Approximation of volume and branch size distribution of trees from laser scanner data

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Laser scanners can be used to produce point clouds from the object's surface and thus to produce a 3D-representation of the object. The point clouds are finite sets of points of the Euclidean space $\mathbb{R}^3$ and they form a sample of the object's surface. We analyze laser scanner produced point clouds from trees and propose a method to automatically extract useful information from the point cloud sample. Particularly, we try to approximate the total over-the-ground volume and branch size distribution of the tree.

The method we propose has three separate parts. The first part of the method is to approximate the mathematical structures of the surface embedded in $\mathbb{R}^3$ from the point cloud sample. The true surface we try to estimate is the result of a stochastic process and as such is not smooth. However, we assume that it can be reasonably approximated by a smooth surface. Then the metric, topology, and tangent spaces of the surface are approximated using the Euclidean metric of the embedding space $\mathbb{R}^3$.

In the second part we identify trunk and branch points from the point cloud sample. The identification is based on strong assumptions about the data and above all geometric characterization of the point's neighbourhoods. Particularly, we define small neighbourhoods of some radii for every point and then calculate the scatter matrices of the neighbourhoods. The eigenvalues and eigenvectors of those matrices give geometric information about the neighbourhoods that can be used to identify the trunk and branch points.

The third part of the solution is the approximation of the size of the trunk and branches. The approximation is based on the assumption that the tree can be reasonably approximated locally as a cylinder. In other words, we assume that the tree can be subdivided into appropriate subsets which can be approximated well with cylinders of different radius, length, and orientation. We use geometric information of neighbourhoods to recognise smaller branches of a bigger branch and ultimately to define the appropriate subsets. Then we use the total least squares method for fitting cylinders to these subsets.

We present the problem and the basic ideas of the three part solution. Also challenges such as incomplete data due to limited scanner positions are discussed. Finally we present some calculations from real data and compare them to measured result.