Cybernetic diagrams: design strategies for an open game

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This paper investigates the use of diagrams related to cybernetics and information theory in experimental design practices in the 1960s and 1970s. Those diagrams are investigated in light of Vilém Flusser’s concept of game, which mediates the modus operandi of computers and possible strategies for design based on distributed cognition. The research adopts the interpretative method to analyze the diagram proposed by cyberneticist Gordon Pask for Fun Palace, the diagrams produced by utopian architect Yona Friedman in the conceptual description of the Flatwriter program and Christopher Alexander’s diagrams for his theories of Synthesis of Form and Pattern Language. In the end, it establishes a brief parallel between current debates of computational design with the cybernetic diagrams, highlighting differences in their approach to complexity and design knowledge.
I. BETWEEN DIAGRAMS

In the second half of the 20th century, there was a revision of the architectural knowledge based on the procedural aspect of the diagrams and on the understanding of architecture itself as a formal system. As proposed by Professor Anthony Vidler [1], this revision can be understood in two fronts: the diagrams developed within the study of semiotics and post-structuralism, and the diagrams developed since the 2nd World War on the basis of cybernetics and information theory. This distinction between a linguistic and a cybernetic approach finds correspondence in recent exhibitions and publications. For instance, Robert Somol [2] discusses the use of diagrams and counters the linguistic propositions of Peter Eisenman to the “efficient functionality of [Christopher] Alexander’s cybernetic version”. In his thesis, João Rocha [3] describes a split in the theoretical transfer of structuralism studies to architecture characterizing two approaches: the linguistic approach to design and the quantitative approach – which adopted mathematical models as new operative and theoretical tools.

Both cybernetic and semiotic diagrams sought to remove design from the autographic and subjective realm of the architect, taking an interest in understanding architecture as a process based on explicit rules. However, while semiotics was interested in understanding design as a linguistic system, cybernetics adopted computational processes to decompose design in flows of information. That is, despite the convergence toward formal design systems, such approaches presented striking ideological and methodological divergences.

While the importance of diagrams developed under the influence of the linguistic turn has already been extensively documented and disseminated, the diagrams of informational processes under the influence of systemic theories have a distinct and unexplored path. Facing this gap, this paper investigates the use of those cybernetic diagrams in the experimental architecture of the 1960s and 1970s. We establish a brief description of three designers that developed those diagrams within their historical context, emphasizing aspects related to design theory. After the interpretative historical research, we adopt elements of Flusser’s philosophy – particularly, the idea of computation as a game – as a conceptual framework to analyze and evaluate the importance of those diagrams to computational design. In the end of each topic and in the conclusion, we adopt this framework to support an analysis of each diagram and to establish comparisons with current computational design trends.

Vilém Flusser [4, 5, 6] associates human technical advancement to a change in structures of thought, production and communication. He states that those “revolutions” are based on increasingly abstract codes and instruments and, therefore, they are also incrementally detached from human bodily experience. This process of abstraction culminates in a crisis.
in which the objective reason acquires autonomy and turns against the human itself. Flusser places computation at the threshold of this crisis, defining it as a totally abstract structure of thought based on mathematical and logical processes that operate on zero-dimensional symbolic representations. This broad definition of computation covers not only the technical aspects of digital computing, as the digital code or boolean algebra, but also the various systemic theories that understand the phenomena as information flows — e.g. cybernetics and information theory.

According to Flusser, computation is seeping into all aspects of human life by spreading black box devices — the apparatuses [4, 5, 6]. This is a critical condition, since those apparatuses acquire an autonomous existence, manipulating the behavior of the individual and of the society in favor of an arbitrary game detached from the concrete world. In this sense, he warns us about a split between the structural complexity of the apparatus and a poverty of its use, manifested in various symptoms of domination, as the society of consumption, the decline of moral, ethical and aesthetic level. In front of the cybernetic totalitarianism and the risk of humans becoming figures to be inserted in formal games, Flusser presents the challenge of dealing with the complexity of those devices, with their operations, inputs and outputs.

But how do diagrams relate to this play with apparatus?

Diagnosing a process of objectification of humanity and of contempt for the concrete world, Flusser suggests that men must learn to play by the rules of the apparatuses in order to subvert them for freedom and dialogue [5, 6]. If cybernetic games are considered both the condition and the model for creative activities, diagrams can be understood as a strategy to deal with the structural complexity of the apparatus, enabling the creation of new games.

In the interwar and World War II, research in the field of engineering control, communication and human-machine interaction contributed to the development of graphic notations to represent the flow of information of apparatus. Such notations dealt with the quantification of the concrete world, with the logical operations of electronic devices and their symbolic exchanges with man [7, 8]. Greatly influenced by circuit and logic diagrams, they made the design, operation and handling of these devices possible. Moreover, in the following decades, with the development of general-purpose computers, there has been a large investment in languages and diagrams to design computer programs (Figure 1 - left).
In the wake of war and digital computing, cybernetics and information theory promoted novel modes of systemic thinking and diagramming. It is worth noting that cybernetics is based on the study of feedback, communication and control, using the term information to deal with all kinds of phenomena – biological, psychological, social or artificial. Cyberneticists understand information as the content that a system exchanges with the outside world and that enables its adjustment and adaptation to contingencies [9]. Such understanding established a cross-reading of phenomena based on their interactions and their behaviors, characterizing them abstractly as systems. Cybernetics and information theory were on the agenda of architectural debates of the 1960s and 1970s, stimulating an architectural culture that favored the use of diagrams of information flows to the detriment of geometric representations.

2. GORDON PASK AND THE DIAGRAMS FOR CONVERSATION

From the 1950s to the 1970s, Gordon Pask established a very peculiar approach to cybernetics, developing experiments related to learning and adaptation [10]. Over the course of his undergraduate studies at Cambridge, and along with his colleague Robin McKinnon-Wood, Pask undertook the construction of various devices and interactive installations, such as the famous Musicolour (1952-57). Along with Elizabeth Pask and McKinnon-Wood, he created the consultancy and research firm System Research (1953), and in the decade that followed, he engaged in the development of training machines, chemical computers and numerical simulations, increasing his contribution to cybernetics.

In the early 1960s, he was invited by theater director Joan Littlewood and architect Cedric Price to join the Fun Palace project, organizing its cybernetic committee [11, 12, 13]. The Fun Palace (1960-1976) was an architectural and social experiment launched by Littlewood, meant to
establish a space for uninterrupted leisure and learning activities, promoting the cooperation of users in favor of engaging in a free and creative subjectivity. Price developed an architectural infrastructure that would enable spatial reconfigurations resulting from various uses and interactions over time. In turn, Pask was dedicated to deploying a cybernetic system to assimilate the pattern of user interest in the configuration of spaces.

In the first half of the twentieth century, many notations for diagrams were developed to deal with systems engineering. Pask appropriated these notations to describe diagrammatically the protocols and information exchanges between the electro-mechanical elements of their experiments and the observers. According to Alper Alkan [14], Pask’s diagrams would even influence Cedric Price’s design strategies, whose representations would emphasize the articulation and programmatic relationships through modeling and simulation.

In 1965, the cybernetic committee presented a diagram depicting the elements and functions of Fun Palace as boxes, with connected lines indicating exchanges and data transfers (Figure 2 - left). The notation of this diagram is very peculiar and seeks to formalize the process of interaction between users and the control system of Fun Palace. From capture, quantification and analysis of user behaviors and preferences, this computer would establish a strategy to change the spatial configuration of Fun Palace over time – providing an “operative space-time matrix of a virtual architecture” [13].

The comprehension of the diagram as a game of determination and freedom is worth noting. On the one hand, the Fun Palace project aims to emancipate the user through adaptation and interaction with the building. On the other hand, when inserting people’s behavior as data in his flow diagram, Pask exposes the cybernetic notion of “control” to criticisms. For example, according Stanley Mathews [13], this diagram treated human being as mere data as the feedback cycle would “function by comparing people coming in (unmodified people) to people leaving (modified people)”. In response, Andrew Pickering [15] states that this criticism evokes a misunderstanding of the definition of control proposed by cybernetics. As in other experiments by Pask, the control system of Fun Palace assumes a capacity for learning and adaptation that, in such exchanges with users, should encourage the subversion of routine behaviors and promote unexpected plays. Although Mathews considers the diagram an authoritarian and deterministic device, at least on a theoretical level, it was intended to be a platform for a distributed cognition, transforming observers into participants in the spatial configuration.

Gordon Pask characterized this type of cybernetic control as a mode of interaction called conversation. Throughout the 1970s, this concern about the potential of interaction unfolded in the formulation of the Conversation Theory, which was part of a broad revisionist movement conducted by the new generation of cyberneticists. Amid a series of publications on conversation, Pask wrote the text Artificial Intelligence in 1972, which would be published as the introduction to a chapter of Soft Architecture Machines [16]. This article was developed to contribute with the ideation and development of intelligent computers that would collaborate with architectural design – the apparatuses investigated in the Architectural Machine Group (ArcMac) at MIT. In the previous years, Pask was already an important theoretical reference to ArcMac founder, architect Nicholas Negroponte [17]. The group’s experiments aimed at a symbiosis that would reconcile the subjective capacities of the human (architect or resident) with the computerized management of multiple forces that structure the environment. Particularly, Pask’s definition of conversation helped Negroponte extrapolate the well-defined and objective approach of artificial intelligence to cover the interaction of human and machine within an environment as part of the idea of intelligence.

The development of Conversation Theory was a great opportunity for Pask to sum up his experiments and machines developed thus far into a coherent set of principles [18]. In Artificial Intelligence, Pask formalized various concepts in a series of diagrams, in order to propose a plan of conversation between two individuals (Figure 2 - right). Paul Pangaro [18] related the conversation proposed in these diagrams with the metaphor of dance, in which both individuals would induce the other to act in support of their own protocols, enabling a continuous control loop that could promote a distributed cognition.
Aligned with the ideals of Littlewood and Price, Pask conceives Fun Palace as a technical infrastructure set up to promote emancipation through the game. From the perspective of Conversation Theory, the symbiosis between user and control system could subvert routine behavior and promote uninterrupted improvisation. The aesthetic power of Fun Palace was neither contained in the protocol of the control system, nor linked to a predetermined set of actions to be promoted by the participants, but set as relational value between space and time. The diagram suggests a game strategy in which the rules of the device stimulate the modification of the game as it unfolds in favor of improvisation and novelty.

3. YONA FRIEDMAN AND THE DIAGRAMS FOR PARTICIPATION

In the 1960s and 1970s, there was a firm belief that technology could be a platform for social change and that vernacular architecture could be a model for a democratic and balanced environment. In combination, those ideas were translated into the undermining of the power of the architect through computer-aided participatory design, which, in extreme cases, acquired the configuration of a game. The trajectory of Hungarian-born French architect Yona Friedman – one of the consultants of Fun Palace and a contributor to the book Soft Architecture Machines [16] – was an example of this approach. In the 1960s and 1970s, his researches on participation are supported by information theory and cybernetics, situating architectural design itself as an informational process that stimulates the diversity of human behavior and new types of social organization.

In the book Towards a Scientific Architecture [19], Friedman uses these systemic theories to criticize the traditional structure of the design and, in particular, the authority and methods of the architect – who would be unable to cope with the demands of contemporary society. Friedman understands the design as information flow and relies on diagrams inspired by the classical scheme of information theory. He considers that, traditionally, the architect was placed as a translator of the needs of future inhabitants, set on building inflexible structures. Friedman presents each element of this “circuit” in explicit correspondence with the scheme of information theory. The inhabitant is the source whose needs correspond to the message. The architect is a limited communication channel that transmits this message to the receiving station – the building. Finally, the use and occupation of the building are the feedback between station and source. For Friedman, this circuit has two informational bottlenecks: the architect’s limited ability to manipulate information and the impossibility of adapting the static building for users’ needs.

As a response, Friedman proposes a participatory circuit of design based on a system called Flatwriter (Figure 3 – left). With the support of combinatorial operations and planar graphs, the user could develop custom
solutions, from basic properties such as room shape, connections between rooms, equipment position, etc. (Figure 3 – middle and right). Provided with objective descriptions of such solutions, the apparatus of Flatwriter could analyze and simulate them in real time, featuring the feedback of the design as an objective prediction of the consequences of individual decisions.

Aiming at a participatory utopia, Friedman breaks down not only housing and urban space but also social organization through objective descriptions of graphs. From the analysis of the topological properties of the graph, Friedman established a structural interpretation of the city and its relationships in search of a non-paternalistic model of organization. In this sense, it is clear that Friedman defends horizontal structures as a model for society in opposition to hierarchical tree structures. Much like Paul Baran in the seminal article “On distributed communication networks” [20], Friedman recognizes the fragility of centralized communication networks. However, his argument associates the technical characteristics of the non-hierarchical communication network to the participatory dimension of a democratic society [19]. In this sense, the proposal of the Flatwriter accompanies the understanding of urban space as a democratic network that subsidizes individual participation in decisions and cycles of reorganization, minimizing conflicts of interest.

Like Pask, Friedman assumes that a technical infrastructure configured for the enjoyment of many participants would provide an extension of the public arena and even a platform for participatory democracy. But, in contrast with Conversation Theory, Friedman’s proposal establishes a predetermined relationship with the users, reducing the space for improvisation. It provides a repertoire of pre-established spatial solutions and feedbacks from an objective assessment of the settings in the game. For Friedman, objective rules that ensure the compatibility of individual agency and the reduction of conflicts are the conditions for a non-authoritarian and self-regulating social system. In this sense, the Flatwriter is characterized as a game with a very broad repertoire of moves, but still limited to a set of rigid and well-defined rules.

4. CHRISTOPHER ALEXANDER AND THE PATTERNS OF AN UNDERLYING ORDER

Architect and mathematician Christopher Alexander was considered by Pask one of the main exponents of cybernetic architecture [21]. Controversial theorist and a pioneer of computational design, Alexander was among the architects who, over the 1960s and 1970s, proposed radical revisions in the field of architecture. Despite the diversity of his production, it is possible to identify a theoretical axis: a structuralist approach that understands not only the various objective constraints but also social reality and human behavior as a set of forces in constant tension with the environment [22]. When considering the human environment as the
extension of a nature that works through interaction between specific and quantifiable forces, Alexander understands design as an artificial way to calibrate architectural form with the forces of the environment.

In the early 1960s at Harvard and MIT, Alexander’s research was part of a movement that sought to understand “architecture as an autonomous branch of technoscientific knowledge” [23]. He approaches fields like mathematics, heuristics, computer science, biology, cybernetics and information theory to propose rational methods of design. In this case, design was understood as a two-step process: analysis and synthesis.

In the analysis stage, the design problem should be decomposed into graphs and sets representing the various requirements and their connections. Alexander was influenced by cyberneticist Ross Ashby’s argument that the ability of homeostats to reach a state of equilibrium against perturbations is associated with their patterns of connections [24]. Alexander appropriates this notion of homeostatic adaptation to emphasize the importance of solving a problem from subsets (or subsystems) of more connected requirements. With the support of computer programs, Alexander organized the problem in a hierarchical tree, indicating its various subsystems of connected requirements as part of a coherent structure. The leaf nodes of the tree indicate the requirements or subsets with greater interdependence; the internal nodes of the tree indicate the various groupings of these leaf nodes within the hierarchy of the problem; and the root node was the sum of all requirements.

From this analysis, Alexander proposes a synthesis of form, consisting on the balance of forces represented in the tree. Alexander approaches the concept of diagram proposed in the seminal book *On Growth and Form*, by D’Arcy Thompson, biologist, which conceives the growth and form of natural phenomena as a diagram of forces in equilibrium [24, 25]. Alexander uses the diagrams as abstract design elements that enable the adaptation between architectural form and the diverse design requirements.

Collaborating with engineer Marvin Manheim at MIT, Alexander works on a method for the design of a highway route in which the diagrams indicate in grayscale the more appropriate areas over the geographical site [26]. While the most desirable location is depicted in black, the white shades are areas where the requirements inhibited form. Another approach to diagrams is presented in his published thesis, *Notes on the Synthesis of Form* [24]. In the design of an Indian village, each diagram suggests a black-and-white schematic spatial interpretation that would respond to the subset of design requirements. In both cases, the optimal solution would be indicated by the association of the diagrams over the nodes of the tree, resulting in a diagram of the optimal solution on the root node (Figure 4 – left and middle). On the highway project, this association corresponds to the weighted overlay of color between diagrams resulting in a diagram in grayscale responding to requirements. In the Indian Village, spatial diagrams
are combined and overlapped, so that the optimal solution is the set of all spatial schemes.

In 1963, Alexander becomes professor of the College of Environmental Design (CED) in UC Berkeley. The CED is a pivotal place in the discussion of the social dimension of architecture and in the revision of rational design methods. For instance, along the 1960s and 1970s, one of the CED’s faculty, design theorist Horst Rittel, develops a political understanding of architecture that situates design problems as complex and contradictory phenomena, ungraspable by pure scientific logic [23, 27]. Although Alexander’s structuralist approach neglects idiosyncrasy and political divergence as bases for the configuration of the environment, his new theories accompany this withdrawal from the scientific problem-solving approach, which unfolds in a review of his diagrams along several publications.

In *The City Is Not a Tree* [28], Alexander establishes a critique of the tree structure and its inability to deal with the complexity of the forces of the urban environment. He ponders that modern cities are sectored and structured hierarchically, as a simplified tree diagram, in which the branches ramify without any overlap. This type of organization would reflect a reductionist view of space, unable to cope with the complexity of the social structure. Faced with this inconsistency, Alexander presents a semi-lattice diagram in which each child node can belong to more than one parent node, indicating intersections in the tree branches and in the sets of elements (Figure 4 – right). According to Alexander, this diagram adequately represents the relationships of complex organisms, like the urban space of the pre-industrial city with its overlapping uses.
In the article From a Set of Forces to a Form [29], Alexander reaffirms the structuralist approach to architecture, but attests the inadequacy of representing human needs in the environment with numerical and analog methods. Departing from the quantitative analysis procedures, Alexander emphasizes a more intuitive understanding of his diagrams of spatial patterns and their combinations.

In Systems Generating Systems [30], Alexander featured two types of system: the system as a whole and the generating system. The first category reaffirms the interpretation of an object’s form as a system of interactive forces. In turn, the generating system is a system of rules that governs how the various parts of a system as a whole will interact and characterize a global behavior. A game, a language, a building system or a genetic system are examples of generating systems that govern the combination of elements, ensuring the correct interaction among those parts.

This review of diagrams culminates in the theory of Pattern Language that Alexander develops with other researchers at the Center for Environmental Structure (CES, founded in 1967) in the 1960s and 1970s. This theory adopts a more ontological understanding of the order that should regulate the production of space, transitioning from the generic concept of diagram to pattern. Alexander understands each pattern as a semi-autonomous set of generative rules to deal with specific problems in the different scales of the environment. Those rules associate a context, the interaction of its subsystem of forces and the spatial configuration that ensures the balance between those forces [31]. This relative autonomy of the pattern allows it to evoke other specific patterns without disturbing its own coherence, composing the language as a hierarchical network in the form of a cascade (Figure 5).
In contrast with the quantitative modeling of the problem in his early research, the patterns store design principles that are supposed to be appropriated by the residents in the production of their own environment, indicating an attempt to eliminate the authority of the specialist. But, in contrast with the previous examples, the game proposed by the Pattern Language is not based on the conversation or the customization of a combinatorial system by the players’ will. The Pattern Language is a game that regulates the interaction between man and environment and its complexity lies in the interface of the generative rules coded in the patterns with the specific circumstances of its application. As those rules are considered immanent to a good environment, the drawback of the language is that any kind of improvisation depends on the creation of new patterns.

5. ON THE TRAIL OF OPEN GAMES

According to Flusser, there are two categories of complexity: structural complexity, in which the elements of the system have very complex relationships between them (as in the apparatus) and functional complexity, where the system provides a complex use (as in chess) [4, 5]. Advocating for the latter, Flusser associates the complex use of a system with the possibility of subversion of established rules through creative plays and dialogues. In this sense, the functional complexity is a prerequisite for an open game able to disrupt the determinism of the apparatuses and to produce innovative and significant information. For example, the philosopher considers chess as a structurally simple but functionally complex game, because “its rules are easy, but it is difficult to play chess well” [4]. Chess becomes an open game when it ceases to be a zero-sum game (one player wins and the other loses) and becomes a platform for each player to play towards the other, producing moves that would be impossible individually. The challenge is to take advantage of plays unforeseen by the individual cognition to produce the maximum of information. In this “plus-sum game”, complexity arises from the contextual actions and improvisations upon the rules of the game [5].

In other words, Flusser’s strategy for freedom is accomplished by the reconfiguration of the human as an active player and of the apparatus as infrastructure for open games. In this sense, the concept of game is a critical device to associate the modes of appropriation of computation (data structures, algorithms, functions and parameters, etc.) to the definition of rules with technical, aesthetical and political unfolding.

The idea of open game remains even more pertinent over the last decade, with the current dissemination of diagrams of information flow and visual languages by the software industry – usually directed graphs, like in Dynamo, Generative Components and Grasshopper (Figure 1 – right). Those diagrams allow the designer to use computational processes to play on top of the predetermined functions of the software and generate a
spatial configuration. Their use is normally associated to the expansion of architectural geometry with generative processes based on mathematical formulae, tectonic patterns, material structures, biological principles, fabrication design logic, or performance analysis [32].

One of the most prominent theoretical frameworks in this respect is parametricism, promoted by architect Patrik Schumacher [33]. According to Schumacher, parametricism is a design research program that situates parametric design systems as the logic that should govern all scales of the environment, empowering the architect to organize the full complexity of the post-fordist society into an integrated, organic form. Schumacher was largely influenced by cybernetics through Niklas Luhmann’s appropriation of the theory of autopoiesis. As in Alexander’s design philosophy, architecture should work like natural systems, where the form is a field of interaction of forces. However, for Schumacher, there is no need to decompose the complexity of the problem into sub-systems, as parametric design allows the scripted association of the different architectural subsystems (envelope, structure, internal subdivision, etc.), constituting a whole composed of adaptive components. In relation to the user, Schumacher considers that the architect should control the parameters that affect the user’s perception and promote a kinetic capacity of the environment to respond to the “dynamic swarms of human bodies”.

Schumacher’s theoretical framework is indicative of a kind of complexity consistent with the logic of programming and even with natural processes, but with rules and plays largely independent of the actions of players. Despite the novel relations between information and matter, this framework promotes games whose rules are still constrained within the authorial domain. Whenever participants are taken into consideration in the design, they are subsumed to parameters in computational systems whose plays are performed automatically within the space of the program.

The proposals analyzed in this paper instantiate, to some extent, a critical relation between design, diagrams and open game. All the diagrams put forward in this article question the traditional boundary of the profession and depend on the actions of participants in the production of the space. They expand the concept of performance from the strict simulation and analysis of physical data to incorporate the interaction of players regulated by shared rules in pursuit of new points of view and solutions. This notion of design has not been developed without technical conflicts, as Pask, Friedman and Alexander demanded custom diagrams and strategies for games that matched their worldviews. In Alexander’s case, his ideas were initially conditioned by the architecture of the computer and data structures available at the time when he developed programs to analyze design problems [34, 35]. Later, Alexander inverted the vector of influence and Pattern Language became influential in computer science – particularly in the development of object-oriented languages and the wiki
software format [35, 36]. Grounded in the belief that a technical infrastructure could extend human agency, Pask’s and Friedman’s diagrams favored a distributed cognition based on a circular process between the apparatus, the participants and the environment.

With the recent developments of the web and computation, we witness a great investment in interaction and amplified cognition in other artistic and design activities, while in contemporary architecture those topics are primarily addressed in the development of responsive components. Cybernetic diagrams promote a horizon in which open architectural games could subvert the prevalence of the lone game of the expert, formalized in generative algorithms. For example, crowdsourcing systems could support distinct models of participation in design, promoting processes such as crowd creation or crowd rating [37], in which the complexity of the design system also lies in the behavior and knowledge of various participants.

At the end of the day, Cybernetic diagrams show that computation is a game of empowerment and, therefore, that the investment in opening the design process remains a critical challenge for contemporary architecture.

REFERENCES


**Pedro L. A. Veloso**

pedroveloso13@hotmail.com