Colorful Math: Developing Algorithmic Methodology to Visualize and Analyze the Dynamics of a Deciduous Tree

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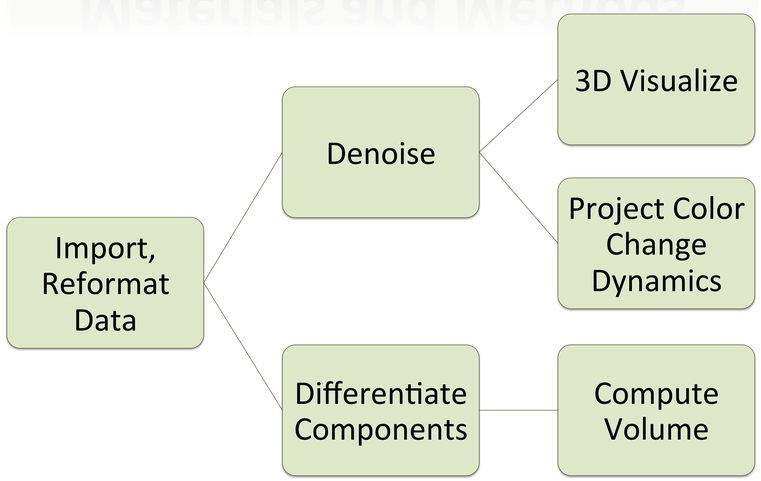
REU Site: Collaborative Data Visualization Applications

Abstract

The purpose of this study is to determine if it is possible to use LIDAR (light detection and ranging) point cloud data collected using a FARO Focus3D laser scanner to: 1) generate a high quality 3D virtual representation of a scanned tree and reduce noise due to environmental variability; 2) develop an algorithm to differentiate between different sections of trees based on RGB values associated with these point clouds and calculate the respective volumes of these sections; and 3) project leaf color change dynamics over time. The visualization tools used are Matlab, R, Unity3D, and ParaView. Additional analysis was done with a high performance computing cluster (Clemson University's Palmetto cluster). The data is of an American Sycamore *Platanus occidentalis* over a period of eight weeks as the tree transitions from fall into winter. The conclusions of this study have implications in establishing innovative approaches to three-dimensional tree dynamic measurement using advanced technology and tools. These approaches can provide the baseline information of a forest structure for greater understanding of how a tree changes seasonally, as well as outlining methodology for making laser scanning software and Matlab's Image Processing Toolbox more flexible to use. The visualization aids in this study can inform and be used to estimate with greater precision the effects that disturbances, such as fires and hurricanes, have on forest structures.

Materials and Methods



Results and Discussion

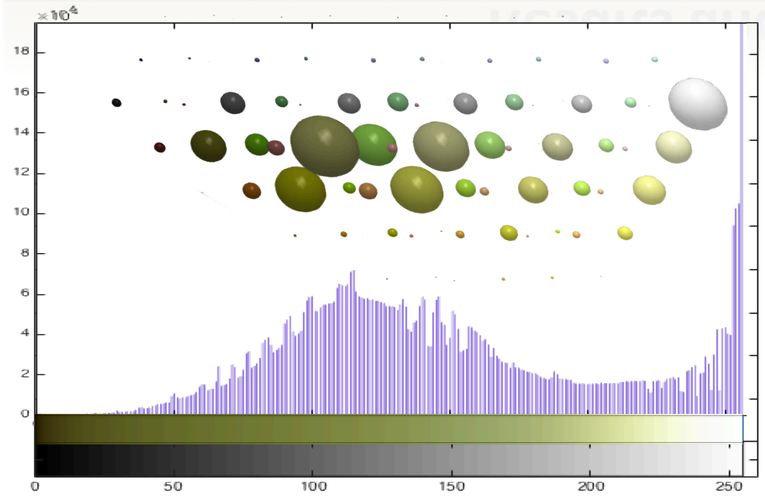


Figure 1. Week 0 data: 3D RGB color distribution visualization overlaid onto grayscale conversion histogram.

Leaf color change dynamics over time were visualized by generating 3D RGB histograms, one of which is overlaid on Fig. 1. These also histograms were found to provide great insight into the denoising process.

Natural neighbor Delaunay triangulation was used for volume computation. Further optimization is required for handling bare tree data due to systematic error. Results for data weeks with full crowns are consistent with those found using destructive volume calculation methodology. Tree components were differentiated and respective volumes found. Using piecewise volume computation yielded more accurate results by addressing slight overestimation issues associated with the algorithm.

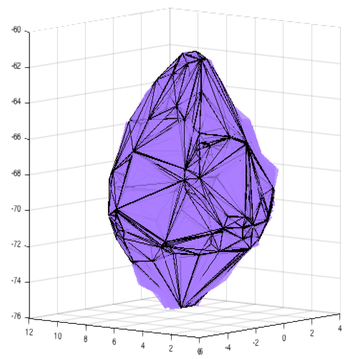


Figure 2. Natural neighbor Delaunay triangulation algorithm for volume.

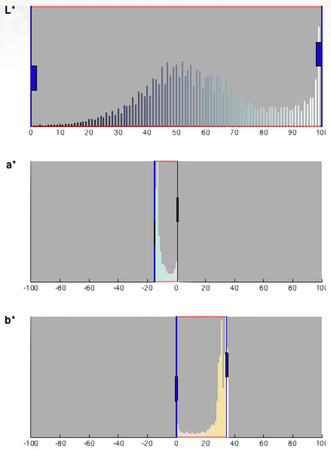


Figure 3. L*a*b* color space user interface while denoising.

The L*a*b* color space in Matlab's *Color Thresholder* application was found to be most effective in both denoising and differentiating tree components. Converting the data to grayscale supported the hypothesis that environmental variability caused the data to be noisy. Additional support was gained by analyzing the color distribution of veil illuminations present in some photographs taken by the scanner; the color distribution of the artifacts corresponded to the RGB ranges believed to be noise.

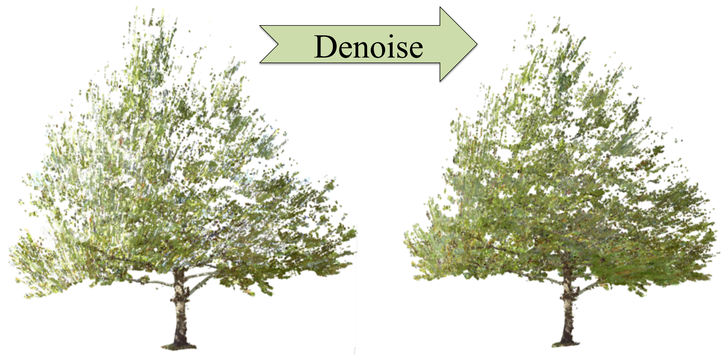


Figure 4. Point cloud data plotted in R before(left) and after (right) denoising.

Conclusion

This research project improves the flexibility of laser scanning technology via supplementary Matlab scripts. It also shows that the default capabilities of the Image Processing Toolbox can be exploited to handle 3D point cloud data. Currently, this application is only branded for use with video and images. The research team accomplished the objectives of this study using this application in spite of its branding. Furthermore, this study suggests that differentiating tree components based on RGB values and using piecewise algorithmic computation yields more accurate volume estimations than Delaunay triangulating the point cloud as a whole.

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