

# Automatic Architectural Floorplan Reconstruction

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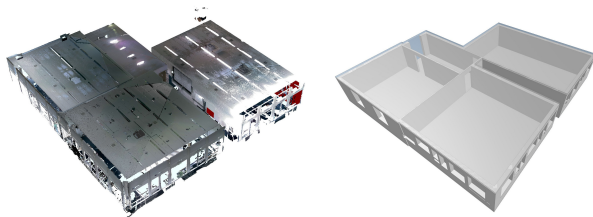


Fig. 1. IFC model of the scanned rooms at the Iff building

## 1 INTRODUCTION

The use of digital scanned 3D models has many potential applications in architecture, civil engineering, construction, and virtual reality. Architectural floorplan reconstruction is a vital task in the field of architecture and construction, enabling architects and engineers to analyze, visualize, and modify existing building designs. However, due to the various artifacts present in 3D scan data, common practical approaches to floorplan reconstruction involve significant manual modeling using software tools.

The most closely related approach of Jung et al. [Jung et al. 2018] is able to extract walls and model doors as well as windows, which is in line with the idea of this work. The drawback of Jung et al. is that their proposed method is not fully automated as several dimensions have to be measured manually. Furthermore, the export of the data is not in the International Foundation Class (IFC) format [Jung et al. 2018] which is the standard in the architecture and construction industry.

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In our work, we present a pipeline to automatically generate a CAD model from input scans, see also Fig. 1, which involves extracting all relevant information from the input 3D scans, such as wall locations, door and window outlines, as well as room dimensions. Using this information we create a 2D floor plan and eventually a full 3D model of the (interior) space, encoded in the standard IFC format.

## 2 APPROACH

The automatic reconstruction process includes three core parts. First, point cloud pre-processing (downsampling, noise removal) is very important to provide a good base for the subsequent algorithms. Next, the main building structures are detected and extracted; finally, the central architectural elements (walls, doors, windows, floors, and ceilings) are reconstructed and stored in the IFC format.

### 2.1 Pre-processing

An overview of our pre-processing pipeline is depicted in Fig. 2. The subsequent calculations and reproduction of the structural elements are based on this data cleaning. This part is based on the work of Mura et al. [Mura et al. 2014], where they present a robust solution for an occlusion-aware selection of candidate planar wall regions. A so processed point cloud is shown in Fig. 3(a).

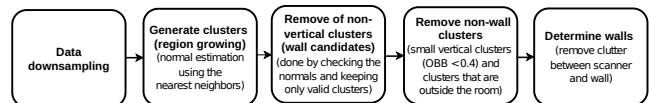


Fig. 2. Steps of the 3D scan data pre-processing.

### 2.2 Extracting wall polygons

After identifying the relevant planar point clusters, the extraction of (watertight) room polyhedra is performed by the steps shown in Fig. 4. The planes are identified for each wall cluster using a RANSAC based plane fitting algorithm. Subsequently the plane intersections and corners do define the wall polygons are computed. In a floorplan view, as shown in Fig. 5, the inner walls between adjacent wall polygons can be identified. Furthermore, by expanding each room polygon by a certain factor (corresponding to a user-defined outer wall thickness), and performing a join operation, the outer wall polygon can now be created. In fact, the polygon of the inner walls is obtained by shrinking the outer wall polygon by the wall thickness and subtracting the room polygons from that.

### 2.3 Extracting wall openings

Once the room polygon model has been created, it can further be refined by adding additional details, such as detecting openings of

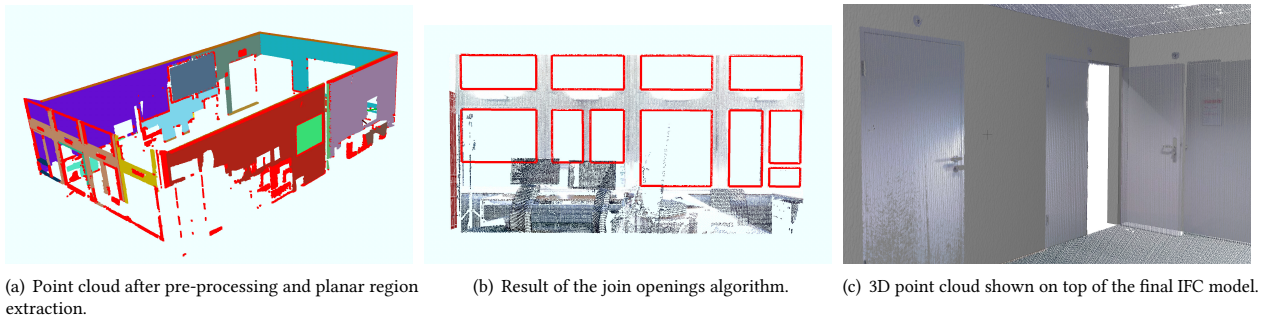


Fig. 3. Visual results from different steps of the proposed approach.

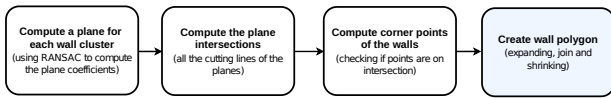


Fig. 4. Pipeline of the planar primitives and wall polygons extraction.

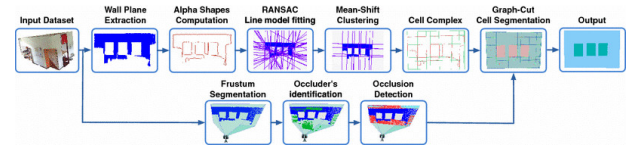


Fig. 6. Wall openings detection and extraction pipeline (from Michailidis et al. [Michailidis and Pajarola 2017]).

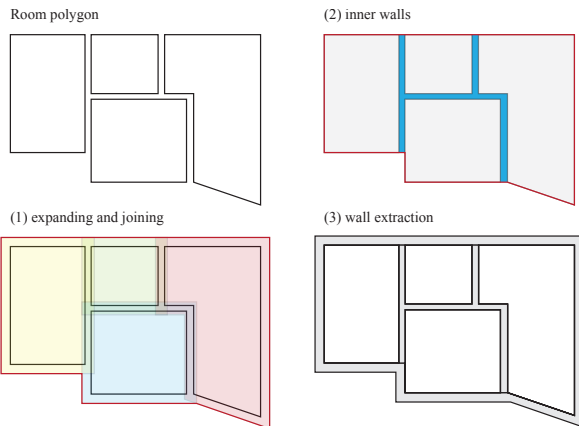


Fig. 5. Generation of the wall polygon for the IFC model: room polygons, (1) expanding and joining to define the outer polygon, (2) the definition of inner walls from shrinking, and (3) the result of the combined inner and outer wall extraction.

e.g. doors and windows as shown in Fig. 3(b). This is achieved by applying the technique presented in Michailidis et al. [Michailidis and Pajarola 2017], see also Fig. 6. For each point cluster of a planar wall, a planar  $\alpha$ -shape is computed and a RANSAC based line fitting algorithm is used to find all linear elements in the  $\alpha$ -shape. Through line clustering and graph-cut based segmentation of the 2D cell complex, the wall openings can be identified.

### 3 RESULTS

The IFC file that is generated in the end is composed of all extracted elements, including rooms, walls and wall openings. The implementation is based on the IFC++ open source library [Gerold [n. d.]]

and only slightly simplified. In particular, the structures not used or generated in our pipeline are omitted.

Fig. 1 shows a real-world 3D scan from multiple rooms and the generated IFC model (without ceiling). In Fig. 3(c) we show a visual comparison between the scanned 3D point cloud data and the final IFC model, with the polygonal IFC model superimposed over the point cloud in ArchiCAD.

### 4 CONCLUSIONS

We have presented a complete pipeline to convert 3D scanned point cloud and export an IFC file that can directly be used in a CAD program. Only individual parts of this pipeline have so far been implemented, or significant manual processing was required.

Current limitations to be addressed in the future include the extension to multiple floors, supporting more general wall/ceiling configurations, or handling stairs.

### ACKNOWLEDGMENTS

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