PhD position on Computer Vision and Computer Graphics

Collaborative project between CSTB and Inria

Remeshing urban-specific CAD formats

Context

3D models of buildings are deeply used for imagining new constructions, analyzing existing sites as well as operating physical simulations to optimize, for instance, the energetic properties of a building. Practitioners use different formalisms as CityGML [1] developed for Geographical Information System (GIS) applications or IFC [2] devoted to Building Information Modeling (BIM). Because the geometry, the topology and the semantics related to these representations significantly differ, there is a dire need for as-automatic-as-possible tools able to transpose a formalism into another. Moreover, the 3D models exploited by practitioners frequently contains topological errors and geometric imprecisions. The correction of these imprecisions is also a crucial problem for operating simulation tasks, and globally speaking, for democratizing BIM models.
Existing works for converting urban-specific formalisms and repairing CAD models usually relies on heuristics-based mechanisms in which decisions for snapping and labeling surface or volume elements are made locally by thresholding operations [3,4,5]. These methods are usually poorly robust to the diversity and complexity of buildings. At least, they require fastidious trial-and-error tuning of the numerous parameters that control the quality of the output models.

Objectives

The main objective of this PhD thesis is to design as-automatic-as-possible algorithms for repairing and converting BIM models of buildings in different urban-specific CAD formats. Contrary to existing works, we want to develop a methodology without local snapping operations and heuristic-based decisions in order to robustly correct geometry and identify semantics. The key idea we plan to explore consists in creating an intermediate representation that partitions the 3D space into surface and volume elements. These elements will later be regrouped to constitute semantic objects and reintroduced into BIM models. Such an idea has been exploited by [3] with combinatorial maps. However, the construction of these geometric data-structures is a complex and usually unstable process based on local heuristics. To the contrary, we want to exploit a kinetic framework in which input polygonal facets expands in a natural and global way until forming a partitioning of the 3D space into polyhedra. Recent works [6] in the Titane team has demonstrated the efficiency of such a framework for computer vision problems and for reconstructing polygonal surface meshes from 3D data measurements.

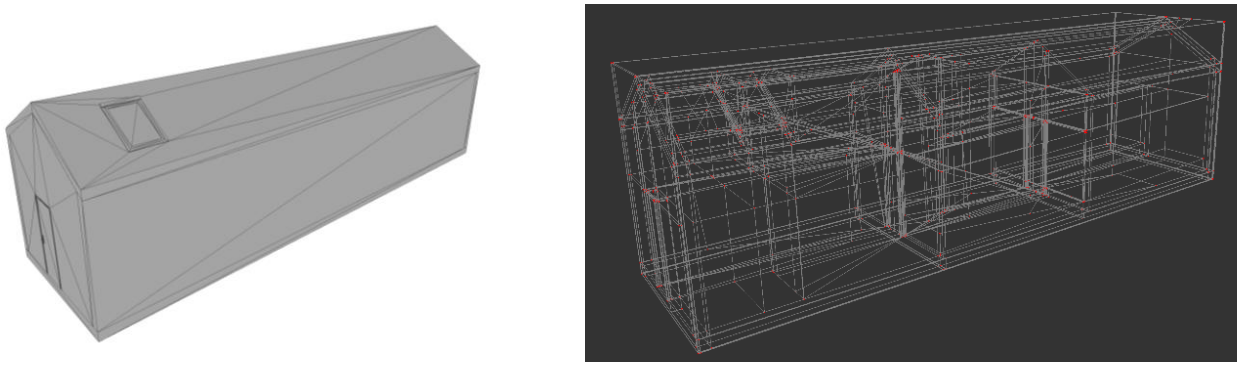

Fig.1 – A CAD model representing a building (right) and the corresponding kinetic partition of the 3D space from the facets of the input CAD model.

Several research directions will be investigated during the project:

Extend the kinetic framework developed in the Titane research team to operate on different urban-specific CAD formats. The input CAD model will be decomposed into a soup of polygonal facets. Each polygonal facet will inherit from the semantic information given by the original format. Redundant facets will be detected and removed before operating the kinetic propagation from remaining facets.

Identify semantics in the kinetic partition. We will regroup volume and/or surface components of the kinetic partition by semantic similarity. Inspired by recent works [7], we will exploit knowledge inherited from the input data combined with supervised strategies that are able to learn urban-specific formalisms. In particular, we will investigate deep learning architectures operating on graphs to identify the semantics on the components of the kinetic partition. BIM models created interactively by design software will be a precious source of knowledge to create training datasets.

Remeshing the input CAD model. After associating a semantic label with each volume and surface component of the kinetic partition, we will propose a strategy to remesh each semantic object of the scene individually while guaranteeing a spatially-coherent connection in between objects.

Keywords

geometry processing, BIM, remeshing, semantic segmentation, deep learning, buildings, CAD models, IFC, CityGML

Candidate profile

The ideal candidate should have good knowledge in geometry processing, computer vision and applied mathematics. He/she should be able to program in C/C++, be fluent in English, and be creative, rigorous and highly motivated.

Working conditions

The job will take place at Inria Sophia Antipolis, France. The research will be conducted in the Titane group (https://team.inria.fr/titane/). The group does research on geometric modeling of complex environments. The PhD student will have a 3-year contract with a monthly gross salary of approximatively 2000 euros. He/she will benefit from subsidised catering service, partially-reimbursed public transport, social security, paid leave, flexible working hours and sports facilities.

Application deadline: April 15, 2019

Contact

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References

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