Exploiting the Room Structure of Buildings for Scalable Architectural Modeling of Interiors

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Problem

Given a raw point cloud of an indoor environment (Fig. 1), we aim to extract a polygonal model that describes the boundary of each room (Fig. 8) as defined by the permanent structures (such as walls, ceilings, floor).

Our goal is to make the modeling feasible on large-scale inputs while producing *full-3D* results, i.e. without imposing restrictive constraints on the orientations of the structures of interest.

Motivation and Background

Reconstructed 3D models of building interiors are used in many real-world application scenarios including space planning, interior design and online property showcasing.

In practice, such models are often created by hand from scanned data using interactive modeling tools. Most of the automatic approaches proposed assume specific orientations of the architectural structures (e.g. vertical walls, horizontal floor/ceiling [2]). The few methods that can capture structures with general 3D orientations [1,3] rely on the use of a global 3D Binary Space Partitioning (BSP) structure for the whole environment, resulting in an unmanageable complexity for larger multi-room scenes.

Our Approach

Most recent approaches aim at a structured reconstruction that segments the environment into different rooms. Our key idea is to perform the room detection early on in the pipeline, so that each room can be reconstructed separately; this allows to build a separate 3D BSP structure for each room, greatly decreasing the complexity of the individual structures and removing the main bottleneck of the modeling process. This way, large multi-room interiors can be processed in a scalable manner.

Room-based Modeling Pipeline

We abstract the planar parts of the scene [3] into a set of fitting rectangles (Fig. 2). We sample the regions of space around them (Fig. 3) to generate synthetic viewpoints (Fig. 4) and cluster them based on the parts of the scene they see (Fig. 5). The clusters obtained reflect the room structure of the environment. We perform a soft assignment of the rectangles to the rooms (Fig. 6) and reconstruct each room separately from each group of rectangles (Fig. 7) following a state-of-the-art approach [3]. We perform a final merging step to fuse the models of over-segmented rooms and obtain the final output model (Fig. 8).

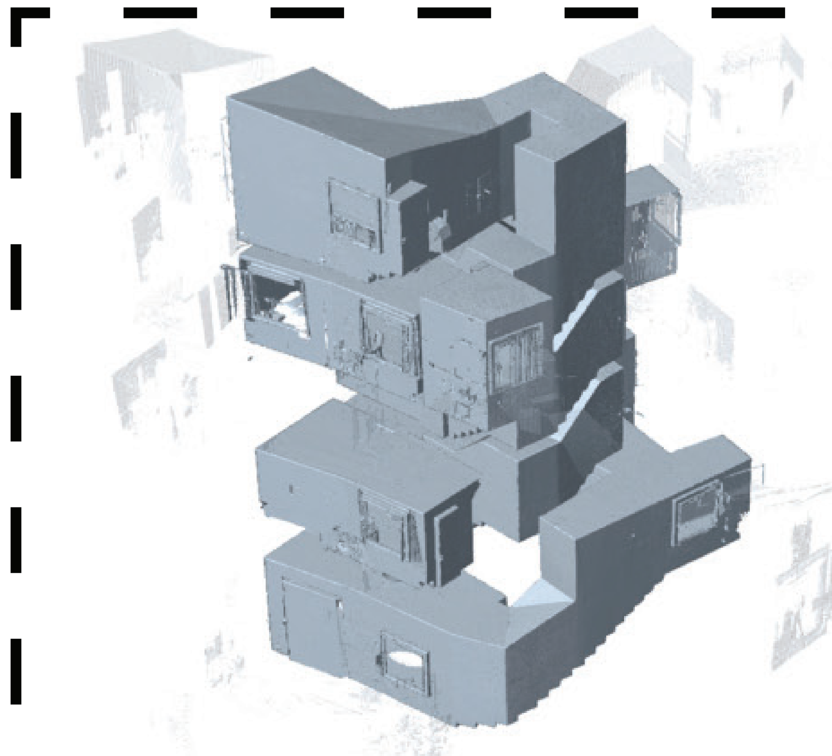

Fig.1: Input 3D point cloud

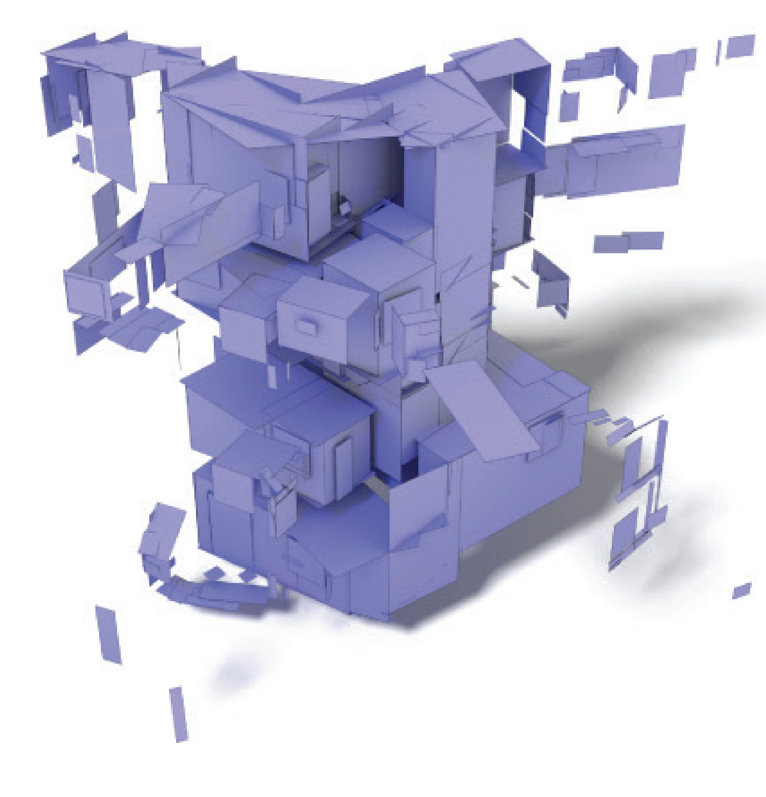

Fig.2: Fitting rectangles

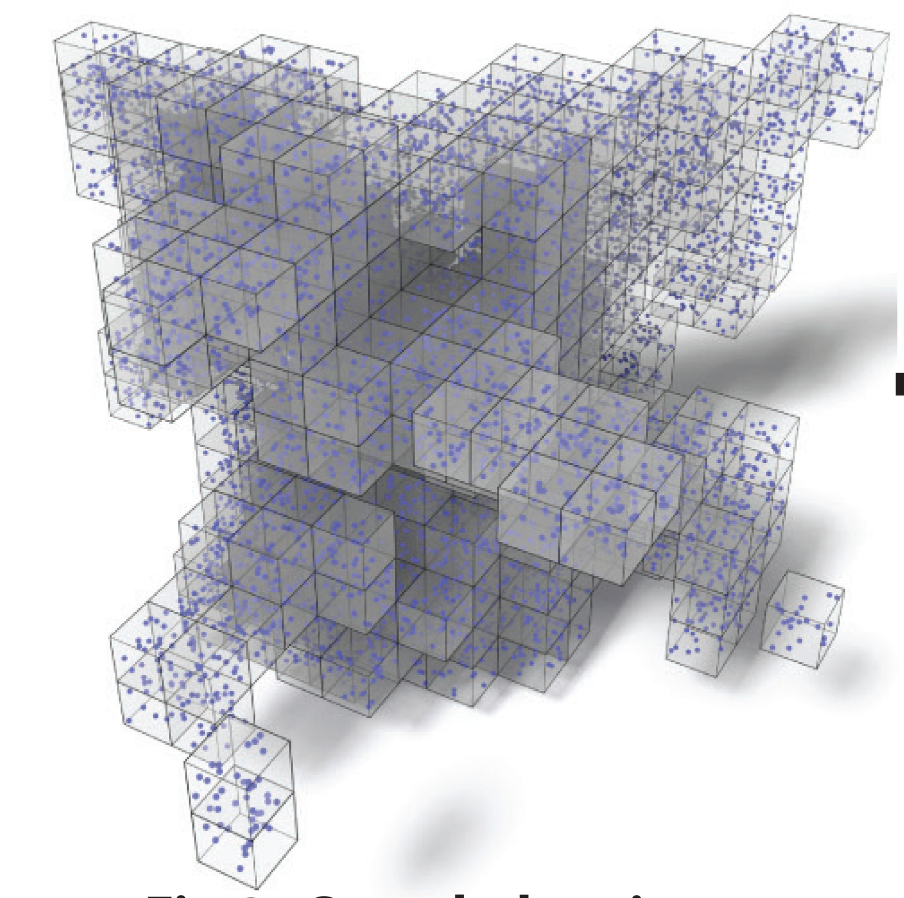

Fig.3: Sampled regions

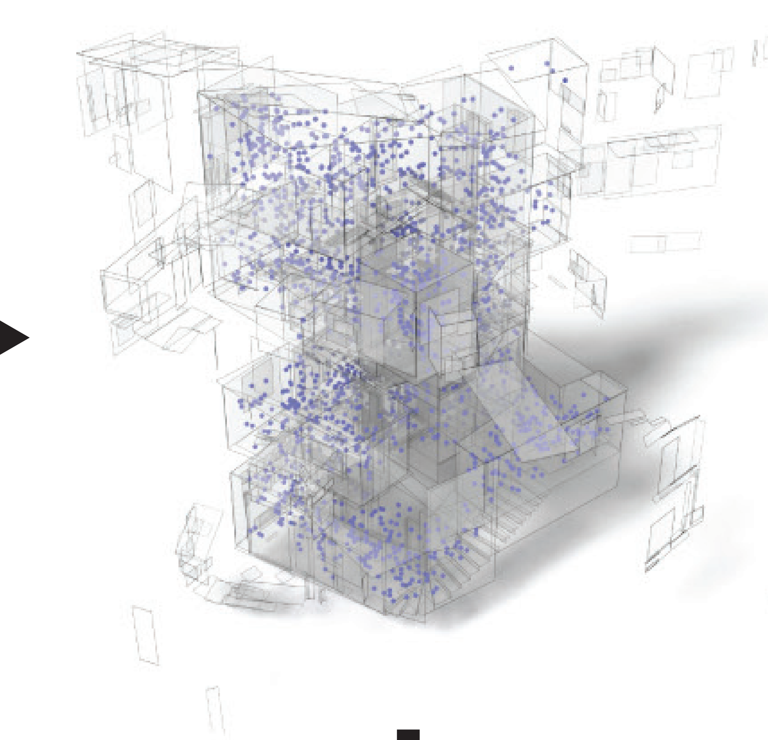

Fig.4: Synthetic viewpoints

Fig.5: Room-based clustering of viewpoints

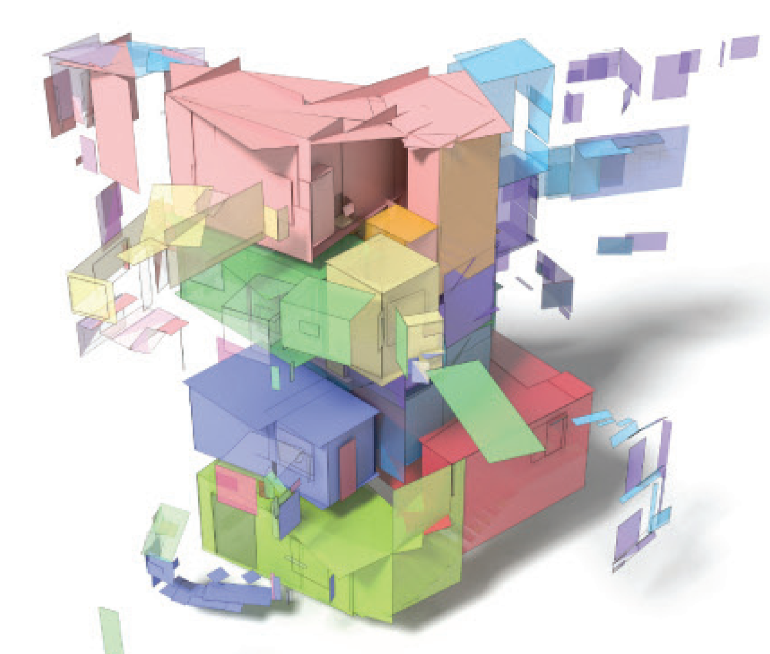

Fig.6: Room-based clustering of rectangles

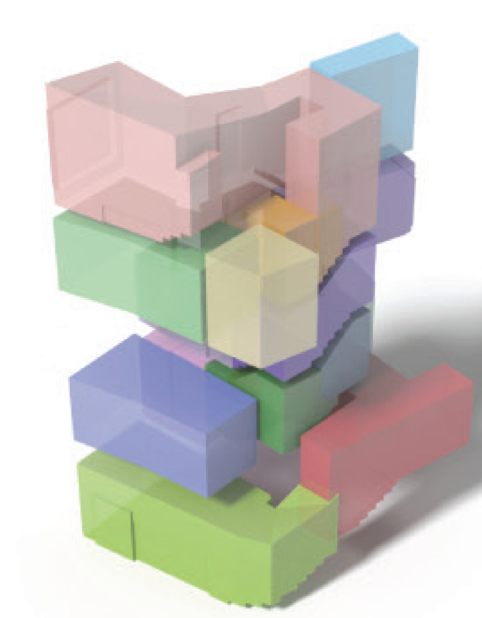

Fig.7: Reconstructed models of individual rooms

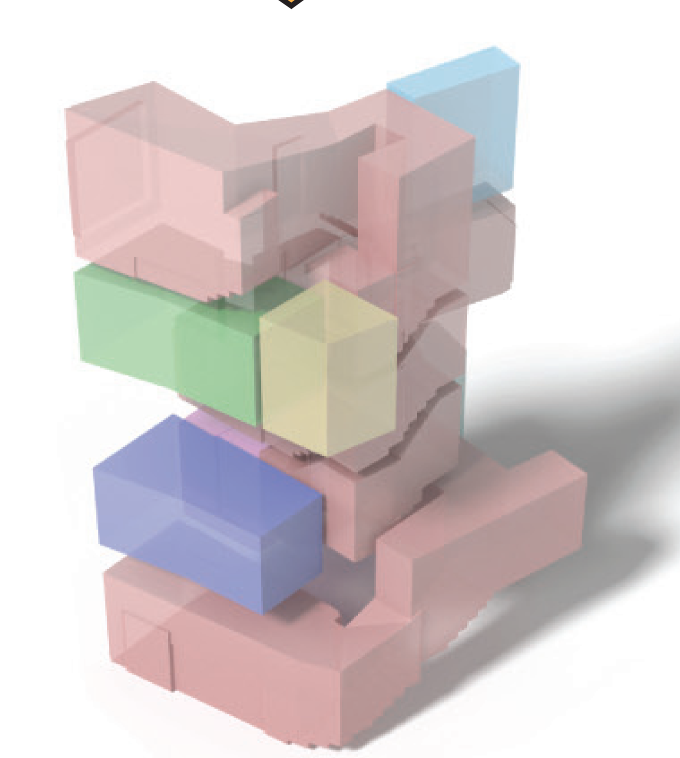

Fig.8: Output polygonal model

Results and Discussion

The results in Fig. 8 show that our method can produce accurate *full-3D* models of large multi-room building interiors. Our test model (9.5M points, 827 rectangles) was processed on a MacBook Pro in about 2 minutes (125.6s). The overall time spent on the construction of the BSP structures was 95.8s, with the largest structure (built from 119 planes) requiring 32.4s. On the same test machine, the construction of a global BSP required the processing of 602 planes and was aborted after over 8 hours, as it exceeded the memory capabilities of the system. This result demonstrates the significance of our room-based modeling strategy, which removes the bottleneck of the construction of a global BSP and allows for a scalable processing of large-scale environments.

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References

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[2] S.Ochmann, R.Vock, R.Wessel, R.Klein. Automatic Reconstruction of Parametric Building Models from Indoor Point Clouds. ***Computers & Graphics*** **54 (2016), 94-103**

[3] C.Mura, O.Mattausch, R.Pajarola. Piecewise-planar Reconstruction of Multi-room Interiors with Arbitrary Wall Arrangements. ***Computer Graphics Forum*** **35, 7 (2016), 179-188**