



## Master project 2023-2024

### Generation of spatial arrangements for lightening by material removal

**Host team and location:** IGG (Computer Graphics and Geometry group) and GC-E (Civil and Energy Engineering), ICube (Engineering science, computer science and imaging research institute), University of Strasbourg

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**Starting date:** from February 2024

**Ending date:** 6 months from the starting date

**Funding:** about 570 euros per month, net salary

**Prerequisites:** Computer Graphics or Computational Geometry



**Fig. 1:** Left: Three spatial arrangements of discs with different properties (two "regular" arrangements and one "irregular" arrangement). Center and right: 3-point mechanical bending test on an MDF wood plate lightened by circular holes.

### Context

The field of Computer graphics has developed various algorithms for generating spatial arrangements of patterns, in particular for creating virtual materials for image synthesis [GAD+20, BAD23]. These algorithms have attracted a lot of attention for applications in computer-aided manufacturing, especially for the fabrication of mechanical metamaterials [MSS+19, LHH+22].

This internship is part of a project involving researchers from the ICube laboratory's GC-E and IGG teams, whose aim is to address the problem of lightening rigid materials for engineering and construction, with economic and environmental implications. Given a solid panel undergoing material removal according to a spatial arrangement of patterns, the goal is to find spatial arrangements enabling a functional stiffness close to the initial stiffness.

While studies have been carried out to make rigid materials flexible [CTJ+20], limiting the loss of stiffness properties produced by material removal remains largely unexplored. Work in topological optimization, which is concerned with the optimal distribution of material within a material under constraints, does not consider the notion of spatial arrangement of patterns [MDL+15], or only at the microstructure scale [WSG21].

## Internship goal

The goal of this internship is to study geometric and statistical criteria to characterize the spatial arrangements of patterns in relation to the desired mechanical properties, and to identify the most relevant arrangements with regard to these properties. The work will be carried out in the following stages:

1. Critical review of the literature on spatial arrangements in relation to known phenomena in material mechanics.
2. Implementation of several generative algorithms to produce spatial arrangements of patterns, as well as implementation of simple geometric and statistical criteria, such as: distance to the nearest neighbor, radial distribution function, Ripley's function, autocorrelation.
3. Based on the method proposed in [MDL+15] and the available code, implement the topological optimization constrained by a spatial arrangement of patterns in order to determine the best arrangements and their parameters.

The trainee will be hosted by the IGG team and will have access to the team's computing resources. Depending on the progress of the work, access to the GC-E team's experimental facilities will also be available for mechanical testing.

## References

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