PhD topic :

Large-scale 3D modeling of LOD2 buildings using Deep Learning

Keywords : Digital Twin, 3D Reconstruction, LOD2 Modeling, Deep Learning, Segmentation

Supervision :

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Localisation :

- Year 1 : ACTE Team - LASTIG Lab – Champs sur Marne (77) FRANCE
- Years 2 and 3 : RD DT Team - Siradel – ENGIE – Rennes (35) FRANCE
- Occasional travel between the two sites will be expected.

Financing : CIFRE (industrial) PhD

Context

(*INTRO*) The 3D digital twin of a territory makes it possible to visualize its present state and simulate its future state. It plays an important role in urban planning and, as a result, its constitution is in high demand across the world. Many uses require precise 3D modeling of buildings. However, it is a complex task due to the diversity of architectures and urban developments, and the difficulty also varies depending on the level of detail of the modeling. The LOD2 level of detail (in the CityGML sense) is frequently requested; it consists of representing the walls, roof sections and significant superstructures in the form of contiguous polygons. Each polygon represents a complete architectural element (unlike triangle meshes) to which it is possible to associate attributes (descriptions, measurement, simulation result).

(*3D DATA*) For realistic and accurate large-scale modeling of buildings, airborne or spaceborne data is used. This acquired data is either LIDAR point clouds or RGB images that can be used to derive elevation maps called Digital Surface Models (DSM). The precision and availability of this data now makes it possible to automate this task using 3D reconstruction algorithms.

(*THE NEED*) Traditional algorithms based on specific geometric criteria are currently the most used. They extract geometric primitives then deduce the structure of the building, but are unable to sufficiently adapt to the richness of architectural forms as well as the imperfections of the data. At the same time, deep learning algorithms have proven their flexibility and accuracy in complex 2D or 3D tasks such as semantic segmentation or data generation. These algorithms are gradually gaining importance in the field of 3D reconstruction of buildings, in particular thanks to the recent creation of sufficiently large learning databases. However, no proposed solution has yet been widely adopted even if the literature forms a solid reference base for the study of a new method of 3D reconstruction of buildings.

State of the art

Deep learning approaches generally follow the same reasoning as traditional geometric techniques, in two stages: extraction of primitives then topological reconstruction. For the extraction of primitives, the architectures used are Point-Net++ or convolutional networks. For topological reconstruction, there are generative or graph-based (GNN) methods. More recently, Point2Building based on PolyGen, uses a generative approach to achieve these 2 steps with autoregressive Transformers. When these networks are connected and trained end-to-end, then better results are obtained by avoiding intermediate steps which are sources of error accumulation. However, the majority of these methods are evaluated on restricted, synthetic data, or even on arbitrary 3D data not specific to buildings.

Goals

The aim of this PhD is to automate LOD2 modeling from airborne data covering large geographical areas. The source data can be LiDAR point clouds (10-15 points/m²) or Digital Surface Models (Stereo correlation - 20-50cm resolution) which will have been automatically classified.

The algorithm developed will be based on Deep Learning. End-to-End methods seem promising because they avoid the propagation of errors between the different stages. However, the chosen solution must be pragmatic and take into account the reality of industrial production (noise, incompleteness, classification error). The topology of the 3D models will also be at the heart of concerns (watertightness, manifoldness, flatness). The neural network must therefore be able to qualify the input data, to assess to what extent it can trust it, and also evaluate the 3D model produced by indicating a reliability score that can be interpreted by a non-expert.

The developed algorithm will first have to confront the Building3D challenge, then Siradel production data which presents a wide variety of urban and architectural configurations.

In urban areas, the density of buildings forms large blocks of connected buildings. The individualization of these buildings is generally little addressed in studies, which consider the 2D contours always available. From an industrial point of view, however, this is a significant stake. Automatic segmentation of building instances (region growth, super-points, etc.), integrated into the processing chain, would therefore be a major additional contribution.

3-year provisional planning

[T0 to T0+3 months] Bibliographic study

[T0+3 to T0+12] Study and evaluation of the most promising methods

[T0+12 to T0+24] Development of a new method

[T0+24 to T0+30] Integration into a complete chain and implementation of the fine-tuning mechanism

[T0+30 to T0+36] PhD redaction

Expected profile

- Masters degree in computer vision, photogrammetry, remote sensing, deep learning.
- Knowledge of 3D geometry would be appreciated.
- Mastery of Python and ideally C++
- Fluent English

Job profile : 3 years contract at Siradel

Remuneration: 34K€

Application

Send an email to bruno.vallet@ign.fr and sebastien.benitez@siradel.com with:

- Your resume
- A cover letter
- A transcript of your master's grades
- One or more letters of recommendation (if applicable)

Bibliography

1. *PC2WF: 3D Wireframe Reconstruction from Raw Point Clouds.* **Liu, Yujia, et al.** 2021, CoRR, Vol. abs/2103.02766.

2. *PIE-NET: Parametric Inference of Point Cloud Edges.* **Wang, Xiaogang, et al.** 2020.