Automatic Segmentation of Structural Elements from 3D Point Cloud: The Case of Occupied Multi-Storey Building

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Abstract of Dissertation

Point clouds obtained from built assets have become increasingly popular in various tasks including heritage conservation, renovations, building maintenance, progress monitoring in construction sites, and urban planning. One of the desirable features of point clouds is the entailment of a highly detailed and accurate geometric representation of the acquired scene or object, which makes it suitable for many. However, raw point clouds contain unordered 3D points and hence lack semantic information about objects, which can limit their usability for further applications. In addition, point clouds acquired from the existing buildings contain diverse and large amounts of occlusions which further complicates its use. Thus, it is essential to extract relevant information about the building features from the point clouds about the building features.

The main goal of this thesis is to propose a robust method of segmenting structural elements from point clouds without being affected by the noise or occlusions present in the environment. The contribution lies in three major aspects: the development of octree-based infrastructure to extract the important features from a point cloud; the identification and merging of the candidate surface patches for the structural elements; and the classification of the identified patches into segments of generic structural elements.

The proposed segmentation method starts with extracting small-sized surface patches from the created voxels, and empirically joining the adjoining patches sharing similar local features. This process returns patches including disconnected patches due to the presence of occlusions and noise in the scene. In the second part, a robust technique is developed to merge the disconnected patches that represent similar surfaces of structural elements. The third part includes classifying and segmenting the merged into class elements which are: floor slabs, floor beams, walls, and columns. A novel classification method was used utilizing the concept of spatial dependency of elements in the structural systems of buildings.

The proposed method is tested on a large point cloud with high levels of occlusions and noise. The evaluation of test results has indicated a good general performance, especially for segmenting the floor slabs where 100% was scored on all the quantitative metrics. The floor beams and walls have shown promising performance with rates above 60% for precision and 80% for recall. The comparison tests were done against the state-of-the-art segmentation methods including the deep learning method where the proposed method has shown relatively good results, particularly for beams that normally are difficult to segment. The performance of the proposed segmentation was highly affected by the lack of a good number of paired planar patches due to occlusion(s) located on one side of the pair-set. Other limitations are discussed and potential areas for improving the study are narrated.