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Editorial

3D Indoor Mapping and BIM Reconstruction Editorial

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Abstract: This Special Issue gathers papers reporting research on various aspects of the use of low-cost photogrammetric and lidar sensors for indoor building reconstruction. It includes contributions presenting improvements in the alignment of mobile mapping systems with and without a prior 3D BIM model, the interpretation of both imagery and lidar data of indoor scenery and finally the reconstruction and enrichment of existing 3D point clouds and meshes with BIM information. Concretely, the publications showcase methods and experiments for the Reconstruction of Indoor Navigation Elements for Point Cloud of Buildings with Occlusions and Openings by Wall Segment Restoration from Indoor Context Labeling, Two-Step Alignment of Mixed Reality Devices to Existing Building Data, Pose Normalization of Indoor Mapping Datasets Partially Compliant with the Manhattan World Assumption, A Robust Rigid Registration Framework of 3D Indoor Scene Point Clouds Based on RGB-D Information, 3D Point Cloud Semantic Augmentation for Instance Segmentation of 360° Panoramas by Deep Learning Techniques and the Symmetry-Based Coarse Registration of Smartphone's Colorful Point Clouds with CAD Drawings (RegARD) for Low-Cost Digital Twin Buildings.

Keywords: scan-to-BIM; BIM; SLAM; 3d reconstruction; lidar; semantic segmentation; pose optimization

1. Introduction

Indoor mapping and navigation are complex tasks that requires detailed and accurate data of the environment. The recent advancements in technology have enabled the development of efficient algorithms and models to overcome the challenges associated with indoor mapping and navigation. A series of papers have been published that present new methods and techniques for improving the quality and accuracy of indoor mapping and navigation.

The first paper, "Reconstruction of Indoor Navigation Elements for Point Cloud of Buildings with Occlusions and Openings by Wall Segment Restoration from Indoor Context Labeling" [1], presents a method for reconstructing indoor navigation elements for buildings with occlusions and openings. This method is based on the restoration of wall segments from indoor context labeling and can be applied to point cloud data. The authors demonstrate the effectiveness of their approach through experiments and results. The results show that the method can detect and reconstruct indoor navigation elements without viewpoint information. The means of deviation in the reconstructed models is between 0–5 cm, and the completeness and correction are greater than 80%. However, the proposed method also has some limitations for the extraction of "thick doors" with a large number of occluded, non-planar components.

The second paper, "Two-Step Alignment of Mixed Reality Devices to Existing Building Data" [2], proposes a two-step alignment method for mixed reality devices to existing building data including preexisting point clouds, meshes, imagery or BIM databases of a facility. This method is designed to overcome the challenges associated with the alignment of mixed reality devices to building data and provides a solution for accurately aligning mixed reality devices to building data. During the experiments, multiple time series of constructions are captured and registered. The experiments show that XR-captured data

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can be reliably registered to preexisting datasets with an accuracy that matches or exceeds the resolution of the sensory data.

The third paper, "Pose Normalization of Indoor Mapping Datasets Partially Compliant with the Manhattan World Assumption" [3], deals with the problem of pose normalization of indoor mapping datasets. The authors present a new method for normalizing the pose of indoor mapping datasets that are partially compliant with the Manhattan World assumption such as the S3DIS Stanford indoor dataset [CITE]. The method is based on the use of a Manhattan reference frame and can be applied to a variety of indoor mapping datasets. In the first step, a vertical alignment orienting a chosen axis to be orthogonal to horizontal floor and ceiling surfaces was conducted. Subsequently, a rotation around the resulting vertical axis was determined that aligned the dataset horizontally with the axes of the local coordinate system. The performance of the proposed method was evaluated quantitatively on several publicly available indoor mapping datasets of different complexity. The achieved results clearly revealed that our method is able to consistently produce correct poses for the considered datasets for different input rotations with high accuracy. The implementation of our method along with the code for reproducing the evaluation is made available to the public.

The fourth paper, "A Robust Rigid Registration Framework of 3D Indoor Scene Point Clouds Based on RGB-D Information" [4], proposes a robust rigid registration framework for small-scale 3D indoor scene point clouds. The framework is based on RGB-D information and is designed to be robust against occlusions and noise. First, the authors propose a point normal filter for effectively removing noise and simultaneously maintaining sharp geometric features and smooth transition regions. Second, a correspondence extraction scheme is proposed based on a novel descriptor encoding textural and geometry information, which can robustly establish dense correspondences between a pair of low-quality point clouds. Finally, a point-to-plane registration variant is implemented via a nonconvex regularizer, which further diminishes the influence of false correspondences and produces an exact rigid transformation between a pair of point clouds. Compared to existing state-of-the-art techniques, intensive experimental results demonstrate that the registration framework is excellent visually and numerically, especially for dealing with low-quality indoor scenes.

The fifth paper, "3D Point Cloud Semantic Augmentation: Instance Segmentation of 360° Panoramas by Deep Learning Techniques" [5], presents a new method for semantic augmentation of 3D point clouds. The method is based on deep learning techniques and can be used to perform instance segmentation of 360° panoramas. The authors first project the point cloud onto panoramic 2D images using three types of projections: spherical, cylindrical, and cubic. Next, they homogenize the resulting images to correct the artefacts and the empty pixels to be comparable to images available in common training libraries. These images are then used as input to the Mask R-CNN neural network, designed for 2D instance segmentation. Finally, the obtained predictions are reprojected to the point cloud to obtain the segmentation results. The results are then linked to a context-aware neural network to augment the semantics. The authors demonstrate the effectiveness of their approach in a series of small-scale experiments.

The final paper, "RegARD: Symmetry-Based Coarse Registration of Smartphone's Colorful Point Clouds with CAD Drawings for Low-Cost Digital Twin Buildings" [6], presents a new method for coarse registration of smartphone's colorful point clouds with CAD drawings. The method is based on symmetry and can be used to create low-cost digital twin buildings.

First, RegARD detects innate architectural reflection symmetries to constrain the rotations and reduce degrees of freedom. Then, a nonlinear optimization formulation together with advanced optimization algorithms can overcome the second challenge. As a result, high-quality coarse registration and subsequent low-cost DTBs can be created with semantic components and realistic appearances. The authors test their method on a large multi-level building, showing that the proposed method outperforms existing methods considerably in both effectiveness and efficiency. Overall, the exploitation of symmetries and textures in 3D point clouds and 2D CAD drawings show considerable promise in the field of low-cost sensor alignment.

2. Conclusions

In conclusion, these papers provide valuable contributions to the field of indoor mapping and navigation. They present new methods and techniques for improving the quality and accuracy of indoor mapping and navigation data and address several important challenges associated with this field. The contributions of these papers will help advance the state of the art in indoor mapping and navigation and enable the development of more efficient and effective solutions for BIM production and enrichment.

Conflicts of Interest: The authors declare no conflict of interest.

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