Promotionsthema

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Reconstruction and monitoring of urban trees based on dense 3D point clouds

In view of the increasing trend of urbanization, the management and functionality of growing cities is of great interest to municipalities and citizens. Although many people may see a city as highly technological, inanimate structure, a large amount of vegetation and nature can be found in urban environments. The most characteristic plants are trees placed along streets and all over the city. Whereas buildings and streets are static necessities, trees are dynamic organisms being responsible for a good microclimate and wellbeing of the residents, and also a habitat for a manifold of species. Since the appearance of a city is highly influenced by its tree population, urban planning has to consider trees in development and conservation of existing individuals. Moreover, as trees will change over time and might require more space, their growth and extent have to be monitored constantly. Also possible dangers caused by instable trees have to be considered in addition to potentially shadowed areas. All these reasons show that the individual tree in a city is of remarkably greater importance than the individual tree in a forest.

Therefore, techniques for a reliable monitoring of individual trees have to be developed. Some municipalities already use so-called tree cadasters to keep track of their tree population. The challenge is to keep these registers up to date and to gather detailed information on the status and growth of the trees. Especially, parameters like diameter at breast height, crown and tree height, and crown volume are valuable measures. One way of acquiring these data is Mobile Laser Scanning (MLS). It allows precise and easily repeatable measurement in urban street canyons, leading to dense three-dimensional point clouds of building facades and surrounding vegetation which are useful in many other applications, too.

Thus, the main goal is the interpretation of dense point clouds in regard to modeling and monitoring of urban trees. In addition to the assessment of their respective current state, a prediction of the future tree growth shall be investigated. The process can be divided into three steps: First, the individual trees have to be isolated from the acquired point cloud. Here, the viability of a graph-based approach in connection with voxel or supervoxel structures shall be examined. Second, having isolated the point cloud of each single tree, the reconstruction shall be done by simulating its natural growth. Skeleton-based methods or statistical description with for example Lindenmayer systems are promising. These have to be extended by a volumetric modeling that also leads to parameters like trunk diameter and crown volume. Nonetheless, the branching itself is important to assess future growth and extent of the tree. Finally, with each tree modeled and parameterized, the respective tree object will have to be found again in later measuring campaigns. The comparison of the objects in the georeferenced point cloud shall be done by a robust matching of tree candidates. Hence, changes can be detected and analyzed. This can lead to a growth model describing the expansion behavior in the past and in the future.

For the experiments, mobile laser scanning data of an urban environment covering an area of about 1 km² in Munich are available and partly labeled, so that the approaches can be validated. We expect to gain a complete process utilizing MLS to derive a realistic, fully automated 3D rendering of segmented single trees with descriptive parameters to be included in tree registers and 3D city models. Moreover, we expect insights on the influences of external conditions on our reconstruction, such as season or the viewing direction. Meaningful measures to ensure reliable change detection in between two acquisition epochs have to be provided and might lead to predictions of future growth. It is to be evaluated whether sufficient detail can be reached by the current acquisition methods and if the presented approaches might be transferable to the clearance of other infrastructure elements like railroad lines.