Deciduous Total Accuracy:80.1%				
Coniferous	80.3	87.2	94.0	81.3
Deciduous	79.2	62.3	51.4	79.2
Douglas Fir vs Western Hemlock Total Accuracy:82.0%				
Douglas fir	81.6	89.7	98.7	82.3
Western Hemlock	86.8	44.0	29.5	86.8
4 Way Classifier Total Accuracy:58.8%				
Douglas Fir	58.0	72.5	94.6	58.8
Western Hemlock	60.0	29.1	19.2	60.0
Red Alder	62.0	51.1	43.6	61.8
Bigleaf Maple	60.0	34.9	24.6	60.0

Conclusions

We have demonstrated the effectiveness of a shape descriptor incorporating Zernike moments.

Future Work:

- Semi-supervised Learning
- Explore Boosting as a classifier and dimensional reduction
- Better model to account for failure cases and sub canopy trees

Bibliography

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