PhD position in Computer Vision and AI

3D building reconstruction with interactive shape control

Context

The automatic reconstruction of buildings under the form of concise polygon meshes from remote sensing data such as airborne Lidar scans and satellite images has been a scientific challenge for several decades. Existing methods mostly focus on producing accurate 3D models in a fast and scalable manner, either with piecewise-planar geometry algorithms [1,2,3,4] or with deep learning approaches that group and connect predicted corner points into surface components [5,6]. These strategies offer good results on standard buildings but fail to generalize to the huge diversity of buildings existing in the world. As a consequence, the production of large-scale city models is never fully automatic and requires human operators to assess the quality of reconstructed models and to potentially modify their geometry by labor-intensive manual operations. While automaticity of building reconstruction seems to be an unreachable quest, the emergence of generative models and their recent advances for creating 3D content appear as a promising solution to this problem. In particular, this could offer to the user the possibility to easily interact on the reconstruction, by proposing, for instance, various possible roof shapes and geometric attributes in case of atypical and complex buildings.

Objectives

The goal of this PhD is to investigate a new generation of building reconstruction algorithms that (i) offer an interactive shape control (which strongly reduces the labor-intensive manual post-modifications of the results), (ii) rely upon flexible geometric data structures able to model concisely any type of buildings (including freeform structures and architectural buildings), and (iii) are robust to data imperfections, e.g., occlusions, and to challenging conditions, e.g., reflective surfaces.

To address the first point, the candidate will investigate deep learning techniques exploiting procedural modeling and conditional generation. Inverse procedural modeling, for instance, can be particularly useful for editing and generating complex structures in a flexible and controlled manner, while conditional generation methods can be effective in handling data sparsity by filling in missing portions or generating plausible data in cases of incomplete or noisy input.

To face with huge diversity of buildings in the world, the candidate will propose a geometric data structure which is more generic and flexible than the commonly-used plane arrangements. He/she will investigate the generalization of algorithms and data structures that depart, not from planar shapes, but from more generic parametric shapes such as quadrics and NURBS. The assembly of such shapes into a space-partitioning data structure is a challenging problem as intersection curves cannot be computed in close form anymore as for planar shapes, impacting both exactness and performance of the geometric construction. A promising strategy proposed in [7], still not scalable and robust to real-world data, might consist in constructing plane arrangements while finely sub-meshing its polyhedral cells along non-planar shapes.

The candidate will also explore how emerging neural 3D representations such as Gaussian Splatting [8] can help improving the robustness of traditional geometric algorithms in challenging conditions. He/she will investigate how traditional mesh processing, such as shape detection and mesh simplification can be adapted to these new representations originally made for solving image rendering problems.

Keywords

Geometry processing, 3D computer vision, Building reconstruction, generative models, geometric data structures

Candidate profile

The ideal candidate should have good knowledge in Computer Vision, Machine Learning, 3D geometry and applied mathematics, be able to program in Python and C/C++, be fluent in English, and be creative and rigorous.

Application deadline: May, 2nd 2025

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[8] Kerbl et al. 3D Gaussian Splatting for Real-Time Radiance Field Rendering. Siggraph 2023