DETECTION OF STREET TREES IN MOBILE LASER SCANNING POINT CLOUDS BASED ON SUBDIVIDED DIMENSIONAL FEATURES

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ABSTRACT:

Those street trees which dangerously overhang the sidewalks and public roads may distract visibility of road signs and lamps or even injure pedestrians. Monitor vegetation encroachment using mobile laser system is one efficient measure for vegetation growth management and preventing accidents above under low labor costs. This paper presents a new workflow for automated detection of street trees in a typical urban environment from 3D point cloud data acquired by a mobile laser scanning system. Our study aims at deriving a street vegetation map layer as well as single tree parameters (e.g. tree height and crown width) in an efficient way. Our newly developed algorithms and software tools provides access to 3D MLS point cloud analysis.

Our method starts the removal of ground points followed by Euclidean distance clustering. After marking individual object, the eigenvalues of neighborhood covariance matrix and the corresponding normalized centroid distance are computed for every point of an object, and we subdivide each point into five categories instead of three so that the adaptability of geometric descriptor (dim-features) can be improved. Finally, the geometry component proportion of one object will be counted as feature vector for recognition by SVM (Support Vector Machine) to achieve tree object.

The processes include pre-processing, features extraction and objects recognition as shown in Figure 1, and the method is detailed as follows.

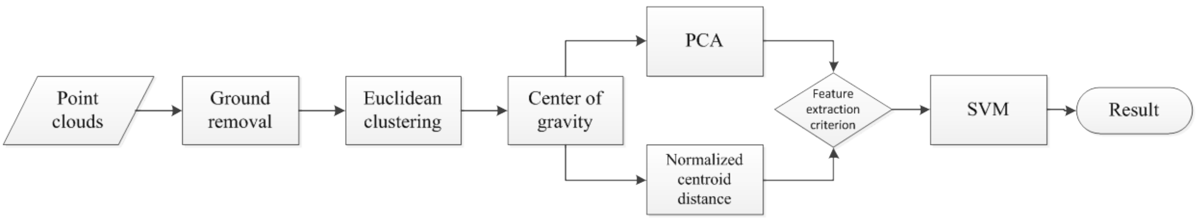

Figure 1. Work-flow for street tree detection

In pre-processing, we firstly segment target located above the ground by removing ground points (Yu's method which counts the voxel which in accordance with upward growth rule) and Euclidean distance clustering as Fig. 2(b), then each individual object will be marked as an unknown target.

In feature extraction, we calculated the normalized centroid distance and three dimensional features for every point of one marked object. The normalized centroid distance d is defined as the Euclidean distance between the center of gravity and the furthest point (radius R in general) within the neighbourhood of interest point:

$$d = \left\| p - \frac{1}{m}\sum_{i=1}^{m} p_i \right\|_2 \Big/ R$$

where p denotes the Cartesian coordinate of interest point $p = (x_1, y_1, z_1)$. This equation means the location measures of interest point on its local geometry. Because the computation of gravity is inevitable step for Principal Component Analysis, it will not add new computational burden. Then the principal component analysis (PCA) will be implemented and normalized eigenvalues $(\sigma_1, \sigma_2, \sigma_3)$ of covariance matrix of interest point will be obtained. By this way, one point can be redescribed as a vector $(\sigma_1, \sigma_2, \sigma_3, \mathrm{d})$. According to the value of vector, a criterion will be set for classifying every point into five categories as linear point, edge point, planar point, surface point and scattered point, respectively.

The recognition approach proposed in this paper includes two parts: geometry components statistics and SVM classification. Firstly, we count points number in each geometric category on an object, then proportion of five geometric categories of one object will be obtained as the feature vector which stands for the inherent geometrical attribution. Secondly, we choose manually several

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ideal tree models from point clouds ground truths as standard training datasets for SVM, and each marked object of processed data sets will be used as feature expression for recognizing street tree.

In conclusion, our method provides feasibility to detect street trees within a constant scale and without adding too much calculation. The street trees are pointedly described by restraining planar features and surface expression, the result shows our proposed algorithm is effective in more complex scene. As shown in the Figure 2, (c) shows the feature extraction displayed by colour coding, where the surface parts (trunks) are purple and planar parts are grey (Bus Stop), leaves are consisted of surface points outside and scatter points (green) inside. Edge points (cyan) shows the roughness and linear points (yellow) mean the shaft. (d) and (e) clearly show the features distribution in building(planar as grey and edge as cyan) and vegetation (green and purple).

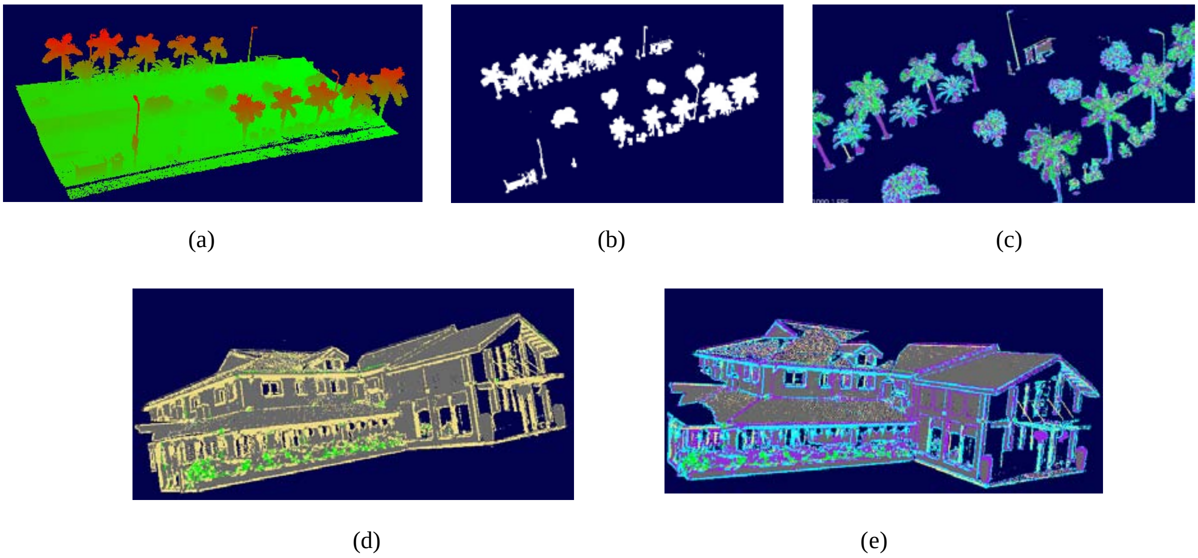

Figure 2. (a) Original MLS point clouds, (b) Results after removing ground points, (c) Features extraction on street trees, (d) and (e) Result comparison of the three dimensional features and our proposed algorithm