[E]motive Architecture: Strategies for a Behaviour-Driven Space Configuration

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Abstract

As Architect and Engineer, we used to work with the concept of Space. Struggling to find an exhaustive definition, we risk thinking about it as a framework with the same properties of the object we are going to design. Looking at the Space as an abstract background of the objects that we are going to place in it, we risk to not understand how it plays a cultural and social role in human affairs. The configurations of people can be influenced by, or influence, a configuration of space: therefore, the apparent effect of Architecture on social outcomes seems to pass through the relation of spatial layouts. Movement is by far the dominant form of space use and, following this logic, we can argue how spatial configuration can influence the pattern of movement in space. Generative design processes can be used to define the properties for a space layout that better stimulate a sense of well-being through human behavior monitoring. The potential role of generative design processes finds its maximum expression wherever a certain problem's parameters and interactions bring a level of complexity, much greater than that could be handled by human cognitive processes alone. Generative design integrates artificial intelligence by using search algorithms to achieve high-performing results. However, the emphasis on the 'automated design procedures' should not overshadow the central role of the designer's intellectual capacity, essential for the critical judgement towards the employment of algorithms, the selection of input data parameters as well as the criteria of evaluation. Architects and planners now have the chance to calibrate their designs looking at human comfort and social interaction.

Keywords: Space; Configuration; Interaction; Movement; Monitoring; Data-driven design; Generative design

Perception of Space

As Architect and Engineer, we used to work with the concept of Space. Struggling to find an exhaustive definition, we risk to think about it as a framework with the same properties of the object we are going to design. Space comes to be seen, quite simply, as the general abstract background of the objects that we are going to place in it. However, following this reason we are doomed to not understand how it plays a cultural and social role in human affairs.

The idea of space is usually transcribed as the "use of space" or the "perception of space". In all these common expressions, the concept takes on meaning in relation to human behavior. "Human behavior does not simply happen in space. It has its own spatial form (Bill Hiller)". The human faculties that include our senses, perceptions and personal history are the basis of how people perceive Space.

Configuration and Movement in Space

The way people live within the space, such as encountering, congregating, avoiding, dwelling can lead to specific configurations. The relation between people and space can influence what we consider as attributes of individuals. "Configuration seems to be a concept addressed to the whole of a complex rather than of its parts" (Bill Hiller). Configuration is a set of interdependent relations among elements of a system and, as such, subjects to variations according to the scale of those interactions.

Movement is considerably the dominant form of space use and, following this logic, we can debate how spatial configuration can influence pattern of movement in space. Through its effects on movements, spatial configuration tends naturally to define certain patterns of co-presence and co-awareness amongst the individuals living in and passing through the space. The configuration of people can be influenced by, or influence, a configuration of space: the apparent effect of Architecture on social outcomes seem to pass through the relation of spatial layouts and natural co-presence.

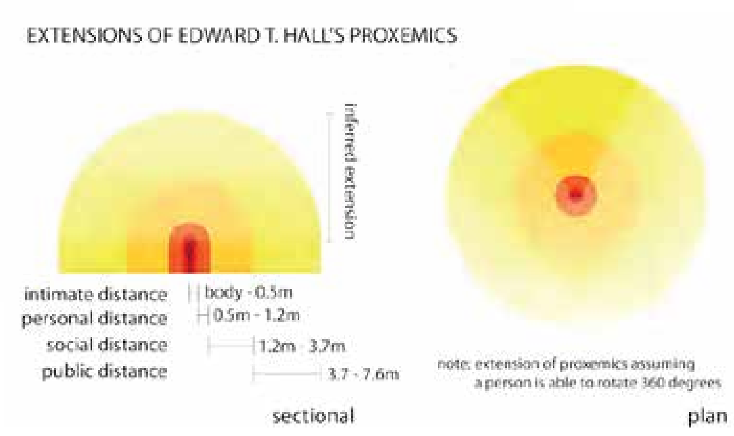
In 1966, the anthropologist Edward Twillich Hall published The Hidden Dimensions, coining the term "proxemics" to describe how both 'man and his environment participate in molding each other'. Proxemics depicts the implicit and explicit experiences of an environment and the physical way people inhabit their sensory worlds.

Architecture is organized and structured in a way that increases one's awareness of his surroundings. In order to positively inform human existence, attention should be paid to human sensory capabilities and social dynamics in order to create contextual environments where the spatial dimensions are evocative of personal, social or public interactions.

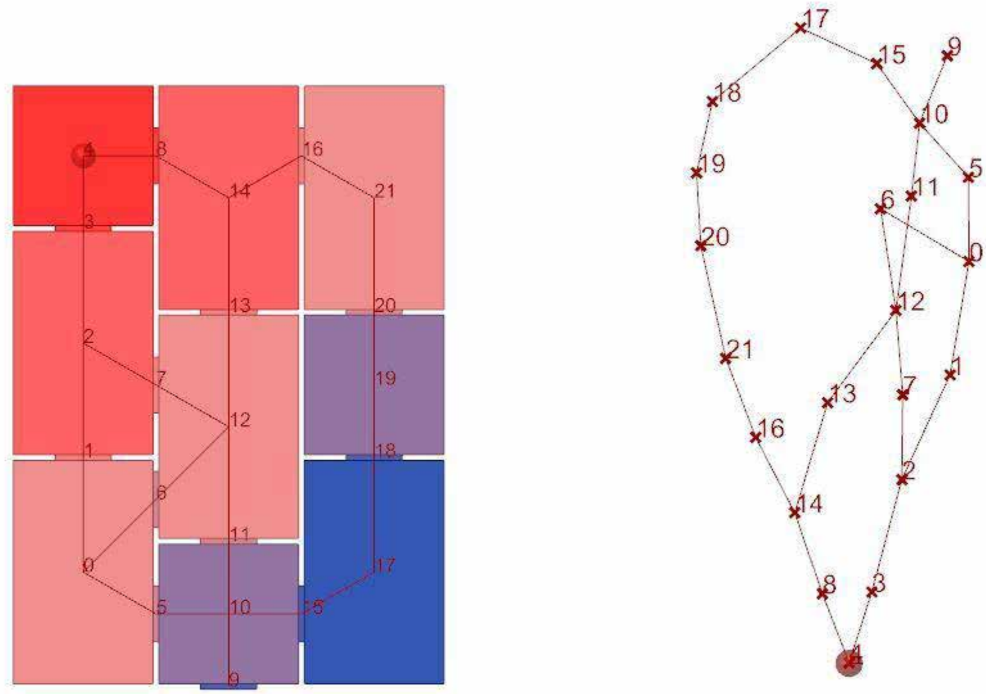
Proxemics and Navigation Design

Proxemics is categorize through four categories related to the concept of Distance: *Intimate Distance*: 0 - 0.5 m, mainly for non-verbal communication where only the intimate people like members of the family and friends can enter into; *Personal Distanc*e: 0.5 - 1.2 m (but varies in different cultures), it is meant for the people who are well known to us; *Social Distance*: 1.2 - 3.7 m related to gatherings with people not particularly well known; *Public Distance*: 3.7 - 7.6 m, where only public interaction is possible and demands louder voice, more formal style of language and reduced speech rate.

Based on these definitions, the architectural theory called an '*Aleatoric Milieu*,' begins with the analysis of human dimensions, and moves to how the awareness of these dimensions is enhanced in the process of moving within the space. Considering a gradation of intimacy and density for occupancy in a designed area, the architects could influence how a person may choose to move from one location to the other. Utilizing light, sound and materials, they lead the decision to walk from point A to point B through a memorable place.



Navigation design is defined as a part of the *Aleatoric Milieu*, where space is configured through narthex, path and node used for wayfinding and creating memory while moving through space. The narthex, an entrance room or space, becomes the decision-making point towards the building navigation. By transitioning from an external public realm towards a greater intimacy, it provides a diminished public scale that informs the users that they are entering a space of lower density if compared to an open street. Therefore, there is a sequence and a hierarchy of proxemic spaces to be considered when designing an entrance room that adds clarity to the transition from public to most intimate architectural space. The aisle consists of a regulated set of visual additional information regarding the node. In such a way, the Path consists of a regular pattern of architectural features and activity necessary to prepare the users to reach the Node, considered as the final goal.



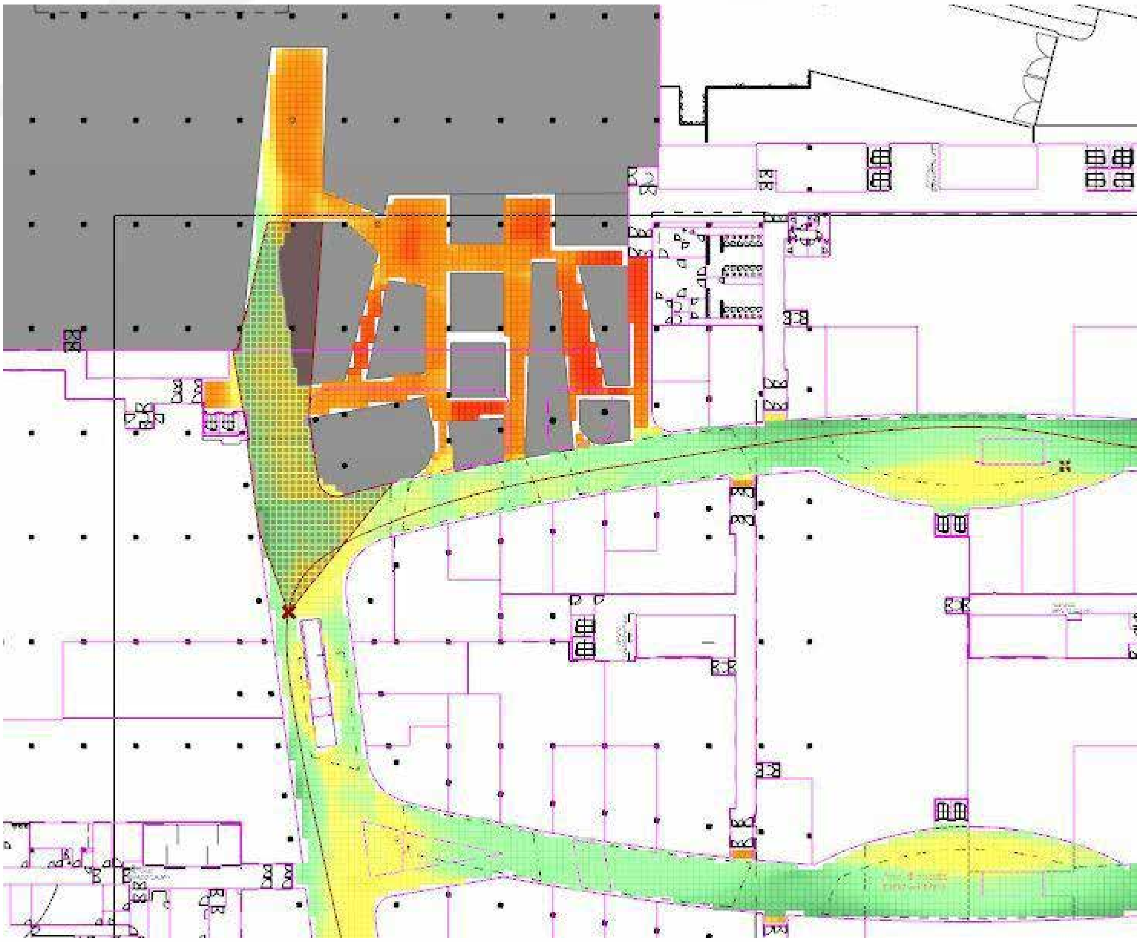
Graph Map examples

Graph Theory

Understanding the way people move through and experience, the space is however, a critical aspect of architectural design since such experiences tend to be subjective and therefore difficult to be simulated by the computer. However, if we look at the problem more closely, we can come up with ways of measuring specific aspects of this experience such as how far people walk between different programs in a space (adjacency), and potential bottlenecks where such movements are concentrated (congestion). These occupant-level metrics give a deeper understanding about the space from the point of view of its occupants and their needs as users. To compute these kinds of metrics we can rely on a branch of mathematics called graph theory, which is based on a data structure called "graph".

A graph is defined by a list of vertices (as such the *nodes* in the *Aleatoric Milieu* theory) which store some properties and a list of edges, which connect sets of two nodes and represent a relationship between them (like the *path* in the *Aleatoric Milieu* theory).

Graph structures are very flexible and can represent many types of relationships. If we represent our spatial information through this system, we can take advantage of many existing algorithms developed for answering specific questions about such structures. For example, if we want to know the length of the shortest path between two points in a space, we can represent all possible paths as a graph of nodes and edges and use *Dijkstra's Algorithm* to efficiently compute the shortest path. In the same way, we can calculate things such as routing, travel distances, adjacency, or clustering through a set of techniques for spatial analysis called Space Syntax.



Generative Design for a 'Positive Space'

All these methods provide ways of measuring how a design performs according to complex real-world conditions, generating metrics for a "generative" design process. The practice of generative design can be defined as a computational design process aimed at creating the best possible solution towards specific performance criteria and against given boundary conditions. Generative design integrates artificial intelligence by using search algorithms to achieve high-performing results, such as decreasing the distance between programs in a floor plan (adjacency) or decreasing a potential overcrowded situation due to multiple crossings (congestion), which makes it particularly suited to be conceived as a data-driven design process.

Along with the parametrization of the design space, there are no strict rules about which measures the designer should choose, or how input parameters should be implemented. Generally speaking, the measures should encode as much as possible of what is important to the architect about a design problem, since they will be the only thing guiding the algorithm through its search. If we try to categorize what can be measured about an architectural space, we might come up with three categories:

1. Geometric values, what can be mathematically calculated (such as floor area or height).
2. Quantitative values, what can be quantified through simulation-based procedure, such as structural analysis, fluid dynamics or agent based simulations of crowds. These simulation methods provide ways of measuring how a design performs and can be used to guide an optimization algorithm in order to find the best performing options.

3. Qualitative values, such as personal preference or specific "environmental quality" that influence human beings. Environmental quality is an umbrella term that refers to the sum of the characteristics of a specific environment and how it affects the users of the space.

The ultimate goal of a project for a 'positive space' results in a general idea of space where all these measures, through the public, social, personal and intimate dimensions, converge in the most welcoming and comfortable architecture.

Biophilic Principles

The positive effects that the natural elements have on our psyche have been summarized in the concept of "*biophilia*" (Wilson, 1984), defined as the innate human tendency to experience an affinity or a deep connection with other forms of life and nature.

Biophilic design is viewed as a possible interdisciplinary link to sustainable design. Low-environmental-impact and biophilic design share the same goals such as energy and effective resource usage, sustainable materials and product fabrication, controlled waste generation and disposal, pollution abatement, biodiversity protection and indoor environmental quality.

But how to introduce those principles as a countable measure within an algorithmic process? What is needed for the algorithm to work are numerical values that will be tried out in order to produce various scenarios (*genes*) that will be ranked through "score" (*fitness*). Several researchers have made the effort to translate into measurable scale those qualitative spatial qualities that are generally left to the designers' sensitivity and not properly quantified.

An example worthy of being mentioned is a joint research program between the Laboratory of Affective Ecology, University of Valle d'Aosta, and IRIS - Interdisciplinary Research Institute on Sustainability, University of Turin, which resulted in the creation of an evaluation tool able to quantify the biophilic property of an architectural environment: the Biophilic Quality Index.

The BQI is composed of five sections as follows:

Section 1: The network - the building in the context; Section 2: The individual spaces within the building; Section 3A: Opportunities for visual contact with Nature; Section 3B: If a garden/backyard/terrace/patio is present; Section 4: Non-visual contact with Nature; Section 5: Sustainability.

The BQI allows calculating to what extent a building is biophilic, and it can be used as a rating system where the final score, a percentage value, represents the room of improvement. In the context of a parametric design approach, the challenge is to decipher which design choices can be introduced as numerical variables to be tried out in order to iteratively increase in percentages the final rating BQI score. In the works of Steven Kaplan and Rachel Kaplan (Kaplan and Kaplan, 1989), we can find some examples of such kinds of variables. More specifically, they describe four key words that can be translated into practical design considerations.

Consistency, refers to the degree of concordance and repetition that distinguishes the various aspects of the environment; *legibility*, property that makes the environment easily and effectively explored; *complexity*, defined by the variability of the environment; *mystery*, that indicates the amount of hidden information that may contain a scene and encourage the visitor to explore it.

These qualities affect how we behave inside a space. We need to integrate multi-disciplinary design application in order to add feasible variables into our parametric process, such as:

- Create plans arranged at different heights to enhance complexity.
- Prefer curving edges rather than sharp corners that reduce legibility.

- Use dramatic shade and shadows to improve the mystery experience.
- Optimize the visual access to indoor or outdoor vistas through element orientations.
- Reduce visual barriers to leave sufficient depth.
- Locate stairwells at building perimeter with glass facade and interior glass stairwell walls to form a dual prospect condition.
- Control light levels to generate gradual sense of mystery.

Monitoring, Adjust, Repeat

These considerations are just one piece of the puzzle to creating a vibrant, sustainable, and restorative environment. Monitoring human behavior in public spaces where social activities and community formation are hosted, as well as tracking building performance can be also used to identify the properties for a space layout that better stimulate a sense of well-being.

Monitoring human activities and building performances can be used to inform spatial design where the final shape is not predetermined, but instead constantly redefined. By creating feedback loops between the mapping of human behavior and configuration arrangement, it is possible to explore a variety of consequential design adjustments that can be implemented right away, adapting the final outcomes better towards the intended functionalities.

Human activities and building performances will become the data mining sources for statistical analysis about energy efficiency, positive emotions and spatial layouts optimization. Increasingly sophisticated and accessible monitoring systems will lead the development of new design processes based on retrofitting analysis of large data sets. Tracking the building's performance, assessing sustainability strategies, and making occupants more comfortable will eventually help save money and resources.

The monitoring of people's behavior through CCTV, Wi-Fi connections and mobile devices might have a potential dystopian dimension, but if approached with the necessary safeguards to ensure privacy and data protection, could bring to the next level the architectural and urban design decision making.

Conclusion

Architects and planners now have the chance to calibrate their designs looking at social interaction along with human comfort with a Data-Driven Design approach where information is collected and manipulated to extract knowledge and insight.

The potential role of generative design processes finds its maximum expression wherever a problem's parameters and input values (quantitative and/or qualitative) bring a level of complexity much greater than could be handled by human cognitive processes alone. The emphasis on the 'automated design procedures' should not overshadow the central role of the designer's intellectual capacity. The employment of algorithms, the selection of input data parameters as well as the criteria of evaluation are crucial human prerogatives and fundamentals in the critical judgement of a responsive design process.

''This form of algorithmic or parametric modelling transcends the understanding of the computational paradigm as a mere promoter of complex forms, and contributes to processes capable of forming models that contemplate several parameters involved in the functional, environmental and of the cities and the buildings they contain'' (Lima & Kós, 2014).

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