# NEW APPROACH FOR MODELING 3D INDOOR ENVIRONMENTS BASED ON TERRESTRIAL LIDAR

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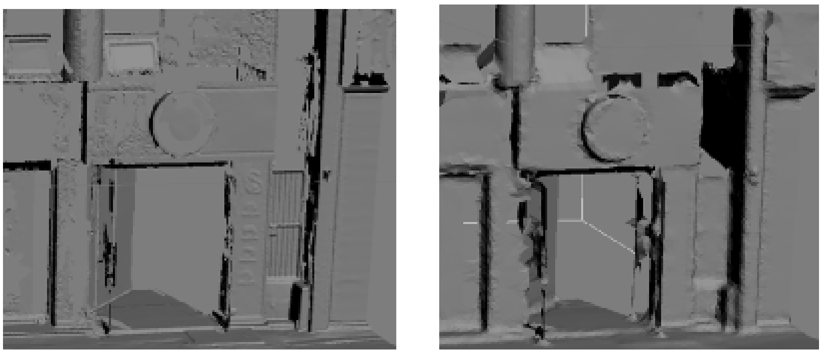
**Abstract:** To satisfy varying demands of spatial information in metropolitan area, three-dimensional models of building interiors are oftentimes desired as an indiscernible component of geographic information system. In this paper, a semi-automatic approach consisting of segmentation and outline tracing processes is introduced to construct indoor three-dimensional models from the terrestrial LiDAR. In the segmentation process, the random sampling consensus algorithm and virtual grid are used to group point clouds that belong to identical planar planes as well as to remove outliers from point clouds. In the outline tracing process, a data conversion and a skeleton algorithms based upon a virtual grid are used to extract lines from those segmented point clouds. However, despite of an improvement of productivity, the proposed approach requires an optimization process to adjust parameters such as a threshold of the random sampling consensus and sizes of the virtual grids for a filtering and a line extraction. It is required to determine those parameters in a heuristic way, depending on the characteristics of indoor environments. Furthermore, the proposed approach needs to be devised to model curvilinear and rounded shape of the indoor structures.

## INTRODUCTION

The role and application of spatial information increase in diverse areas such as construction management, disaster management, and Location Based Services (LBS). To satisfy varying demands of spatial information, three-dimensional models (3D) of building interiors are oftentimes desired as an indiscernible component of Geographic Information System (GIS) and Building Information Modeling (BIM) (Koller et al. 1995, Zlatanova, 2005). In the field of geo-spatial information science and engineering, the 3D reconstruction is closely related to the reverse engineering that includes the process of re-producing drawings when designs of old building structures are not known (Brenner 2005, Vosselman 2001, Sequeira 2001). Although various sensing technologies such as depth camera and optical camera have been introduced to construct 3D models of building interiors, the terrestrial LiDAR emerges as main mapping technology in that it provides fast, accurate, and reliable 3D data to describe details of building interiors.

However, in conventional approaches for three-dimensional modeling, point clouds from the terrestrial LiDAR are used to be reduced to 50-90% of its original point clouds. The point reduction is necessary since huge amounts of point clouds cause a system failure when loading them into 3D drawing software. 3D indoor models are then manually constructed with 3D triangular meshes converted from the reduced point clouds. In addition to low productivity in the conventional manual approaches, the point reduction process causes low geometric accuracies of 3D models. In Figure 1 (a), 3D triangular mesh data is converted from 10% reduced point clouds. In comparison to that in Figure 1(b), the mesh has indistinct boundaries and irregularly zigzagged shapes. The loss of details would result in inaccurate 3D model. Therefore, for the purposes of solving these problems, this paper introduces a semi-automatic approach to improve productivity, accuracy, and data reduction without loss of productivity and accuracy.



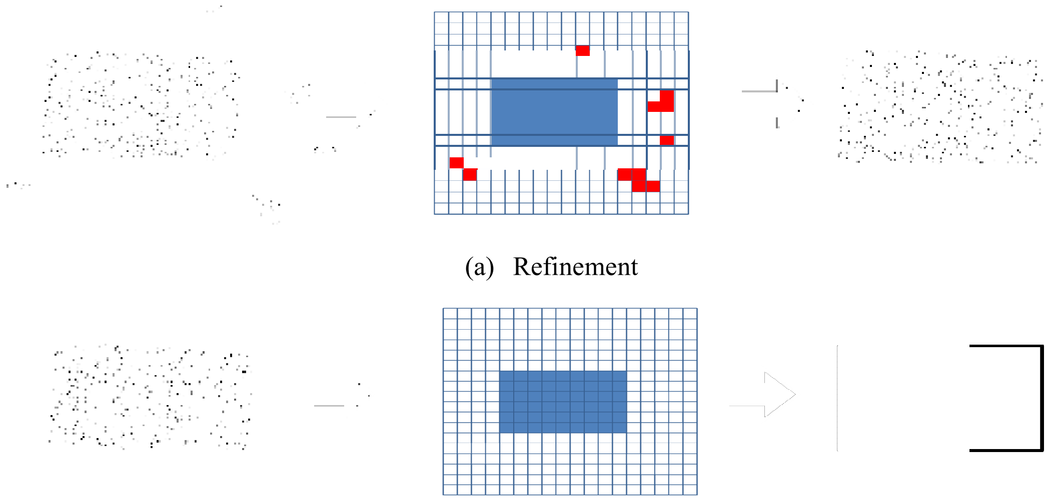
(a) 100% Mesh data (b) 10% Mesh data

**Figure 1:** Geometric accuracy issues in 3D model production

**PROPOSED METHOD**

In this paper, a semi-automatic approach consisting of segmentation and outline tracing processes is introduced to construct indoor three-dimensional models from the terrestrial LiDAR. In the segmentation process, the random sampling consensus (RANSAC) algorithm is used to group point clouds that belong to identical planar planes (Fischler and Bolles 1981). However, the segmentation method only classifies point clouds with respect to mathematical planar models. In irregular-shaped and complex indoor environments, incorrect segmentation might happen when a single planar model includes points on multiple walls. Therefore, the virtual grid is utilized to refine misclassified points as illustrated in Figure 2 (a).

In the outline tracing process, each of segmented point clouds is converted into binary images to extract its boundaries. Points inside the boundaries are then eliminated to reduced size of original point clouds (Figure 2(b). Another concern is to model hollow or isolated parts of building interiors such as pillars, windows, and doors. For this, their boundaries are extracted after the binary image is inverted to represent the hollow or isolated part.



(a) Refinement

(b) Boundary Extraction

**Figure 2:** Virtual Grid

**APPLIACATION AND RESULTS**

The proposed approach was applied to point clouds obtained from a class room in the first engineering hall in the Yonsei University. The test site was scanned with the terrestrial LiDAR, FARO Focus 3D. The proposed approach requires several parameters such as a RANSAC threshold and grid sizes for refinement and boundary extraction, respectively. In the optimization process considering, each of those parameters was determined as 5 centimeters the minimum size of discernible objects in the classroom. Outcomes from the approach were converted into VRML composed of traced boundary lines and 3D triangular meshes generated from remaining non-segmented point clouds. 3D models are manually produced after importing the VRML files into 3D drawing software, 3D Studio Max.

**CONCLUSION AND FUTURE STUDY**

In conventional production of 3D indoor models, point clouds from the terrestrial LiDAR are generally reduced to 50-90% due to its huge size to import into 3D drawing software. In addition to low productivity, this point reduction process oftentimes causes the low geometric accuracy of 3D models to use in diverse applications. Thus, in this paper, the semi-automatic approach was introduced to improve the manual 3D modeling procedures. However, despite of an improvement of productivity, the proposed approach requires an optimization process to adjust parameters such as a threshold of the random sampling consensus and sizes of the virtual grids for a refinement and a boundary extraction. It is required to determine those parameters in a heuristic way, depending on the characteristics of indoor environments. Furthermore, the proposed approach needs to be devised to model curvilinear and rounded shape of the indoor structures.

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