Permanent indoor structure detection in cluttered point clouds from indoor mobile laser scanners

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Abstract:

Manual creation of indoor 3D models is an expensive and cumbersome process for large buildings such as airports and hospitals. Indoor mobile laser scanning (IMLS) is a popular choice for data acquisition and generating 3D models. However, in spite of flexibility of IMLS systems the presence of occlusion caused by clutter in the point clouds is hindering indoor reconstruction. It is specifically challenging to automatically detect walls, subdivide the space to the rooms and distinguish between occluded parts and genuine openings. We present a method for wall detection and labeling of openings from IMLS point clouds in complex indoor environments. IMLS systems, besides point clouds, provide a continuous trajectory of device locations instead of few discrete station points in TLS. We exploit this trajectory for our purpose. Our approach has four main steps: 1. detecting doors, 2. subdivide the space to rooms, 3. use indoor topology knowledge to detect walls and 4. opening detection by means of occlusion test. The process initializes with voxelizing the point clouds. For door detection we detect voxels that represent door centers by means of three main rules: 1. Inside an open door there is empty space, 2. door center should be near a trajectory point, 3. above the door center there should be a specific amount of points as door top edge. By finding each door center and top edge we are able to find the left and right borders of the door. Next step is subdividing the voxels to empty space which is encapsulated by occupied voxels (clutter, walls). To reach this goal we store all empty voxels between floor and ceiling within a margin (e.g. 30 cm) of occupied voxels. This provides us with individual spaces between walls and clutter, while with already detected door locations we can subdivide them to the room candidates. The knowledge of the rooms and doors facilitates the wall detection process, since each room is enclosed with walls and doors. Our wall detection method offers a flexible approach by using topology characteristic of segments. To detect walls we implement a surface growing segmentation and then label segments which are connected to the floor or the ceiling and neighboring walls as wall candidates. This includes walls with non-Manhattan structure and non-vertical orientation. Segments with wall label are considered as input for the occlusion test which result in opening detection. We label voxels containing planar wall points as occupied, otherwise unoccupied. For the occlusion test we exploit the trajectory and by means of points position related to the wall we discriminate between gaps caused by occlusion and real openings. Results are wall voxels labeled as openings (door, windows), occluded (gap), occupied (wall) or unoccupied. The result of occlusion test can be cross-checked with door detection from first step to ensure the true number of detected doors. By further iterations after occlusion test the model would be improved. Further work is required to apply more topology and geometry rules to generate a complete CAD model.