



Postdoctoral position: Valid Large-scale Mesh Generation (PEPR NUMPEX project)

Job environment

The job environment is the one of the Exama project from the NUMPEX programme (see below). We will collaborate with Strabsourg University (See in particular the [CEMOSIS](#) center - Center for Modeling and Simulation) on the first workpackage (“Discretization”) relating to geometry processing and scalable mesh generation, based on the CGAL library.

NUMPEX software building blocks for future exascale machines. The Numpex programme's objectives are to design and develop the software building blocks required to equip future 'exascale machines' and to prepare the major application domains that aim to fully exploit the capabilities of such machines for scientific research and industry alike. This project is part of France's response to the next EuroHPC call for expressions of interest (Projet Exascale France) in hosting one of the two major exascale machines planned in Europe for 2024. Numpex will contribute to the creation of a set of tools, software, applications and training which will enable France to remain one of the leaders in the field of international competition through its national Exascale ecosystem that is in step with European strategy.

EXAMA (Methods and Algorithms at Exascale) – Summary: There is a growing number of problems where experiments are impossible, hazardous, or extremely expensive. Extreme-scale computing enables the solution of vastly more accurate predictive models and the analysis of massive quantities of data thanks to AI. Combining predictive modeling with data, coupled with machine learning and AI strategies, can create new opportunities in science. In particular, move from Human-in-the-Loop towards hybrid Human and Artificial Intelligence-driven design, discovery, or evaluation. However, various scientific and technical challenges need to be met to exploit exascale computing capabilities. These bottlenecks impact methods and algorithms in a profound way on all aspects of the simulation toolchain through (i) avoidance of communication, (ii) adaptive parallel grain and more compute-intensive at node level, (iii) handling of heterogeneous hardware and data representations and (iv) self-parametrization. The ExaMA project concentrates on the Exascale aspects of the numerical methods, ensuring their scalability to existing and forthcoming hardware. Furthermore, it is a transverse project, proposing methods and tools where modeling, data and AI, through algorithms, are central.

Workpackage 1 (Discretization). Geometric domain representations and their discrete counterparts such as meshes are usually the main starting point and support of the simulation. These include efficient, parallel representations of large-scale 3D models that are adaptive, possibly multiresolution, robust to defects and resilient to heterogeneous input.

Assignments:

We will explore the automated generation of large-scale meshes, either from measurement data such as carefully-designed CAD models or 3D point clouds acquired on a building, a city block or an entire city. The figure below depicts a city-scale reconstruction of Paris using the CGAL library. Such input data require 3D reconstruction and meshing algorithms capable of dealing with heterogeneous, defect-laden representations. We will look for meshing algorithms that scale, and are unconditionally robust to input defects. Valid meshing herein translates into output meshes that are watertight and without self-intersections. The meshing algorithms will also provide detail levels with fine-grain and adjustable balance between complexity, resolution and approximation.

A recent example of the types of robust algorithms we wish to devise is the “Alpha Wrapping” algorithm from the CGAL library (see [link](#)). In addition to unconditional robustness, the main objective is to make some of the algorithms from CGAL scalable, i.e., running in parallel for the distributed memory model.

Collaboration: The recruited person will closely collaborate with our partners from Strasbourg University (France).

Responsibilities: The recruited person will be responsible for the exploration and implementation of novel algorithms for scalable mesh generation.

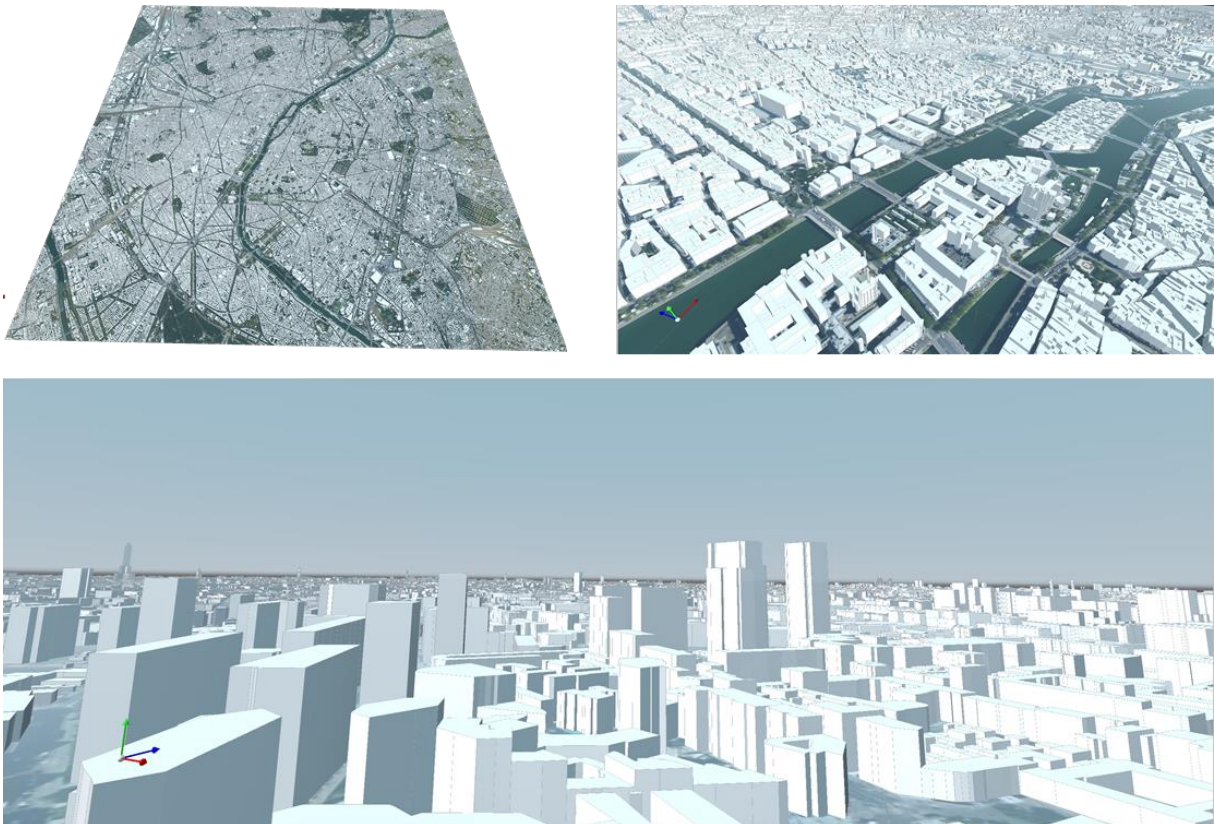


Figure 1. City-scale reconstruction of Paris via the CGAL library. The objective is to estimate view factors and shadows between buildings to estimate the solar potential, and to enable a wide range of other simulations.



Main activities

- Devise and implement scalable geometric algorithms (distributed memory model)
- Evaluate solutions on large datasets
- Benchmark the solutions on various platforms and high-performance computing frameworks
- Write documentation
- Exchanges with partners of the project

Skills

Technical skills and level required:

- Geometric data structures and algorithms
- Mesh generation
- Geometry processing: 3D point sets and meshes
- Advanced C++ programming: generic programming, STL
- Experience with the CGAL library is clearly a plus (see www.cgal.org)

Languages: French and English

Relational skills: Taste for team work and collaborative activities

Contact

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