

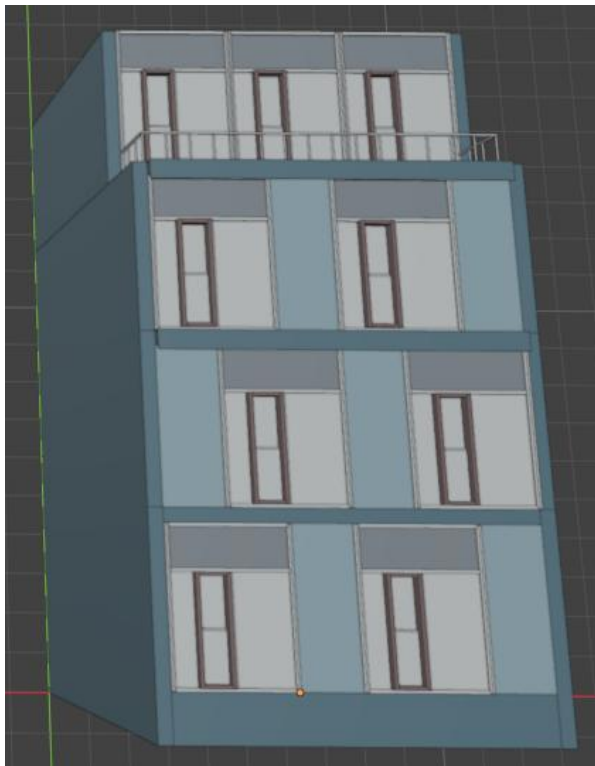
Internship – procedural generation of buildings with shape grammars

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Application deadline: December 15th, 2026

Location	Noisy-Champs (≈ 20 minutes from Paris)
Gratification	≈600€/month
Contract	Internship (4 to 6 months)
Remote work	Partial
Start date	Before April 1st, 2027

Keywords: procedural generation, shape grammars, 3D models, digital twins, virtual worlds, Blender.



(a) Blender rendering of a CGA-based building.

```

Lot -->
    // extrude the building
    extrude(buildingH)
    // split top floor from lower floors
    split(y){ ~1: MainPart | floorH : UpperPart }

UpperPart -->
    // create a set-back by splitting in the
    // direction of the building depth
    split(z){ ~1: TopFloor | balconyDepth : Balcony }

MainPart -->
    // create a facade on the front face, walls on the
    // side faces, and a roof on the top face
    comp(f){ front: Facade | side: Wall | top: Roof }

TopFloor -->
    // create a floor (marked with -1 as top floor) on
    // the front face, walls on the side and roof on the top
    comp(f){ front: Floor(-1) | side: Wall | top: Roof }

Balcony -->
    // set balcony height to 0.7 meters (railing height)
    s(scope.sx-2*borderwallW,0.7,scope.sz-borderwallW)
    center(x)
    comp(f){ front: Rail | left: Rail | right: Rail }
  
```

(b) Excerpt from the building shape grammar.

Figure 1: Shape grammars define compositional rules to automatically instantiate new buildings based on common architectural styles. This is one example of **procedural generation** applied to buildings, the main topic of this internship.

1 Context

Development of digital twins requires producing a high-fidelity representation of the territory, in the form of a virtual 3D world. However, commonly available sources of geographical information are not accurate enough to model the all the

details that might be useful for visualization [3]. In particular, geographical information systems (GIS) – such as OpenStreetMap¹ or IGN's BD TOPO² – nearly always model buildings as 2D footprints, sometimes also storing the height data. 3D visualizations are then produced by extruding the footprint according to the building height, resulting in the so-called *shoe box* model, with most building rendered as rectangular blocks. Architectural elements such as facades, roofs, windows, doors, or archways, are not modeled. Yet, these structural elements could benefit many use cases of digital twins, from visualization to simulation. For example, properly orienting building entrance and exit points (*i.e.* doors) according to the road network helps modeling pedestrian foot traffic in the neighbourhood [6]. Modeling windows is useful to simulate intervisibility, *i.e.* what inhabitants might see from their residence, and from where they can be seen. Since these data are not available in the authoritative source, digital twins need a way to impute the missing information in a plausible way. Procedural generation has been a long-standing solution to improve the realism of these simulated 3D environments [7, 4] and to generate training data for deep models [2].

This internship aims to implement and improve procedural building generation algorithms, in order to “fill in” the low-fidelity models automatically extracted from GIS with plausible details inspired by real world buildings. Especially, the goal is to implement procedural generation based on **shape grammars**, that allow a high-level of control on the generation process. Shape grammars have been a popular solution to procedurally generate buildings [1], in particular thanks to their (closed-source) implementation as CGA (*Computer Generated Architecture*) [5] in ESRI's CityEngine³. Our goal is to propose an alternative open-source implementation of building shape grammars, tailored to the lab's topics of interest. This will give us the option to produce buildings that are geotypical (*i.e.* similar to buildings from a specific region), likely (corresponding to real building usage) and realistic (exhibiting the same core characteristics as real buildings).

2 Objectives

The intern will be tasked with implementing and improving a procedural building generation algorithm based on shape grammars. More precisely, we will target grammars similar to CGA grammars (*Computer Generated Architecture*). This work will be implemented in Python and will be integrated into the **WorldWeaver**, a Blender plugin we are developing at LASTIG. The end goal is to allow users to provide custom rulesets to produce geotypical buildings of interest, tailored to the area (*e.g.* rural vs. urban architectures). If relevant, this implementation could take advantage of Blender's *Geometry Nodes* system.

In summary, the intern will have the following objectives:

1. Develop an **open source Python/Blender implementation** of the mean operators available in CGA grammars,
2. Design **rulesets of grammars for the main building types** available in most GIS (residential, commercial, agriculture, industrial, cultural, administration),
 - At the building facade level (windows, doors, archways, etc.);
 - At the roof level (flat, two or four-sided slopes, dormers, etc.).
3. Implement these building generators into the WorldWeaver code base
 - Depending on its relevance, using the Geometry Nodes features from Blender.
4. Validate the generation process over a small set of areas of interest in France.

The applicant will join the procedural generation task force and will collaborate with PhD students and researchers working on inverse procedural generation and neurosymbolic generative models. If time permits, the intern might also contribute to other features of the WorldWeaver procedural generator. For example, they might participate to ongoing works on procedural texture generation, especially focusing on walls and building facades. Other improvements might involve focusing on the generation of noteworthy and/or historical buildings (monuments, ruins, bridges...). These extensions depend on the skills and preferences of the intern to be hired.

3 Applicant profile

Requirements: (we expect you to check all these boxes, if you don't, feel free to explain us why you think you still fit)

- The ideal applicant is working towards their masters of engineering degree, with a specialization in computer graphics, video game programming, formal languages or 3D modeling.

¹<https://www.openstreetmap.org>

²<https://www.data.gouv.fr/datasets/bd-topo-r>

³<https://doc.arcgis.com/en/cityengine/latest/cga/cityengine-cga-introduction.htm>

- This internship involves a heavy amount of coding, therefore it is expected that the applicants can demonstrate significant experience in programming, preferably in Python.
- A taste for team work and research projects is very welcome.

Ideal skills: (you should be at least willing to learn those but you get points if you already are familiar with them!)

- Some level of familiarity with the basics of formal languages – in particular grammars – is expected, but this requirement can be raised for applicants skilled in other areas.
- While not mandatory, a first experience working with **Blender** – either using the graphical interface or using the Python API – is definitely a plus.
- An interest for procedural generation algorithms, 3D modeling or overall computer graphics is appreciated.
- Although not required to work in the lab, spoken and written French can be helpful for the day-to-day life.

4 Where you will work

The *Institut national de l'information géographique et forestière* (National institute for geographic and forest information) (IGN) is a French public organization under the ministry of Ecology. IGN produces and releases authoritative geographical data and maps of the French territory and its forests. Thanks to its engineering school, Géodata Paris, and its pluridisciplinary research laboratories, IGN drives high-level innovation in geodesy, forestry, photogrammetry, artificial intelligence, spatial analysis, 3D visualization, etc.

The LASTIG (LABoratory in Sciences and Technologies of Geographical Information, <https://www.umn-lastig.fr>) is research unit managed by IGN and Gustave Eiffel University. The lab focuses on methods and algorithms to deal with geographical information. Its STRUDEL team focuses on reconstructing processing spatio-temporal phenomenon, to extract and structure knowledge about the territory. In particular, the team leads high-level researches on synthetic data for simulation.

Location: the lab is located in the Géodata Paris engineering school in Champs-sur-Marne (77), 20 minutes from Paris by train (RER A).

Perks:

- Remote work one or two days a week,
- Sport equipments (swimming pool, gym, tennis courts...) available on the campus
- Access to the cultural and sports associations from Gustave Eiffel university
- Subsidized lunch to the Gustave Eiffel university cafeteria
- Public transport pass reimbursed at 50% (or direct subsidies if you bike!)

Hiring: based on CV, with an on-site or remote interview with a technical test.

Application

Send an email to Nicolas Audebert and Julien Perret with a resume and a short paragraph explaining your interest in this internship topic and why you think you might be a good fit. Please note that **LLM-generated applications will be rejected without further consideration**.

References

- [1] Bernhard Hohmann et al. "A GML Shape Grammar for Semantically Enriched 3D Building Models". In: *Computers & Graphics* 34.4 (Aug. 1, 2010), pp. 322–334. URL: <https://www.sciencedirect.com/science/article/pii/S0097849310000749>.

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- [5] Pascal Müller et al. “Procedural Modeling of Buildings”. In: *ACM SIGGRAPH 2006 Papers*. SIGGRAPH ’06. New York, NY, USA: Association for Computing Machinery, July 1, 2006, pp. 614–623. URL: <https://dl.acm.org/doi/10.1145/1179352.1141931>.
- [6] Rémi Cura, Julien Perret, and Nicolas Paparoditis. *StreetGen : In Base City Scale Procedural Generation of Streets: Road Network, Road Surface and Street Objects*. Jan. 17, 2018. arXiv: [1801.05741](https://arxiv.org/abs/1801.05741) [cs]. URL: <http://arxiv.org/abs/1801.05741>. Pre-published.
- [7] Jean-Eudes Marvie, Julien Perret, and Kadi Bouatouch. “The FL-System: A Functional L-System for Procedural Geometric Modeling”. In: *The Visual Computer* 21.5 (June 1, 2005), pp. 329–339. URL: <https://doi.org/10.1007/s00371-005-0289-z>.