Diagrams as Logical Machines
Informing the Design Process Through Permutation

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Abstract: The morphological school of Italian tradition, developed in the 1960s, is grounded on the investigation of the urban environment and architectural form. It reconstructs the contemporary environment's configuration as a historical process derived from a previous structure through maps and typology. From a broader perspective, the process mentioned is similar to an evolutionary process in which some elements change at different times with a logic that can be different in each part of the globe but can be understood thanks to a logical tool. Despite criticisms of the urban morphology approach and its aim to predict a specific urban environment based on evolutionary recurrences, looking at the city as composed of permutations encourages the possibility of defining new scenarios for the city and the project. This shift in reading the city led to a significant change in the study of urban form, pivoting the tool from maps to diagrams. That is why the diagrammatic logic may directly connect the reading of the urban environment with the design process. Indeed, the iteration with software, especially when it allows to show dynamicity, has expanded the range of outputs. It provides a diagram that is neither entirely mental nor purely iconic, which can be manipulated to produce other diagrams and urban configurations. Maps translated into diagrams can be used as a starting point for computational design thinking activities. The innovation from informing the design process through the permutations extracted from the diagram became the driving force for new projects. Informing the design process through permutation means searching for a way to interpret the process of transformation of the city. For this reason, the paper focuses on the potential of the diagram as a machine built using a logical process that can lead to reading the city logically but focusing on its exceptions without fixing a specific rule of transformation. Moreover, the expected result is to open a debate on methodology that directly links the analysis with the urban design.
Keywords: Urban morphology, Diagram, Methodology, Information, Permutation.

Introduction

Informing the design process necessitates providing evidence as a foundation for the design. According to the Cambridge Dictionary, evidence is a proof, a reason, or something that clarifies whether an assumption is true or false. Decoding the city with evidence is closely linked to data and numerical information about a specific event. However, what is more interesting is connecting the evidence with its logical construction and the qualitative study of the city's shape and its components. In urban design, it is possible to inform the process not only by translating the urban form into numerical data but also by understanding the dynamism of the city's transformation process. The evidential data in the transformation process includes the consistent building typologies that remains the same over the years as

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a benchmark of good practice. On the other hand, discovering their evolution and variation allows architects to explore various dynamic urban structures.

Traditionally, the study of cities has primarily focused on their stable elements, following the lead of renowned international scholars like Aldo Rossi. Within the Italian urban morphology tradition, the concept of permanence was broadly explained by juxtaposing it with the concept of variation as another perspective on the city, but without focusing on interpreting the transformation process. Aymonino in 1977 introduced two variables for understanding the city: invariants and permutations. However, merely identifying laws that help us comprehend how a place changes or why certain elements remain constant does not concretely help us understand the emergent possibilities that each environment can offer. It is precisely because the replication process between one phase and another is imperfect that it opens the possibility of variations and recombinations of elements (Ingold, 2019). This precise point is where the concept of permutation as a way to perceive the city's space comes in, defining new possible approaches to urban design. The contemporary city is no longer seen as a system of permanence but as a realm of continuous and diverse permutations. Each change represents a unique and unrepeatable transitional process.

Nowadays, the need is not just to recognise this process but to find a method to interpret it. The starting point to embrace this concept is the idea of diagrams as a tool capable of elucidating a logical process. It is worth highlighting how this tool can represent the city and its evolution through change and design. In fact, diagrammatic logic can be directly related to understanding the urban environment through design. Using this approach to interpret urban morphology can highlight potential generalisations, not of the phenomenon itself, but of the method employed to comprehend the city. As a result, from the method used to define permutation, it is possible to extract a potential design tool or, at the very least, a different perspective for viewing the city.

1. From Image to Diagram

The morphological school of the Italian tradition focuses on investigating the urban environment and architectural form. It reconstructs the current configuration of the space by tracing its historical process from a previous structure using maps and typology (Marzot, 2022). This mapping process delves into the fixed aspects of the city and examines why its shape has adapted over time without fundamentally altering its nature. The map serves as a static image, akin to a snapshot of a specific place at a particular moment. This way of interpreting the city emphasises the permanences of the urban form. Only by overlapping and comparing different maps of the same place over time is it possible to resemble the evolutionary process of the city. In fact, despite recognising the fixed terms, others undergo significant changes guided by distinct logics that can vary across different parts of the world but still maintain a particular interest in the project. This process of linking together different representations leads maps to resemble diagrams, as both share the property of being images with a solid logical construction that is transferred to the viewer.

Starting from criticisms of the urban morphology approach and its tendency to prefigure specific urban environments by prioritizing permanences, shifting the perspective on permutation through diagrams offers a wide range of possibilities for defining new scenarios. Traditional morphological analysis typically emphasizes interpreting structure as a fundamental aspect while identifying the changing elements as exceptions; however, the diagram places both parts on an equal footing. In this paradigm, permutations are no longer exceptions, and the rules derived from them are logically constructed similarly to those governing permanence. The diagram becomes a tool, and its logical construction is a medium informing the design process.

From assemblage theory, the diagram defines spatiotemporal multiplicities and represents changes by establishing a new reality. Moreover, as it arises from an abstraction process, it continuously generates different readings (Muminovic, 2019). The diagram itself encompasses a multitude of possible and unrealised scenarios. It serves as a graphic assemblage that delineates the relationships between activities and forms based on an organisational principle. Hence, it serves as the most effective tool for grappling with the complexity of reality. Thus, the diagram is not merely a drawing but a depiction of potentiality, presenting not only the abstract representation of a model of how things behave in the world but also a multiverse of configurations (Allen, 1998).

During the 1990s, diagrammatic techniques in architecture underwent significant advancements due to the spread of new software capabilities. One of the main focus during this period was the manipulation of digitalised inputs; these diagrams aimed to represent architectural concepts and ideas more dynamically and interactively. One prominent example is Greg Lynn, who discussed these ideas in his *Animated Form* book. By incorporating dynamic elements and variables into the design process, Lynn aimed to create shapes and forms that emerged due to the modelled and animated variables. The diagrams produced during this era often had a pictorial look, combining verbal concepts and mathematical operations. They were not merely static representations but rather dynamic and interactive visualisations. The challenge for architects and designers was interpreting these diagrams and extracting the information that unexpectedly emerged from the modelling and simulation processes (Gómez, 2010). This perspective has led to the perception of the diagram as the outcome of a design process facilitated by software tools, giving a reductionist value to the diagram, which is seen not a tool but a representation method.

On the other hand, when used generatively, the diagram can actively define a method of reading and visualisation. Beyond its pictorial role as an image, the diagram shifts towards logical diagrammatic construction (Allen, 2009). It is no longer merely a tool used for representation; instead, it can generate mechanisms and establish relationships between the urban fabric and information. In this context, the diagram becomes an operative medium, differentiating itself from the concept of diagrammatic architecture, where architecture takes on the characteristics of the diagram and loses its real essence (Gasperoni, 2022).

Understanding the diagram in an operative sense means attributing to it the ability to unfold concepts, leading to the proliferation of different meanings. It constitutes a method capable of generating, destabilising reality, and promoting discovery. Through the diagram, composing a thought process and a complex argument or synthesising a set of circumstances is possible. It can also be associated with a projective function, with vectors pointing in unknown directions (Gansterer, 2011). In this condition, the diagram leads to the continuous reformulation of a hypothesis (Knoespel, 2002). The diagrams, through their practice, can raise questions about design methods and tools (Garcia, 2010).

The logic behind the diagram, looking at the city as a whole made by permutations, is the medium between the urban form of the city transformation and its design. From this assumption, this article, part of a broader research (Gugliotta, 2023), will retrace the importance of the diagram in the generative approach to design, not by defining its relationship with data but by explaining its construction as a logical tool to investigate the city and generate new projects.

2. The Diagram as Logical Machine

The concept of the diagram as a logical machine capturing and representing complex processes in architecture has been influenced by the works of Deleuze and Guattari. Tradition-

ally used to depict the city and its transformations, the diagram can also serve as a tool for understanding and visualising the urban environment within a design project. When adopting a generative approach, the diagram moves beyond its role as a mere image. It becomes a logical and constructive tool for generating relationships and understanding the urban fabric and information. The output of a diagram made not just to represent but built with a logical framework is a system of rules and relationships.

This assumption signifies a paradigm shift, moving from the map as a guide towards an already specific project (Palma, 2001), to the map, or the diagram, as a speculator of multiple project possibilities. This consideration arises from using the diagram to generate new realities of the city composed of permutations. The purpose is to escape the taxonomic nature of urban analysis and instead explore the realm of project possibilities where typology and topology engage in dialogue. Urban analysis is already a construct, as it not only derived from surveys but primarily from conjectures and analogies. Furthermore, it is inherently abstract, as it is almost inevitably subjected to a process of abstraction.

In his publication, Gansterer correlates the term "figure and thought" with Astrit Schmidt-Burkhart exploration of "figures of order" from 2004, forming a basis for the investigation and analysis of scientific texts in visual culture, graphemics and diagrammatic representation. The term comes across as establishing various concepts, models, and processes to highlight the role of diagrams as tools of thought capable of stimulating a collateral point of view on the environment analysed. Figures of thought can be placed on different levels of abstraction, with the process often involving multiple iterations of abstraction. Rather than beginning with purely mathematically abstract or verbal abstractions, diagrams incorporate formulations that can be visually depicted to describe a procedure or process, that, in the case of the contemporary city is the process of city transition.

The use or application of these figures of thought thus leads to forms that are comprehensible through drawing (Gansterer, 2011). The diagram as a drawing becomes a medium translated into an operative machine. Consequently, permutations become explicit through reconstructing the logical processes of the diagrams. Developing methods for reconstructing permanences contributes to qualitative features in the design processes of the contemporary city.

3. The Diagram as a Method

Reading the urban form with a diagram is only sufficient if the diagram focuses on permutation. For this reason, the first hypothesis on transforming the maps into a diagram is to build one of the multiple possible representations of a diagram, a matrix. It incorporates all the traditional morphological analysis information previously contained in the map to change the perspective of reading the city. Each component of the classic reading of urban forms, such as scale, time, and each part of the city involved in the process of transformation, has been decomposed and recomposed in the new space of the matrix. All of this is done to reconstruct the rule behind the permutation and understand its variety. The matrix, as it is built, uses generative diagrams and assemblage theory to define itself as a specific tool that addresses the need for a dynamic city. In this way, the tool can give different information simultaneously and display, in the same matrix, multiple points of view on the city.

Through the matrix, considerations arise regarding methods for representing the city and its transitions. Permutations, initially identified in the maps, are now normalised and used as catalysts for project development. For the investigation, it is not essential to observe the specific permutations of individual contingencies but to identify a method that allows for their identification through the decomposition into rules and permutation variables. The

specific contingency becomes a pretext for a methodological analysis. Starting from the relationship between reading the city and designing it (the design is influenced by the method used to read the city), the image of the diagram (Figure 1) becomes a provocative representation of the city in transformation, opening up new possibilities for representation.

The results of the representations aim to underline the variety of analysis possibilities of the transition, defining the logical framework of the method. The diagram highlights the importance of diagrammatic logic, which becomes a tool for revealing hidden urban dynamics. Consequently, it becomes evident that the diagram's objective is not merely the representation of a specific scenario, but rather highlights its character of multiplicity in providing ever-different scenarios informing the design. The diagram is the diagrammatic object that composes the representation, but its diagrammatic logic is exportable and adaptable to new and different images. Beyond the meaning of the image, the purpose of visualisation becomes having a critical point of view, opening up new perspectives on possible representations of the transitioning city.

For this reason, the diagrammatic reconstruction of the map is just one of the possible interpretations that, through the decomposition and exploitation of hypothesis relationships, aims to provide a new point of view on the city. As understood in this way, the diagram does not correspond to a single image but to a logical system. From this methodology, the starting point for the design shifts from the static part of the city to those undergoing change. These changes bring to light the dynamic nature of the of the urban environment, emphasizing its propulsive features.

4. Using the Diagram to Interpret the City as Permutation

Diagrams are essential representations for thinking, problem-solving, and communication in design disciplines, particularly those related to creating physical forms (Do & Gross, 2001). The ability to develop multiple scenarios leads once again to consider the diagram as generative, representing and analysing existing realities and envisioning realities that do not yet exist on paper or in time. It becomes a carrier for non-specific design visions. The diagram, functioning as a map, serves as the genesis of computational design thinking and activates the development of multiple projects in the city from a specific configuration of the urban environment without excluding the architect from the design process in favour of a software-based approach based on a sorting process. Conversely, the information on permuta-

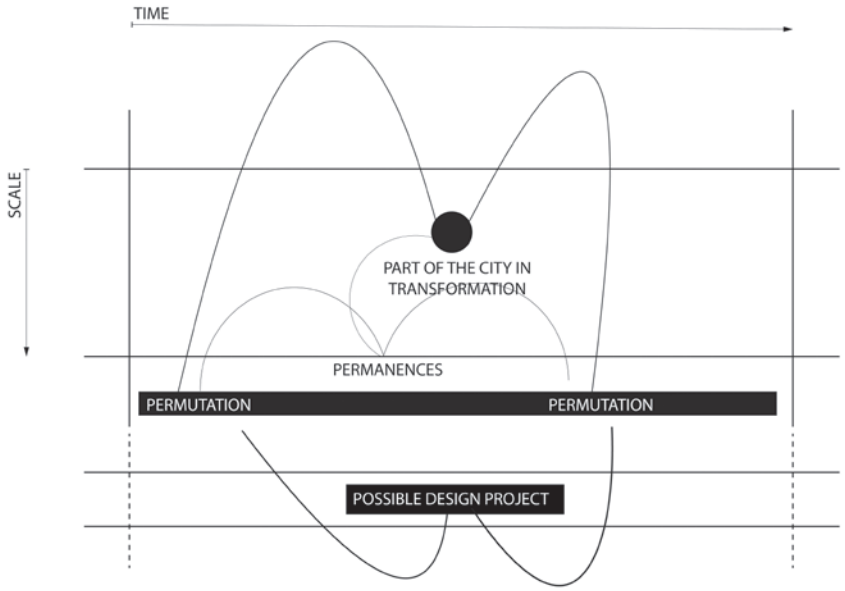

Figure 1. *Informing the design process through a diagram permutation-based. Representation of a possible matrix for the design that contains all the elements of the traditional morphological analysis.*

tion extracted from the diagram becomes the driving force for a new project. The architect is a "researcher-designer", as defined by Lak and Aghmolaei, who designs and evaluates the project according to evidence (2020). Evidence that, in this case, is not based on quantitative analysis, numbers, or indices, but on the logical construction of the analysis.

Indeed, there are contrasting interpretations of the term "diagram" in current discourse. On one hand, some perceive diagrams primarily as tools for systematisation and problem-solving (Lucan, 2015). This understanding considers diagrams as aids facilitating numerous perceptual inferences, making them highly accessible to human understanding. This perspective emphasises the role of diagrams in organising information and simplifying complex concepts. On the other hand, an opposing viewpoint sees diagrams as catalysts for unfolding processes or as maps of movement. According to this perspective, diagrams go beyond static representations and capture dynamic and evolving phenomena. They are seen as instruments that provoke the exploration of various possibilities and reveal hidden relationships or patterns. Rather than providing fixed solutions, these diagrams encourage the generation of new ideas and the discovery of novel perspectives (Gansterer, 2011).

The results of reading the city as a permutation through diagrams as maps of movement lead to the definition of a new paradigm in the urban environment, a brand-new perspective. This approach opens up a methodological discourse beyond the simple relation between causes and effects. This approach allows the architect to have some qualitative data as a set of relationships between parts of the city. The data are not numbers but relations that inform the designer to develop a city vision.

Conclusion

The morphological approach proposes the idea that morphology has the potential to be the driving force behind the urban design process. Many studies have related morphological characteristics translated into numbers with aspects related to building energy, social effects, or urban evolution (Dibble *et al.*, 2019; Fleischmann *et al.*, 2021). Conventional morphological features are defined based on qualitative descriptions or manually selected indicators, which include subjective biases, thereby limiting the generalizability of possible computational approaches (Cai & Biao, 2021). Li and Han (2011) argue that architectural design requires an integrated balance of complex adaptive systems. Generative design emerges as a solution, focusing on translating and simulating design concepts using computational models that facilitate decision-making, the construction of connections, and project optimisation. These computational models rely on extensive data and the extraction of rational rules to generate new design proposals (Do & Gross, 2001). In this context, combining qualitative morphological analysis, which highlights permutations with logical diagrammatic construction, which helps define rules, supports generative design as a strategy to propose new project visions.

From the definition of the method, analysis and design have been treated separated practices; instead, their connections need to be defined. The perspective of the project changes: analysis does not aim to establish what already exists, and design does not express a desire for invention. A mechanism of mutual exchange is established between the two, within which there is recognition of existing patterns that are not taken as prejudged conclusions but are reformulated (Rispoli, 2016). To develop an urban matrix, with the help of the diagram concept, capable of preserving the complexity of dynamism, continuous questioning of analysis during the design process is essential. The role of the diagram in design is placed upstream and not as the outcome of software but as its construction. Generative parametric architecture demonstrates how the diagram has a raison d'être in architecture as a working tool (Brauer & Rogers, 2019).

Furthermore, due to its logic-based construction, the diagram can be exported to inform the design process through software developed from the matrix, conceived as a system of thought. Historically, designers have engaged with mathematics and logic either to build knowledge (informing the design) or without rules (using the tool without understanding its functioning). In between lies the grey area of grey boxing (Witt, 2018), where only partial knowledge is available, yet it still generates potential. To implement this transition from analogue to digital, logical construction in urban analysis is of fundamental importance. The diagram can be useful as cross-disciplinary way of thinking, capable of reading what changes in the city to align with the new emergencies of the contemporary world. The expected output of going deeper into the research is to investigate new diagrams and matrices able to show more than what the maps were showing in the traditional morphological reading, permutation at first, but also the actors involved in the process, economic and societal factors. The perspective on the design product is multiple, from using the diagram as a platform for a bottom-up process to the use of the matrix as the first approach to control computational and parametric software.

This new concept of interpreting the city through diagrams and using a specific matrix built, underscores the significance of permutation in the built environment, ultimately generating a new image of the city that helps design new spaces and urban forms.

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