Semantic Segmentation of Dense Point Clouds

Martin WEINMANN

Institute of Photogrammetry and Remote Sensing, Karlsruhe Institute of Technology
martin.weinmann@kit.edu

For us humans, the visualization of a dense point cloud already allows reasoning about specific properties of a considered scene. On the one hand, a diversity of objects such as buildings, ground, road inventory, cars or vegetation can easily be detected by solely considering the spatial arrangement of 3D points. On the other hand, the human capability to detect a diversity of objects is rather robust to occlusions, strongly varying point density and an irregular point sampling. Accordingly, it seems desirable to transfer such a capability to automated systems. In this regard, each 3D point of the point cloud should be uniquely assigned with a semantic label. Thereby, a respective approach should also be capable of coping with local variations in point density and irregularly distributed 3D points, which are for instance given when considering different types of point clouds derived via terrestrial or mobile laser scanning, airborne laser scanning or multi-view stereo reconstruction.

To achieve a semantic point cloud labeling via automated systems, different concepts have been presented. In this regard, many scientific and application-oriented investigations focus on assigning a semantic class label to each 3D point of a considered point cloud by involving a standard classification technique. Thereby, the classes of interest need to be defined in advance and may for instance be given by Wire, Pole/Trunk, Façade, Ground and Vegetation. The class labels thus represent object categories and are not specific for each single object in the scene. When focusing on such a semantic classification task, the number of defined object classes and the similarity between the classes typically play an important role, and the involved features have to be sufficiently distinctive to allow for distinguishing between the defined object classes. In contrast, there are also numerous investigations which aim at providing a meaningful partitioning of a considered point cloud into smaller, connected subsets corresponding to objects of interest or to parts of these. For this purpose, a variety of clustering techniques may be applied which deliver numerous segments exhibiting a homogeneous behavior with respect to a pre-defined criterion. Based on the corresponding characteristics, the derived segments are then assigned a respective semantic label, whereby a labeling with respect to object categories is typically pursued. However, it may also be desirable to assign point-wise labels that are both class-aware and instance-aware (i.e. each 3D point is assigned a semantic class label indicating one of the defined object categories and an instance label indicating the respective object in the scene). This task is commonly referred to as an instance-level segmentation.
In the scope of this presentation, the focus is put on the semantic segmentation of dense point clouds with hundreds or thousands of 3D points per m² and different strategies that can be followed to achieve such a semantic segmentation. First, the rather classical strategy for semantic point cloud segmentation is considered, which is based on the use of hand-crafted features provided as input to a supervised classification technique. After the pre-processing of acquired data to address signal noise and varying point density, the focus is put on the extraction of appropriate geometric and radiometric features. In this context, different options for defining local neighborhoods as the basis for extracting geometric features are discussed. Based on the defined set of features, the benefits of involving feature selection techniques are explained. Such techniques allow reasoning about the relevance of single features and feature (sub)sets with respect to the considered classification task. The selected features serve as input for classification, where classifiers relying on a diversity of learning principles may be exploited. This includes standard classifiers for point-based classification as well as more complex classifiers for context-based classification. Subsequently, the strategy for semantic point cloud segmentation relying on the interplay between traditional classification and segmentation techniques to assign point-wise labels that are both class-aware and instance-aware is presented. Beyond such conventional strategies, particularly the strategy of involving modern deep learning techniques for semantic point cloud segmentation has recently been followed. Consequently, the last part of this presentation addresses a brief overview of approaches involving deep learning techniques.

References


