PhD Thesis Topic 1

Architect–AI co-design through interactive generation of variants under constraints and preferences

Scientific context and research problem

Architectural design can be understood as a complex, multi-objective optimization process in which project parameters must be iteratively adjusted to satisfy a wide range of often contradictory objectives (Deb, 2001; Cagan et al., 2002). These objectives may appear either as constraints or as objectives, and many of them remain implicit, handled through the architect's expertise rather than through formal rules (Oxman, 2006; Woodbury, 2010). Typical examples include limiting construction cost, maximizing spatial and aesthetic qualities, minimizing environmental impact from a life-cycle perspective, ensuring structural robustness, achieving adequate energy performance, providing healthy indoor environmental quality, offering good daylight and acoustic comfort, complying with fire-safety regulations and urban codes, or achieving strong contextual integration (Oxman, 2006; Schumacher, 2011). Many of these criteria are not formally specified during the early stages of design. In practice, many high-level criteria remain implicit, even though they strongly influence the exploration of design alternatives (Woodbury, 2010).

The architect's work begins with reading the brief (the architectural programme). The architect then develops the project (plans, materials, systems) through successive refinement loops. This design is subject to regulatory validation by engineering consultancies, which assess, among other things, the environmental footprint over the life cycle of the proposed building as well as its performance (thermal, energy, daylighting, acoustics, etc.) using physics-based simulation software. If performance is considered insufficient, the process loops back to a revision of the design, followed by a new validation, and so on. If the results are satisfactory and comply with the applicable standards, the design is validated with respect to performance.

The MIAI Cluster ARCHIMED Chair aims to explore how AI could help shorten this design loop by assisting the architect during the design phase, thereby reducing the design–regulatory validation cycle. An architectural project is a complex project involving a large set of heterogeneous constraints: legal, functional (brief), mechanical, physical, aesthetic, integration of the building into its urban context, etc. Modelling and taking all these constraints into account within a generative AI system with the aim of automating design is not considered a viable approach. The founding hypothesis is instead to work within a framework of collaboration / co-design between the architect and AI. The proposed vision is as follows: the architect has a global view of the project and all its constraints. Drawing on experience, the architect proposes an initial sketch and refines it through successive stages. In parallel with this process, the objective of generative AI is to propose evolutions of the current sketch that improve performance according to the objective criteria for which it has competence (for example, energy performance or visual comfort). Since AI has only a partial view of the constraints, it may propose evolutions that degrade performance with respect to constraints it does not know. The architect, through a global understanding of the constraints, is responsible for selecting, among the proposed evolutions, the one to retain in order to continue the design process. This envisaged mode of cooperation raises the following research questions:

Central research question

Q1: Generative AI relies on modelling a probability distribution of buildings. The first challenge therefore concerns the computational representation of the architectural object. The model must be able to represent and transform a sketch while preserving the essential properties of its form, spatial organization, dimensions and topology. The difficulty is to obtain a representation that is rich enough to enable the generation of variants, while remaining sufficiently structured to guarantee their architectural coherence.

Q2: Generating alternative models that improve, for example, energy performance requires taking the associated physical phenomena into account. One possible approach is to start from a parametric representation of the current sketch and optimize its parameters using an energy simulation engine based on the equations of physics. Such an approach can capture a large part of the complexity of the solution space, but it may require computation times that are incompatible with the pace of design activity. One possible response is, on the one hand, to replace costly simulations with surrogate functions and, on the other hand, to replace the explicit exploration of the search space through optimization with a generative AI trained by integrating these surrogate functions into its cost functions or guidance mechanisms.

The question then becomes: how can surrogate functions and an associated generative AI be learned jointly so that they are capable of addressing the complexity of the problem space while maintaining response times compatible with design activity?

An active-learning approach will be investigated in order to progressively guide the construction of these functions towards the regions of the solution space actually explored by the architect.

Hosting environment

The PhD is part of the scientific programme of the ARCHIMED Chair – ARCHItectural Multi-criteria Exploration & Design, funded by the MIAI Cluster within the France 2030 programme (ANR-23-IACL-0006). ARCHIMED aims to develop architectural design-assistance methods combining artificial intelligence, multi-criteria evaluation and human–AI co-design, with particular attention to the early stages of the project, when choices concerning form and performance remain open.

Candidate profile and desired skills

Applicants should hold a Master's degree, an engineering degree, or an equivalent qualification in computer science/AI, applied mathematics, engineering sciences, computational design, or a related field. Candidates with a background in architecture may also be considered if they have strong skills in programming and machine learning.

Particularly valued skills

- Python programming and experience with a deep-learning environment;
- knowledge of generative models and machine-learning methods;
- interest in active learning, uncertainty estimation, out-of-distribution detection, or optimization;
- interest in computational geometry, architectural modelling and/or building physics;
- ability to work in an interdisciplinary context, scientific autonomy, and ability to write in English.

Practical information

- **Type of contract:** 36-month doctoral contract.
- **Expected start date:** January 2027.
- **Salary:** according to the statutory salary scale applicable to doctoral contracts.

Application

- The application file must include:
- CV
- cover letter
- academic transcripts (Master's and Bachelor's)
- Master's thesis or an equivalent document enabling assessment of the candidate's previous work
- copies of diplomas

Deadline for applications: 15 November 2026.
Shortlisted candidates will be interviewed on: 18 November 2026.

Applications must be sent to:

bensaci.a@grenoble.archi.fr

With a copy to:

patrick.reignier@univ-grenoble-alpes.fr

stephane.ploix@grenoble-inp.fr

***Suggested subject line**: "Application PhD Thesis 1 ARCHIMED _ LAST NAME First name".*

References cited in the text

*Cagan, J., Shimada, K., & Yin, S. (2002). A survey of computational approaches to three-dimensional layout design. *Computer-Aided Design, 34*(8), 597–611.*

*Deb, K. (2001). *Multi-objective optimization using evolutionary algorithms*. Wiley.*

*Oxman, R. (2006). Theory and design in the first digital age. *Design Studies, 27*(3), 229–265.*

*Schumacher, P. (2011). *The autopoiesis of architecture: Volume I*. Wiley.*

*Woodbury, R. (2010). *Elements of parametric design*. Routledge.*