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Beyond Drawing: Algorithms, Scenarios, and the *Èkphrasis* of the Future City

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Abstract

The article analyses the evolution of representation tools in architectural design, from traditional drawing, to CAD to the information model in a BIM environment, to the integration of Visual Programming Environments (VPE). The article specifically focuses on the potential of the latter methodology and how VPEs can overcome the static nature of traditional representation. Through an algorithmic approach, VPEs make it possible to describe entire families of solutions, bringing them closer to the notion of *èkphrasis*. This approach is implemented here to manage the uncertainty and complexity of urban design, adapting to different conditions and approaching the needs of the 'scenario-based design' methodology. The paper describes the development of an algorithm that translates the design logic for defining urban-scale projects. This algorithm is applied to a case study in Turin, demonstrating how VPEs facilitat the definition of evolutionary scenarios and the tracing of a detailed 'design history'. The article discusses limitations and opportunities of this approach, emphasising the role of design intuition. It concludes by highlighting future perspectives, with a focus on human-computer interaction and the impact of these methodologies in architectural and urban design.

Keywords
Visual Programming Language, Visual Programming Environment, Digital Drawing, Scenario Design, Urban Architectural Design.

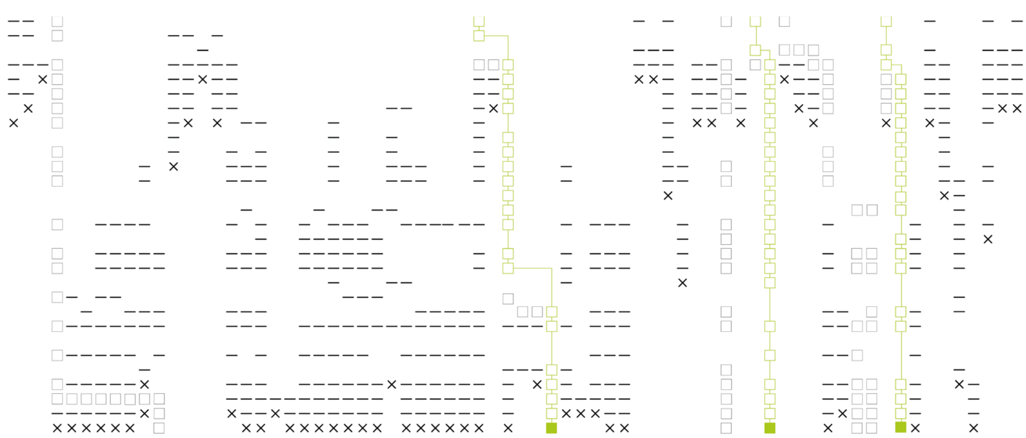

Diagram of the results for each phase of some of the scenarios generated through the use of parametric VPL tools (elaboration by the authors).

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Introduction

This paper explores the evolution of representation tools in architectural design, reporting on the transition from traditional drawing, at first manual and then computer-aided design (CAD), to the use of information models (BIM), and the more recent integration of Visual Programming Environments (VPE). The focus is to highlight how VPEs enable the overcoming of the inherent static nature of traditional project representation, paving the way for a dynamic and flexible approach thataligns more effectively with 'scenario-based design'.
These environments closely relate to the notion of *èkphrasis*. While traditional *èkphrasis* aimed to 'give voice' to an artwork through words, VPL allow the 'giving voice' to the design idea through a set of rules and relationships (conveyed through algorithms) that generate not a single solution, but a family of possible configurations, each responding to specific scenarios and objectives.
The article is divided into five sections: (i) A brief overview of the evolution of representation tools; (ii) An in-depth exploration of the concept of *èkphrasis* in relation to VPLs is explored, analysing the potential of these tools in the representation of families of design solutions; (iii) the presentation of a case study applied to a district in Turin (Ex-Thyssen area); (iv) a discussion on the scenario-based design methodology supported by VPE application; (v) Finally, the implications of this approach in a broader context are presented, highlighting limitations, opportunities and future prospects in the field of architectural and urban design.

Evolution of representation tools

Hand drawing allows a great freedom of expression and immediacy that favour the creative process. Even today, it remains the quintessential tool for the conception, study, development, and communication of architectural projects. The architect's hand, guided by knowledge and experience, traces lines that define spaces and relationships. In this context, hand drawing can be considered as a 'language', characterised by its own syntax, through which the architect dialogues with and about the project [Spallone 2012]. Drawing, through its construction and layering of lines, acts as a 'record' of design thinking, a dynamic, non-linear thought, made up of trial and error, errors and second thoughts. However, drawing by hand has limitations, in terms of modifiability and reproducibility.
The introduction of CAD (Computer-Aided Design) software in the 1960s and 1970s brought about an initial transformation in the way architectural design was represented. However, early CAD software did not fundamentally alter the design approach. At least initially, CAD was mainly used as a 'digital drafting table', a different tool to produce drawings, but without altering the creative process [Tedeschi 2014]. It can be argued that, particularly in its early stages, CAD partly limited the expressive freedom and immediacy typical of hand drawing, introducing a certain rigidity into the design workflow.
The transition to BIM (Building Information Modeling) models in the 2000s marked a revolution in the field of architectural design. BIM is not a modelling software, but a working methodology that introduces the concept of an 'information model' of the building. Each element of the BIM model (walls, floors, windows, etc.) is not a simple geometric representation, but an 'intelligent' object enriched with semantic information. This approach facilitates collaboration among the various stakeholders in the construction process, enables integrated management of the building life cycle phases and allows for more complete control of the project, reducing interference and errors [Lo Turco 2015].
In parallel, Visual Programming Environments (VPE) developed to overcome the structural limitations of applications with a predefined interface [Shu 1986], represent a new paradigm in architectural design.
Overcoming the static nature of traditional drawing and the 'linear' approach of CAD and BIM software, Visual Programming Languages (VPL) introduce algorithmic logic. The design is described by a set of rules, relationships and parameters that define a generative process.

This approach, approaching the concept of *èkphrasis,* understood as the description of a visual entity, describes the process that generates a family of possible design solutions, becoming the new language of 'description' of the architectural idea, not limiting itself to a single instance, but to a multiplicity of possible outcomes.

VPE and scenario-based design

The concept of *èkphrasis*, originally referring to the verbal description of a work of visual art, can take on a new meaning in the context of algorithmic design. In antiquity, *èkphrasis* aimed to 'give voice' to the artwork, to put into words the emotions, sensations and meanings that the work aroused in the observer. It was an exercise in interpretation and mediation between the artwork and the audience.
Scenario-based design is a design approach based on the idea of defining not a single solution, but a family of possible configurations that respond to different conditions and requirements. Each scenario represents a possible evolution of the design in response to variations in input parameters, changes in the context or different design choices. This approach makes it possible to manage the uncertainty and complexity of the project, and to adapt the solution to the specific needs of a given context [Xiang, Clarke 2003]. VPE address this need by allowing designers to define rules and relationships that govern the evolution of the project in response to changes in input parameters.
This approach makes it possible to assess the impact of different design choices, facilitating decision-making and promoting greater awareness of project implications. Through VPE, scenario-based design manages increasing complexity and becomes a true iterative process of exploration and evaluation.

Project context: the ex-Thyssen district in Turin

The project area chosen for the application of the scenario design methodology using VPL applications is the Ex-Thyssen area, located in the Lucento district of Turin. This large-scale disused industrial site (350,000 sqm), located in a strategic position between Parco Dora

Fig. 1. Area capture of the site, framed in relation to the defining elements of the city of Turin. Source: Google maps (elaboration by the authors).

and Parco della Pellerina. Moreover, its proximity to Corso Regina Margherita ensures high accessibility and connection with the rest of the city.
The choice of the Ex-Thyssen area as a case study for the application of the design methodology for VPL scenarios is motivated by several reasons. First of all, being an existing portion of the city makes it possible to extrapolate data, shapes and information from the context, which can be translated into numerical inputs comprehensible to the algorithm. Secondly, its large size and the promise of total reclamation turn it into an urban void within consolidated city fabric. Finally, the ongoing public debate on the site's redevelopment makes it a particularly relevant and timely case study.
The Lucento district presents a heterogeneous urban fabric, characterised by the presence of residential, industrial and commercial buildings. Over the centuries, multiple attempts were made to establish a central urban core, yet all proved unsuccessful. This lack of a functional and symbolic centre is accompanied by another critical issue: the insufficient quantity and quality of local services.
The redevelopment of the Ex-Thyssen site thus represents a strategic challenge for the vitality of the urban fabric, offering an opportunity to stitch together the district's fragmented parts and introduce a new urban center. This center is envisioned as a symbolic, tangible, functional, and social focal point for Lucento.

Applied methodology

It is important to emphasize that the objective of the proposed methodology is not to achieve a single project, but rather to translate the design process itself, systematically tracing choices and variations [Fusero *et al.*, 2013]. By nature, the design process is iterative, characterized by a series of key decisions that influence the final outcome. This led to a deconstruction of the process, in which five fundamental phases were identified: (i) urban context analysis; (ii) definition of the urban fabric; (iii) characterisation of the blocks; (iv) determination of the built environment; (v) designer's decision-making.
Assuming this macro-division, the design process was deconstructed into different parts, each translated with the aid of VPE applications suited to achieving specific objectives. It is emphasised that in this process considerable importance was given to the role of variations and the desire to keep track of the entire decision-making process.
For the algorithm to work, it is essential to analyse and redesign, both geometrically and informatively, the context.
On the digital model of the area, input parameters were defined, such as: the boundary of the project area and the characterising elements of the context defined as points-context. The urban fabric can be defined as the organised set of physical elements of the city observable at different scales [Kropf 1996]. The second phase of the process determines two of these key elements: the street system and the urban blocks. Starting with the road system, the input parameters introduced by the designer may be origin and/or direction, which, although generative elements, do not necessarily translate into visible geometric components in the urban fabric. Next, the street pattern is defined through the algorithm for shape, size, relationship with surrounding streets and hierarchy. The tool allows the designer to choose between two possible street configurations, grid or radial, which define the layout of the primary grid. The secondary grid, on the other hand, is derived and managed by modifying the parameters.
The developed algorithm generates different scenarios, where the design outcomes vary depending on the weight assigned to input data. Particularly relevant in this first phase is the process by which the project's viability is evaluated.

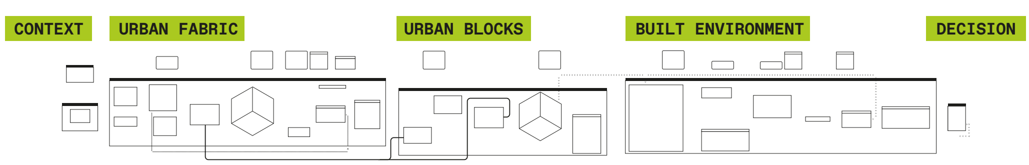

Fig. 2. Summary diagram of the process with the subdivision of phases (elaboration by the authors MNGP).

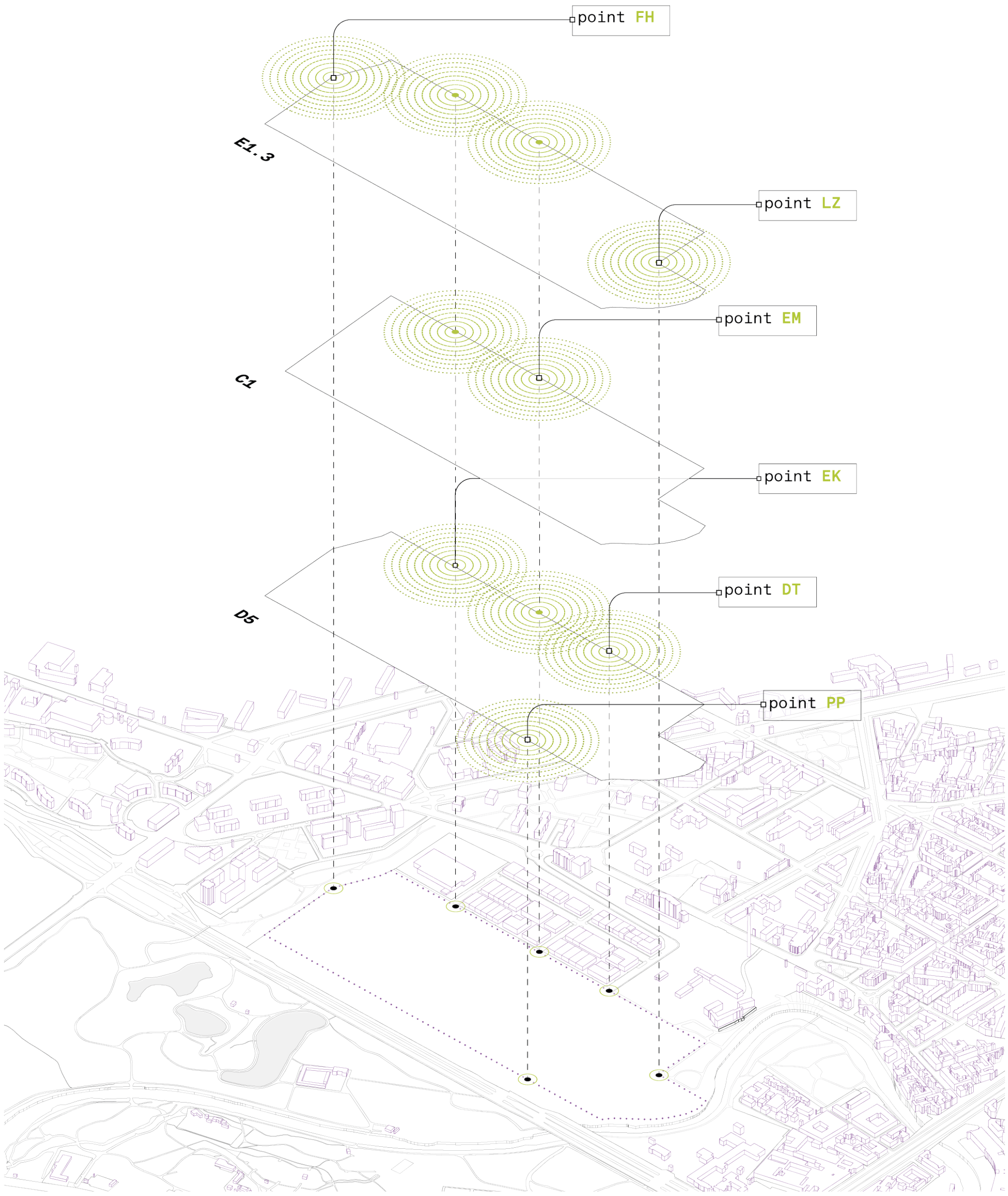

Fig. 3. Drawing of the context and the boundary of the selected project area (below). Identification of points-context for three selected scenarios (above)(elaboration by the authors IZ).

By applying a multi-objective optimization algorithm, the model generates a street system that minimizes the difference between the street pattern areas produced and those required based on mobility data analysis. The latter is based on data provided by the Metropolitan City of Turin [IMQ 2022], from which it was possible to calculate three different values that distinguish the mobility flow categories into high, medium and low. The roads generated were assigned specific values through two different analyses, in consideration of the proven correlation between the human movement patterns and the spatial configuration of the road network [Hillier 1993].

The first investigates the degree of accessibility of a segment with respect to the entire road network, returning a quantitative result. The attractiveness analysis, on the other hand, provides a qualitative value by measuring the influence of points-context on the road system. The results obtained through the use of the *Wallacei*, optimisation multi-objective optimization plugin, enable the designers to make more informed decisions when analyzing results and selecting optimal solutions.

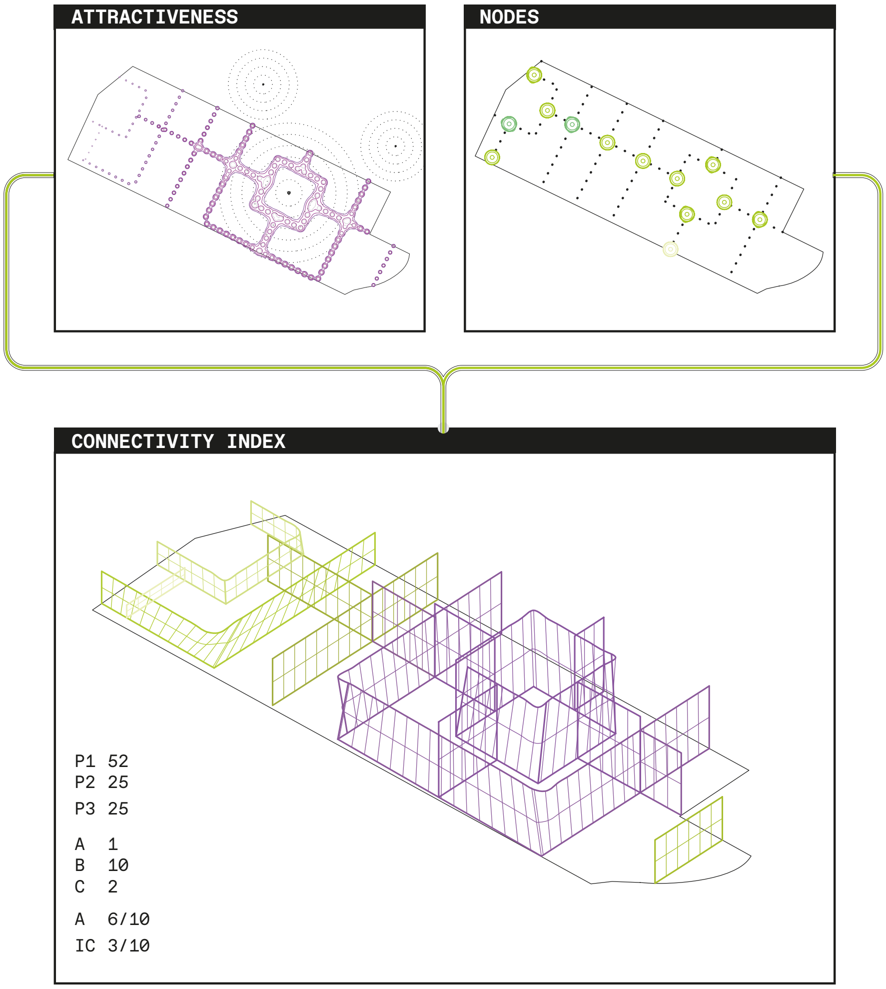

Fig. 4. Representation of the analyses for calculating the connectivity index using heatmaps of a single scenario (elaboration by the authors MNGP).

The selected result, which defines the configuration of streets and blocks,serves as the input for the next phase: determining the built environment. To establish the building types within the urban blocks, an analysis of the Coverage Value (COV) is conducted. By correlating the road connectivity values (previously defined) with the attractiveness of context points, a COV value is assigned to each block. This allows us to classify the blocks into three different clusters: low, medium and high ground densities, identified with D1, D2 and D3, respectively. In this academic research, density is seen as a key tool to promote urban *mixité* [Otti 2014]. In the process developed, it translates into the diversification of building types that simultaneously allows for the control of the full/empty ratio.
Based on a+t architecture's study in the book *Why Density?* [a+t architecture 2015], seven different building types were selected and clustered with respect to their COV value. The designer associates each urban block cluster with a corresponding building type. The building forms thus chosen undergo a process of adaptation to the size of the block and the conditions imposed by the designer through specific parameters of shape, size and relationship to the void.
Starting from the previously determined building footprint, the height range for each building type is automatically defined. These ranges are established by a minimum limit, chosen by the designer, and a maximum limit, calculated by the algorithm in accordance with the city's building regulations. The process concludes with a verification phase, in which a single-factor optimiser identifies the volume configurations that best respect the land index prescribed by the building regulations. Finally, the designer selects the solution that best suits the area and is most consistent with the design idea, with the possibility of repeating the process if the result is unsustainable with respect to the set objectives.

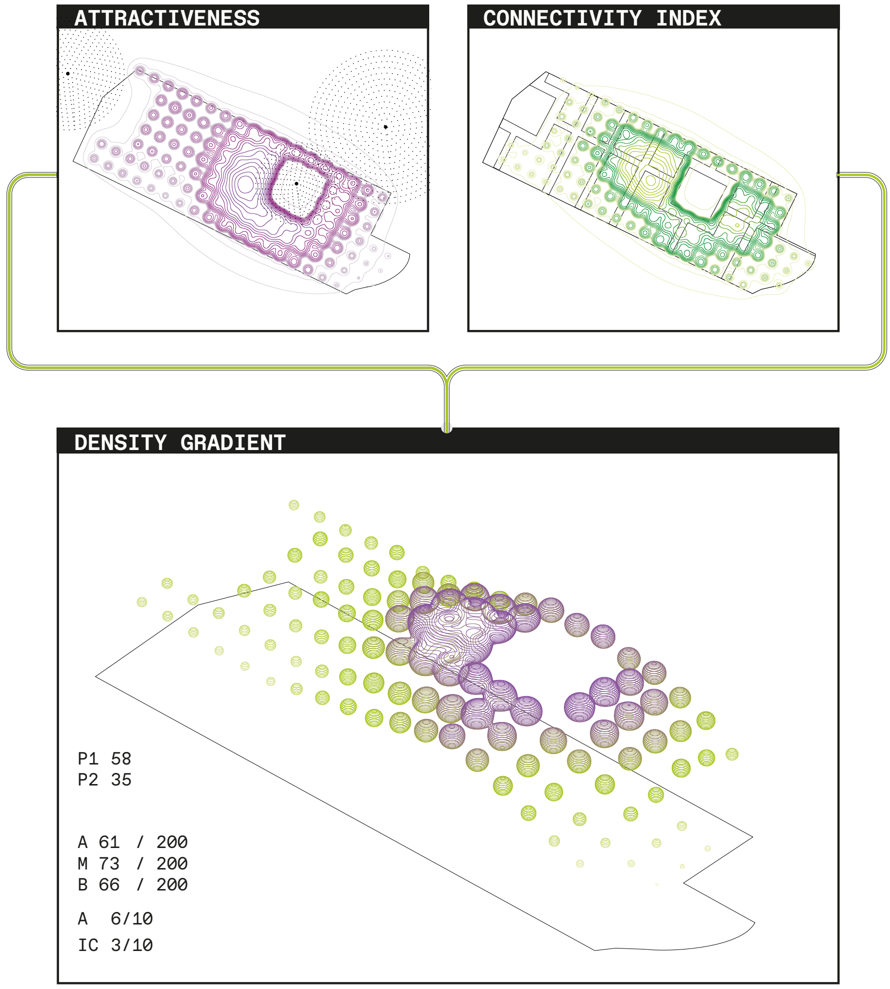

Fig. 5. Representation of the analyses for identifying the density gradient using heatmaps of a single scenario (elaboration by the authors IZ).

The translation of the compositional idea through VPL methodology, unlike traditional representation tools, allows to trace a complete 'project history'. Every change, parameter variation, decision made by the designer is recorded and documented in the flow diagram. This allows for the reconstruction of the entire design process, facilitating an understanding of the rationale behind each choice and an evaluation of the impact of different alternatives. The 'design history' should not be regarded as a mere technical report but rather as a tool for critical reflection. By analyzing the model's evolution, the designer can identify the strengths and weaknesses of their approach. In this way, the process itself becomes a form of *èkphrasis* of the design.

Conclusions

Scenario-based design enables the management of uncertainty and complexity in urban projects, allowing solutions to be adapted to the specific needs of a given context. In this regard, the scenario-based design methodology developed demonstrates how VPL methodologies can be particularly effective in managing the complexity of an urban project and in exploring a wide range of solutions.
The development of an algorithm that synthesizes the design concept allows to generate and, subsequently, evaluate different configurations of the area, much faster than traditional processes. The 'project history' drawn up through VPL tools is a valuable tool for learning and critical reflection. However, the proposed methodology has some limitations. First, the complexity of VPL tools requires specific expertise. Moreover, algorithmic modeling does not easily account

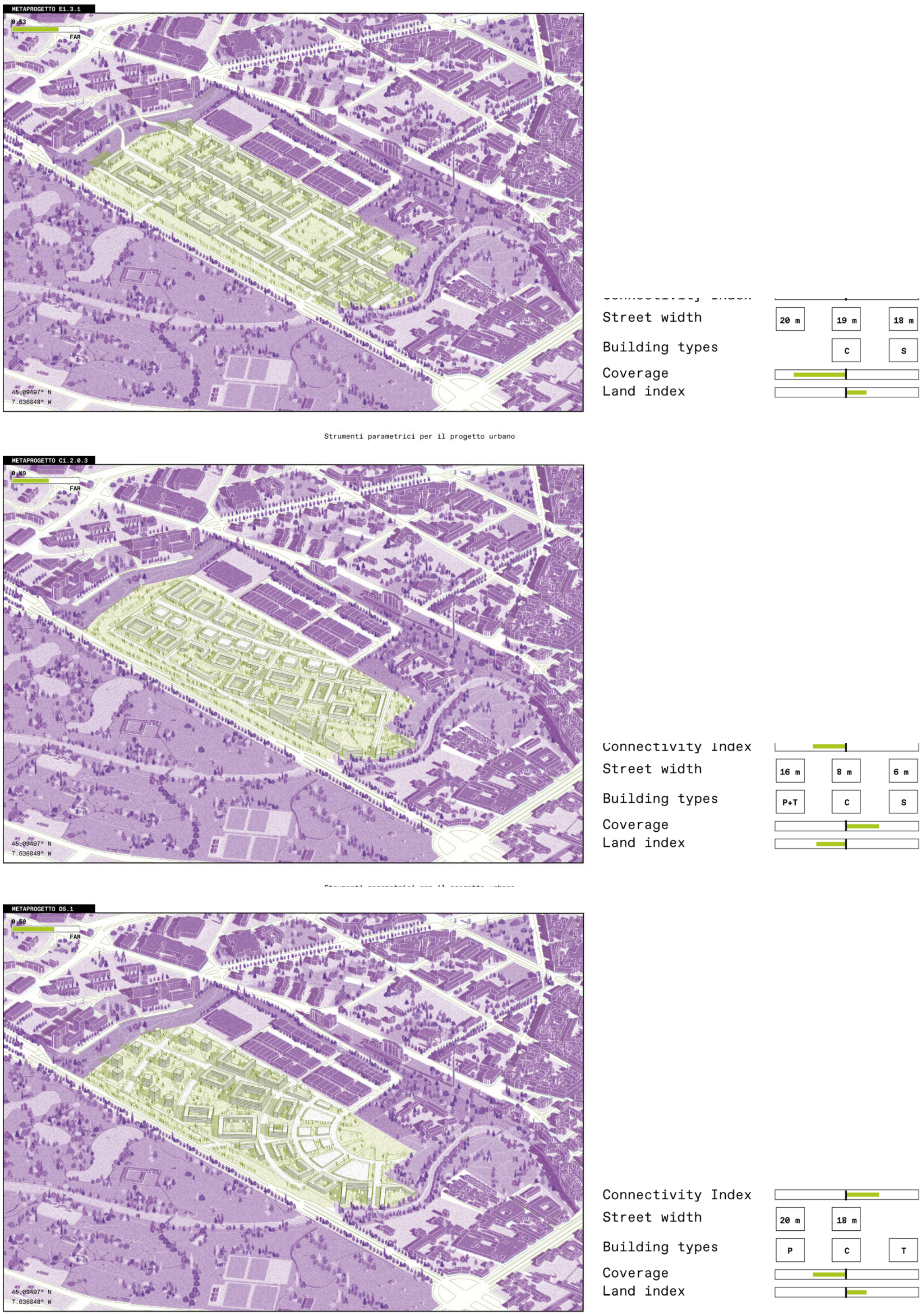

Fig. 6. Meta-design scenarios with achieved results (elaboration by the authors MNGP).

for all aspects of urban design, particularly qualitative factors that resist algorithmic representation. Despite these limitations, the methodology offers considerable opportunities. It can be assumed that the future of design will increasingly be characterized by the interaction between man and machine, between intuition and algorithm. As a result, the architect will have to acquire new skills, not only technical but also creative and critical, in order to make the best use of the potential offered by digital.

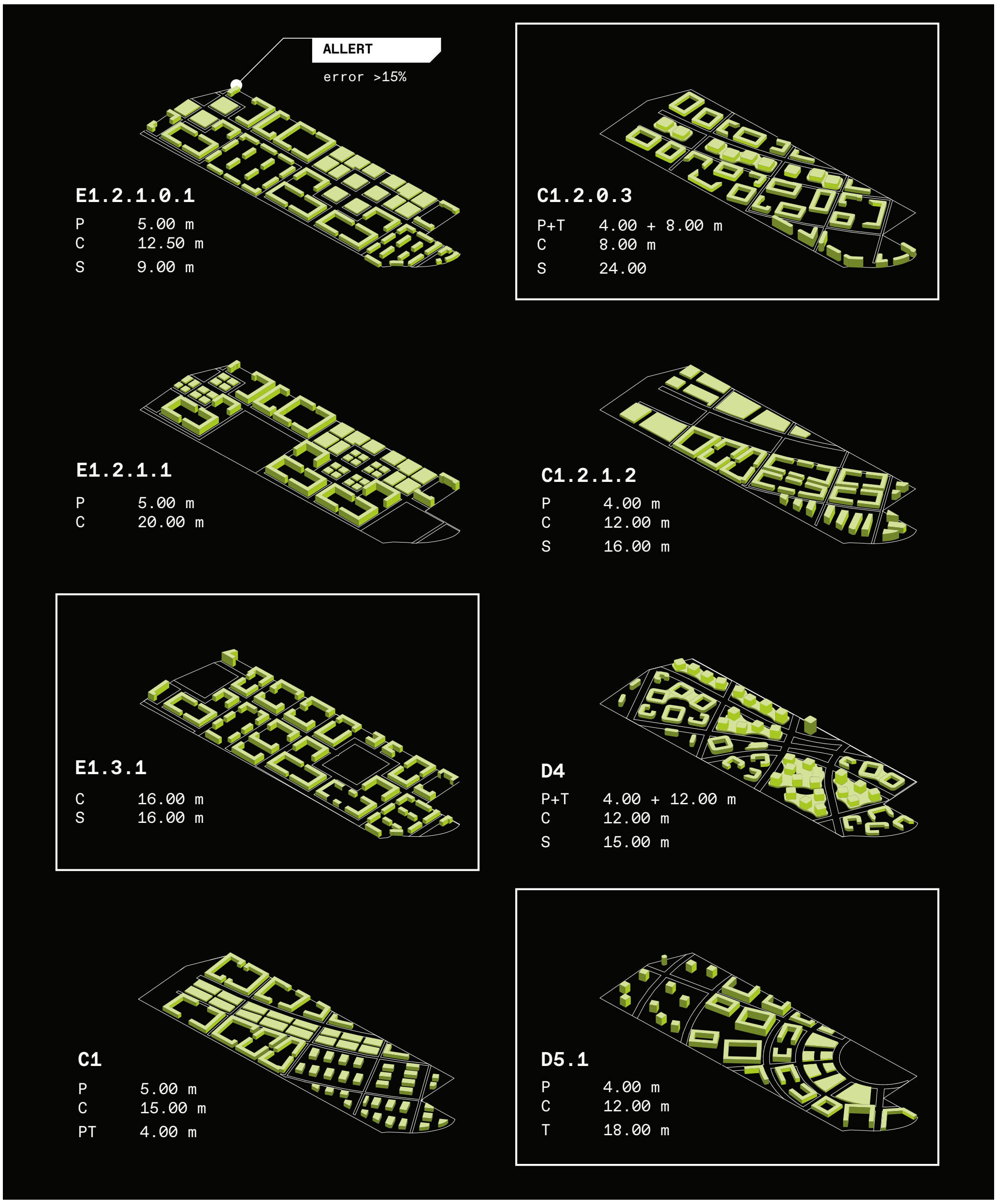

Fig. 7. Some volumetric variations of the scenarios (elaboration by the authors MNGP and IZ).

Acknowledgment and credits

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