

Evaluating Complexity – Ethical Challenges in Computational Design Processes

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Abstract—Complexity, as a theoretical background has made it easier to understand and explain the features and dynamic behavior of various complex systems. As the common theoretical background has confirmed, borrowing the terminology for design from the natural sciences has helped to control and understand urban complexity. Phenomena like self-organization, evolution and adaptation are appropriate to describe the formerly inaccessible characteristics of the complex environment in unpredictable bottom-up systems. Increased computing capacity has been a key element in capturing the chaotic nature of these systems.

A paradigm shift in urban planning and architectural design has forced us to give up the illusion of total control in urban environment, and consequently to seek for novel methods for steering the development. New methods using dynamic modeling have offered a real option for more thorough understanding of complexity and urban processes. At best new approaches may renew the design processes so that we get a better grip on the complex world via more flexible processes, support urban environmental diversity and respond to our needs beyond basic welfare by liberating ourselves from the standardized minimalism.

A complex system and its features are as such beyond human ethics. Self-organization or evolution is either good or bad. Their mechanisms are by nature devoid of reason. They are common in urban dynamics in both natural processes and gas. They are features of a complex system, and they cannot be prevented. Yet their dynamics can be studied and supported.

The paradigm of complexity and new design approaches has been criticized for a lack of humanity and morality, but the ethical implications of scientific or computational design processes have not been much discussed. It is important to distinguish the (unexciting) ethics of the theory and tools from the ethics of computer aided processes based on ethical decisions. Urban planning and architecture cannot be based on the survival of the fittest; however, the natural dynamics of the system cannot be impeded on grounds of being “non-human”.

In this paper the ethical challenges of using the dynamic models are contemplated in light of a few examples of new architecture and dynamic urban models and literature. It is suggested that ethical challenges in computational design processes could be reframed under the concepts of *responsibility* and *transparency*.

Keywords—urban planning, architecture, dynamic modeling, ethics, complexity theory.

I. INTRODUCTION

IN recent decades there have been constitutional changes in urban form, centrality and the role of periphery as well as in

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location principles, turning the city to a *Metapolis* of today.

Numerous changes beyond our control have forced us to start seeking for novel tools to better understand these phenomena. Recently classical science has started to perceive the complexity of systems, and this new paradigm has started to emerge in several fields of science. Complexity, as a loose theoretical frame, provides a background for explaining many problematic phenomena in highly complex systems, such as cities [1]-[3]. The term “complexity” has often been informally and misleadingly used to refer to various cases of unpredictable or non-intuitive issues. Nevertheless, some features of the scientific complexity may be pointed out. Complex systems are totally unpredictable. They give rise to (seemingly) non-causal, surprising behavior. They have numerous interactions and feed-back loops, and dissipative decision-making. Additionally, it is impossible to divide complex systems into sub-systems. Ignoring any part of the system or the interaction between the agents will probably lead to the loss of the essential features of the system [4]. Practically all macroscopic systems are complex because of their molecular structure, yet there are naturally differences according to their scale [3]. In other words, in complexity the systems are regarded as being organized bottom-up, and far from equilibrium; they are neither reducible nor predictable.

A. Complexity and Urbanity

Gradually we have begun to understand that ongoing constant and unpredictable changes in urbanity are by nature far beyond our control: Cities do not aim at equilibrium. Non-linearity, chaotic sequences and self-organization are in their very essence not just “flaws” in the system. With innumerable individual factors acting bottom-up, the global cities are complex and far-from-equilibrium systems. Cities and regions are “complex and open in the sense that their boundaries allow flows of material and information, and are difficult to govern. Order and stability spontaneously emerge from within the system, through a process called ‘self-organization’ ” [5].

Modernistic planning and architecture aimed at social reform and centralization of power [6] have ignored the unpredictable and concentrated on improving and renewing the city. As was seen, this regulatory urban planning and design have failed to bring order to the chaotic features of the city. According to a self-organization approach, no plan is capable of fully controlling the city [7]. Yet even though the complex nature of the urban environment is today generally acknowledged, the planning systems of today are still modeled on modern rational planning theory [8]. According to Allen,

since we must nevertheless make decisions and take action, the use of dynamic models can help us to avoid some evolutionary dead-ends and errors otherwise possible. However, diversity, flexibility and pluralism are to be encouraged and a strict plan that might reduce these should be thoroughly examined [9], and understood as part of the evolutionary process. Therefore, fast data processing has offered appropriate tools to understand – although not yet to control – the ongoing development in the city.

B. Complexity and Architecture

Since the 1970's, several theoretical attempts have pursued an evolutionary, emergent approach in architectural design. Ideas of complexity, evolution, adaptation and emergence offered a new aspect for design. The dynamic features of a building's formation process and multiple factors in and information from the environment could be taken into account.

Greg Lynn, one of the pioneers of the new architectural philosophy, claims that "in fact, the pathological necessity for architecture continually to announce its newfound interest in complexity is perhaps the most important feature of architectural theory and design since the climax of late-modernism." [10]. The complexity theory has also been seen as a way to use the methods of modern science while still preserving the diversity of the world. Reductionism in its conventional form can be avoided. Using the computing capacity of today an enormous number of relations can be taken into account [11]. Nevertheless, while some sort of reduction is needed when formulating the simple rules for calculation, the result can still be complex and diverse. Lynn also recognized a need to pay attention to the hidden and formerly suppressed forces behind architectural form. He opposes the autonomy of ideal form and architecture as a higher order. Formation is a continuous, adaptive process that cannot be reduced to Euclidian geometry. More information can be introduced into the system when the symmetry and formal homogeneity are broken [12].

According to a scientific or "naturalistic" point of view, the aim of architecture in general could be seen as a necessity to make places habitable, not depending on the time of the day, the year, or the climate. The "architecture must emerge in specific places...in a continuous process of re-foundation of the territory" [13]. Architecture must interact with the specific place according to the territory's own essential rules, so that the structures built follow the natural order of the place - the order that emerges from basic principles and patterns aiming at the generation and conservation of life. An architectural project should have a connection with the energy and potentials of the environment, leaving appropriate open conditions where life can operate. The multi-scalarity of built environment implies that there is an inseparable connection between a building project, its environment and the urban structure. Thus every project must integrate itself into its habitat by "...resonating in tune with the energy wavelength of the place, or acting as a transformative element, detecting

the potentials for modification produced by the new operating conditions on site." [14] The systems from which form emerges are maintained by the flow of energy and information from the environment. A constantly changing pattern of flow is maintained in equilibrium by feedback loops from the environment [15]. Information molds the form of the building in an open, interactive process, which means the system's capacity for autonomous development - the project is able to grow or change without human intervention.

In addition to pure auto-generative, algorithmic architecture, the parallel branches of "neo-pragmatic" or "inductive" design are also discussed here. As bottom-up approaches, they have some ground in common with the algorithmic approach, even though they provide a more conventional appearance. Examples of these will also be used in later in the discussion. A simplification of the computational approaches has been used according to the degree of computation for purposes of evaluation. The real spectrum of the today's architectural field is naturally richer and its connections more rhizomatic.

Despite the autonomous development of the city and auto-generative computational design methods, planning and architectural design are still processes aiming to organize human environment. Nevertheless, not much attention has been paid to their ethical implications.

In this paper some ethical matters of rapidly evolving technical devices and processes are contemplated as well as the design philosophy arising from new concepts. In light of new the theoretical background, the question is:

What are the ethical challenges in computational design methods in complex urban environment?

"Architectural design" and "urban planning" models are discussed here not on the basis of their scale but of the purposes of their use. Urban planning models refers here to pre-design, an analytical tool, as architectural models produce forms. The classification could also be something else. Also, "new" architecture refers to a wider range of design approaches, including not only algorithmic architecture but also some earlier examples of "generative" or "computational" design. Despite their differences, they have in common a bottom-up approach.

II. METHODS

A. . Some Terminology: Self-organization, Evolution and Adaptation

Self-organization appeared in cybernetics and systems theory in the middle of the 20th century. In the complexity theory of today it is based to a considerable extent on the work of Prigogine and Haken, starting from the 1960's and 70's, with its origin in "hard science", physics, chemistry and mathematics but has also had a great influence on understanding of today's urban dynamics [4], [3].

By definition, self-organizing systems are able to form

macro-level behavior and patterns on a scale much larger than of micro level agents. In chemistry, as large numbers of un-intellectual molecules succeed in being at the right time in the right place, they create various states of spatial organization. In a similar way, numerous individual interactions form and re-form the cities constantly, on a scale beyond their imagination.

Evolution is a biological term meaning continuous, self-organizing series of events over generations, sensitive to the environment. It changes the properties of population towards the greater adaptation. One of the essential mechanisms, natural selection, occurs when only part of the population survives causing mutations over generations. This adjusts traits so they become adapted to an organism's environment: these adjustments are called adaptations.

In biology, *adaptation* is one of the basic phenomena. It refers to the process whereby an organism tries to adjust to the environment to derive greater benefit from it. Thus in the evolutionary process a population becomes better suited to its habitat. The adaptation occurs over many generations. Adaptation helps e.g. the immune system to “learn” to react to a new type of virus [16].

B. New Features and Design

Self-organization is a common feature in nature and in all open and complex systems, and cannot be prevented. The planning practice of today has totally ignored the unpredictable, or seen it as an exceptional rupture in linear development with many negative side effects. To maintain sustainable development, we should start to take serious account of the generative features in complex human processes, such as city planning. But total liberation of the praxis is not the solution. Even if we see the total hierarchical control of the city to be far beyond our reach, *laissez-faire* policies with free market guidance are not the answer. Lack of appropriate anticipation could lead to risk avoidance and the pursuit of short-term profit [17], [18]. As a natural phenomenon self-organization is neither good nor bad. Ethical issues arise from how we deal with it.

A simple and harsh way to see the town in the light of self-organization and evolution would be a system with a metabolism, taking in energy and resources and giving out waste, living or dying in a competition for resources and efficiency [19], [3]. Nevertheless, many scientists have adapted the theory for softer purposes, to use it as a conceptual framework. In the pioneering work of Juval Portugali, the social sciences have been brought together with the hard core of natural science. He succeeds in finding common ground and similarities in social theories and self-organization, combining the heuristic approach of simulation with hermeneutics in social sciences, but he also sees the disadvantages of the approach. There is no hard causal reason for self-organization, only triggers that can push the system over the threshold and into an unexpected chaotic sequence. Prediction is impossible. From the perspective of self-organization, we can “theorize about the cities for their own

sake and – as a single evolving multiple system” [20].

Peter Allen takes the view that even though sustainable equilibrium in the city is not possible, we could try to seek a “sustainable trajectory” and to avoid unsustainable ones. Thus observing self-organization could lead to more adjustable planning practice: “the plans that encourage variety and diversity...tend to lead to creative and adaptive systems capable of generating their own development and to respond to the challenges of economic, natural and social environment.” [21] Allen also claims that the concept of self-organization gives us a better understanding of sustainability and evolutionary processes and that “survival is more important than efficiency” [22].

In contrast to the analyzing applications in urban planning, in architecture scientific features like “self-organization” are seen as an actual form-giving procedure of a material system, as in nature. As the energy and information flow from the environment cause a morphogenetic process of formation, where natural evolution is not a single system, but distributed multiple systems with interactions, the emergent whole can be seen as a multi-scalar system that can form an environment for another system [23].

Marcos Novak perceives the connection of architecture to biology and evolution through artificial life: Evolution creates mutations, new species. When space and culture changes the architecture must also change. New space is “alive, activated, inter-activated, ‘trans-activated’ “. Space is no longer “a mute vacuum, it is an intellectual and vocal plenum” [24].

Even though the design process is not really evolutionary unless it includes the iterative modeling of phenotypes, self-organizing material effects of form finding and industrial logic of production [25], possibilities for different degrees of human involvement in the computing process are discernible. From the ethical point of view, their implications are also different depending on the degree and stage of intervention or lack of it.

C. Ethical Evaluation of the Process

There is no doubt, according to designers and authors proclaiming the new paradigm, that new approaches are able to take into account innumerable factors and process data at a speed we could never have imagined. Emerging from complexity theory, new approaches are arranged bottom-up, able to describe dynamic, emergent and self-organizing behavior and stand against hierarchical designing and planning practices in a creative way. They are able to combine and merge information from a specific environment and situation, and to free the architect from presumptions. Consequently, the new approaches offer a real potential for a competing paradigm to conventional design practices. They have also been seen as a shift in architecture away from a fixation on aesthetics and towards a more ethical design practice [26].

As the designers celebrate the benefits of their approach, the new methods have also been criticized for being vague, self-centered and unethical. Before we can evaluate the

methods, we must have a look at the critical discourse of the ethics of the techniques and architecture of today. [32].

1) Ethics of the Technology

Adopting any new technology such as a computer-aided or assisted design process always entails some uncertainties at the general level. Topi Heikkerö points out that unintentional consequences raise a question of steering and responsibility [27]. Who steers the technological development of the modeling device? According to social contract theory, special responsibility is assigned as professional ethics to the computer professionals [28], but in the case of design tools, the responsibility could vary from project to project, and rest partly with the software engineer, partly with the architect, or the design or steering group developing the strategic rules and limits of the process.

According to Deborah Johnson, computers and ethics are connected as long as we can use them to do things we could not do before, or do them in a new way. New ways of doing something can change the whole nature of the “action type” (such as designing), and also its moral features. Very simple movements become very powerful actions. But technology does nothing independent of human initiative. Again, human responsibility must be shouldered in technology-instrumented activities, especially when something goes wrong [29]. According to Terzidis, in using algorithms capable of producing unpredictable, uncontrollable, evolving entities, “it always has to be human being responsible for anything that resembles intellectual behavior.” [30]

2) Design Ethics

Computational, “designer-less” design methods have naturally also raised many questions about ethics. Michael J. Oswald asks about the “ethical implications of a design process that seemingly obscures authorship, abrogates responsibility and seeks authority from external sources?” and “Is it even possible to consider the ethics of a design process in isolation from the object it produced?” [31] He considers that ethical issues can be seen largely in the light of “professional virtues and learnt duties”.

Oswald has classified the ethical challenges of the processes of the new architecture under the three following themes:

Authorship refers to the visible responsibility an architect takes for the work during the design process. Attempts to obscure authorship (e.g. by hiding the actual origins of a design) are regarded as ethically flawed.

Comportment refers to the level of clarity present in the design process, as a potential learning experience through which new knowledge might be gained for the sake of humanity.

Motivation refers to the fact that the design process should be shaped by the architect’s desire to only acknowledge instrumental (computational) tools, concepts and methods. Consequently, an architect should not seek false authority for a work or seek unfair acclaim for the complexity of a design

These themes are applied later in this paper to evaluate design processes involving modeling. Schematic categories of *responsibility* and *transparency* are introduced to clarify the ethical features of the approaches.

Also, I consider some aspects of Oswald’s *comportment* - an architect’s obligation regarding adequate resourcing and commitment to the design - fundamental to the architect’s traditional professional ethics, not specific to the new approaches. They are not discussed here.

a) Responsibility

Oswald points out some blurred logic in certain current designers’ rule-defining principles “It is not clear why other rules were not used..., but such selectivity is typical of the process.” [33] The model can only answer the question asked. Thus only the features that affect the phenomenon we elect to study are modeled [11], [34]. If the purpose of the modeling process is to study the interactions between information and formation, between rules and resulting patterns, limiting the number of rules is understandable.

Thus even though a simple model (like any other) does not imitate reality exactly, it is still a useful tool for interpreting the interactions and learning about the dynamics of the system. The most important thing is to be aware of the nature of the information at hand: *What features* of reality one is modeling, and *what kind of interactions* the agents really have, using scientific and/or empirical data and logical reasoning.

Watanabe’s Sun God City is a good example of the designer’s responsibility for the decisions as “we” outside the process of computing. “*We erect a large cubic structure to a prescribed height filling the building site to its limits. Then we cut tunnels in the structure so that sunlight reaches the back-side units. We do the same thing for all the other units that do not have adequate access to sunlight. ... the very simple code...produces an entity of diversity.*” [35] In the end, numerous solutions are not introduced, but the program will select the “fittest” according to the parameters formerly defined (such as buildability or structural integrity) [36].

Bernhard Franken, in an earlier phase of the auto-generative approach, clearly describes the process: “The shape is not created by the formal intention of a designer, but by the software through the deliberate search for a form-generating law and the application of specific boundary conditions. In the program, information becomes a form.” [37] He describes the procedure with clarity: “We analyze the task...translate the core issues...into a spatial scenario. ...We have developed a design method...which generates form on the basis of physical algorithms”. [37] In contrast to the work of Makoto Sei Watanabe and Michael Hensel, for example, the problems according to Oswald appear after the computing, in the manual selection of the final design, as described later under the theme of transparency.

Evolutionary, auto-generative methods have rendered these

approaches further from just learning from nature's logic, even more similar to actual natural processes. While nature's mechanisms of form giving are studied and applied, the designer's position in control of pre-decided formal output is criticized, and a need for a method of "emptying oneself of pre-conceptions of form" has been identified.

Michael Hensel considers that the aim of the new architecture is to allow maximum flexibility, "generation of motile [spontaneously moving] material arrangements that are responsive to their environment" [38]. This is carried through several feedback loops, between context specific forces, material form, human subject, and environment. The process is described as fascinating but distant – yet part of the fascination is probably the totality of the auto-generation. The role of the designer is as a spectator of captivating natural forces of auto-poiesis. "Dynamic form evolves through morphogenesis under changing force-cases, including both generation and adaptation of form. Adaptation of material system in situ therefore engages a third task for form finding that commences after the construction processes by means of analysis and feedback of the impact of inhabitants and habitat onto the built environment." [39] Here the biological phenomena definitely do occur according to their own laws, without human interference. Nevertheless, there is a persistent aim towards a totally computerized process, and the architect's responsibility can be seen in her role as a prudent developer of the device. The elegance of the process must not overshadow the responsibility of the architect.

As Terzidis points out, the algorithmic process is about discoveries, not inventions. They cannot be controlled by the human mind as such, even though the logic of the system can be captured and studied by computing. The whole process is external to the human mind. The issue of responsibility is quite problematic in the processes creating emergent or self-organizing patterns. The most challenging is the "life-creating" machine, the algorithm-making algorithm, the process that could by no means be under any human control. Nevertheless, if the designer is seen as an operator producing data, the accountability could emerge not from total control of the details, but from steering and adjusting the flow of information and interrelated dynamics of the system. The output – or a criticism of the output - of an algorithm must be associated with the human mind, either of the programmer or the designer [40].

In analyzing tools of urban planning, the ethical challenges are still quite similar to those in architecture.

The CA-based "Nekala-Vaasa" model [41] of urban dynamics studied the self-organizing characteristics of the city on a local scale. This model was made for studying the spatial interactions between different actions (here the commercial and welfare services, warehouses, small industry, housing and offices). The hypothesis that is based on empiricism is that in a self-generating area, urban activities interact with each other, forming clusters not only on the regional level, but also on the lower aggregate level. These clusters grow and decline forming emergent patterns on the higher level.

The rules of interaction are:

I Define the new degree of efficiency on the site according to its current state (e.g. filling up the empty sites, emptying the almost-empty or full ones, or conserving the use of the site).

II Define the rate of different actions according to the number of actions in the neighboring sites.

The resulting behavior may be steered by control parameters defining the desired proximity of different actions. The aim of the model has been to demonstrate the capacity for self-organizing behavior in two so-called "urban fallow" areas. The term refers to an area that is in some way declining, but having potential for autonomous generation and self-organization. These areas can be seen as important for the sustainable development of the whole city.

In the Nekala-Vaasa –model, the urbanity is seen as self-generative and emergent, but human steering (as planning) has been considered a necessary procedure to avoid total unpredictability (or Allen's "undesired trajectory"). Thus, despite the adaptive features of environment, urban development is not considered a natural force beyond any control [34]. The design solutions – as well as interpretation of the simulation– have an important role in molding the real city. According to the authors, the model does not aim to simulate reality or give answers regarding the priority of some locations in real world planning. It is to point out that a certain degree of freedom and restriction enables the emergence of chaotic sequences which enable self-organization and regenerate urban dynamics. The model is to help a planner make decisions for the future [34].

The fundamentally neo-darwinistic approach of MVRDV's Space Fighter gives us an example of autonomous processes on an urban, or global, scale. The evolutive "game" can be seen as manifesting more than a piece of design equipment. Here the continuously changing and re-forming urban regions and cities are considered an independent and self-conscious life form, constantly competing for resources and energy. Cities flourish, decay and are destroyed, they adapt, mutate or die in the "battle of regional survival" [42]. The game is an arena for an architect to learn and develop his intuition and skills in making choices for survival. The aim of the game is not merely theoretical knowledge, but production, so the social and political issues are abandoned. The absence of the designer is clear. Nevertheless, in spite of the declarative tone, ultimately the game is seen quite generally as a tool for understanding urban phenomena, just like the other examples of urban models above.

It must be conceded that in the decision-making in computational processes the implication is that the notion of intention differs from the traditional idea of causal interpretation of design as goal-oriented, conscious decision-making. A more intricate relationship of decision and intention emerges from the idea of "decision-making" unconscious agents in the process of computing. The notion of intention does not have to be associated with the source but rather the process itself. The intention could be adopted after a "successful" design decision made by algorithms that was not

intended by the designer in the beginning [43]. Here the responsibility for and ethics of the decisions – although not necessarily initially intended – and of the interpretation could be separated from the naturalistic phenomena in an algorithmic context, with no ethical implications whatsoever.

b) Transparency

The transparency of the process concerns the description of the design process and its background information in an understandable and verifiable way. Here the greatest clarity is needed, for otherwise tracking down the impulses of the resulting trajectory in complex system becomes completely impossible, endangering the evaluation and development of the tool. In the coding process, this also applies to the hidden values and pre-assumptions in a computer program and code, which may become a problem if the designer is not involved in the coding process, while it impedes the evaluation and diminishes the educational aspects of design.

Early examples of logical and transparent reasoning can be seen in MVRDV's earlier what is known as "conceptual" or "neo-pragmatic" (computational even though not algorithmic nor auto-generative in any sense) works. They can be seen more as statements against conventional problem-solving than on behalf of the dynamic design. Nevertheless, simple rules such as those of maximum floor area combined with building conservation regulations or adequate natural light result in unexpected design solutions. According to Watanabe, in the design process, it is all about reasoning, making clear why to make certain selections.

"The idea is not to automate design. It is not about being able to complete a design with a click of the mouse. The purpose is to clarify aspects of the process that were vague up to now, so as to get a better idea of what we really want. It is about higher quality, not more efficiency. We want to do it better, not faster." [44]

Among others, Makoto Watanabe Sei claims that the process of conventional design is not entirely conscious activity. Logical analysis helps us to classify contradictory elements of the design task, but Watanabe criticizes the emerging of the final solution "out of nowhere". He sees a theory of a single design as similar to the scientific theory, which should be replicable independent of the designer. We must learn to design with our logic alone, "without our hand". He emphasizes the transparency of the action: The design process should be verifiable, and open to anyone to understand. Watanabe wants to develop methods for "practical utility". The aim is not to produce a design, but rather a program that could create numerous different solutions e.g. for a "good rout" depending on varying preferences [11].

In classical analytical tools for urban planning the theoretical background, rules, methods, and results are usually transparently described because of their scientific nature. For example, in Peter Allen's well known modeling experiment

[4]¹ is heavily based on former theories, statistics and the expertise of professionals in various branches. This model is constructed step by step, with a punctual concluding after every single phase, bringing up and evaluating disadvantages for development in the following stage [4]. In the Nekala-Vaasa model, the rules and principles of emphasizing the actions are transparently described. Nevertheless, compared to Allen's models, there is still a need to open up the theoretical and empirical background. The designers' choices have been made visible by describing some locations of different actions as "more desirable" than others in simulating different development paths. The limits of the modeling are described quite carefully: "The simulation can only answer the questions asked. While defining the rules, the designer is obliged to make visible the very principles on which the model is based. The intuitive character of the [future] designing doesn't [necessarily] change, but the data-processing on the analytic phase becomes more accurate and effective" [34]. The communicational and educational aspects are well delineated in both cases. The model is seen as a platform for experimenting with different possible futures and testing the alternative tracks of development by altering the rules and boundary conditions in a communicative process. "Through this process of exploration and testing, users will both improve the model, and improve their understanding of both the real system, and the model that is supposed to represent it. This learning process may perhaps be the most valuable part of the whole enterprise, since it can genuinely build mutual understanding and consensus between the actors." [45]

Ostwald finds the "*deus ex machina*" situation problematic, when, after numerous iterative experiments of trial and error, changing the "forces" and evaluating the results, the optimal design solution is somehow "found", as at the end of Franken's earlier description. Even though each result is "evaluated spatially", and the architect takes responsibility for this evaluation – besides the rules and programming - lack of transparency in choosing the form is obvious. There the architect is absent during the process, and suddenly intervenes by stopping it. There is no doubt that the full potential of computational methods is not used. On the other hand, the computing procedure can be seen as a learning process: Altering emphasizes the rules, the architect may search for emerging patterns during iterations (by computer or not), and make assumptions and theories that can be tested further [34]. Naturally the designer must be committed to the learning process. Many of the models (especially in urban planning) work this way, as an analytical and educational tool. The problem of "violent halt" may occur when a design process is not completely "automatic", and aims to produce a buildable entity as such, so to get a cross-section of dynamic formation process it must be stopped manually. The heuristic method of evaluating (by computer or not) and altering the rules for

¹ (described in his book "Cities and Regions as Self-Organizing Systems – models of Complexity",)

numerous iterations in feedback loops might be less problematic than Ostwald thinks, as long as the clarity of the whole process – including rules, manoeuvres of the program, transparency and responsibility of the designer - is obvious.

While new tools and fascinating concepts are available, the designer needs to understand the nature of the equipment and concepts more thoroughly than ever. At the worst, Ostwald claims that heavily coded language, obscure mathematical analogies and pseudo-scientific terms are used as a way to authorize the production of novel forms or to enhance the designer's reputation. Using the "exact" language of science and mathematics may provide the user with a semblance of power. This is another aspect of transparency that should be discussed.

According to Heikkerö, the objectivity and idea of value free science may be seen to be contradictory to un-rational normative ethics, the methods of which are not empirical or mathematical. This may lead to an (unintentional) situation where the use of the "scientific" paradigm or terminology, such as "evolutive" design, justifies the use of a certain technique without hesitation, as a natural consequence. Technique, and perhaps even science, should be seen as a human action that cannot be totally value-free [46]. This can be even more problematic if the real scientific background is missing and vague metaphorical jargon is used to justify the form or use of the device.

Unfortunately, it seems to be quite common in algorithmic design discourse to obscure the true means (vague or not). Ostwald has translated as an example the description of Achim Menges and Michael Hensel's work, which he characterizes as a "description, itself a microcosm of the definition of the auto-generative process"[47] :

"[e]volutionary computation is used to initiate a process that coevolves different generations of two interlocking surfaces through perpendicular or tangential sections. The morphogenetic process yields an ever-increasingly complexity of the two coevolved surfaces that nevertheless remains coherent through the logics of the material system and the manufacturing [process]." [48]

This translation of Ostwald can be reformulated as follows:

"We used computer-modeling software to experiment with two overlapping organic shapes until we were happy with the result. We then used a different piece of software to select the optimal cutting schedule for the material thickness required by the manufacturing process." [49]

He admits that some of the information is lost, but claims that the essential message is understandable. One could add that we need new terminology for the new paradigm, and the discourse might seem obscure at first. On the other hand, there are also examples of a less "naturalistic" manner of speech that is able to capture the essential features of the case in former texts of Franken or Watanabe.

There has also been criticism of the nature of complexity in the design process that fits under Ostwald's title of "motivation". Kostas Terzidis is critical of the design process for emphasizing complexity. While the result of a design process may be complex, the strategy itself does not necessarily follow that complexity. The most emergent and evolutionary design strategies are based on simple means to produce complex outcomes. The real complexity of auto-generative design is heavily dependent on ready-made computer programs, not the user [50]. While the instrumental use of the computer is by no means objectively "wrong", the designer's consciousness of the type of process is important to guarantee the transparency for later valuation and development.

This may not be as problematic in modeling urbanity. Many urban dynamics models of today are direct descendents of scientific models from mathematics, chemistry and biology. In the Nekala-Vaasa model the emergent features of complexity are studied in a bottom up process; "sites" interaction appeared in emergent patterns on the higher level. In the result, the model succeeds in capturing the chaotic states in the behavior of the system: causing self-organizing and complex behavior by simple rules and interactions between agents [34]. Here the danger lies more in the transparency of the simulation process and especially the pre-assumptions of interactions between agents (activities on sites) and the interpreting of resultant patterns. It is a question of *transparency of information and decisions*. In terms of reliability, more empirical data is needed.

Ostwald considers that lately these problems in design have been obvious, even with the so-called "grand old men" of the branch, such as Gregg Lynn. Nevertheless, Ostwald still finds it possible to carry through an ethical design process using algorithmic methods. However, it needs a high level of self-awareness and self-reflection [51].

Terzidis remarks that naturally any human based process is associated with subjectivity and personal interpretations, and any production of form must be understandable and open to criticism. The problem with the computational approaches is that they do not "allow thoughts to transcend beyond the sphere of human understanding" [52]. Nevertheless, this observation does not decrease the importance of the call for transparency, which does not differ much from the scientific requirements of verifiability – this also applies in the fields of science where complex interactions and effects can be tracked down only at the level of the process.

III. RESULTS

A. Modeling the Real & Ethics "for Starters"

In this complex and self-generative reality, we cannot evaluate the ethics of these natural phenomena, because there is none. We cannot control or predict the future, but we cannot let go, either. To understand, steer, and take dynamic account of multiple factors and their unpredictability, we now have an effective co-worker that is not just an extension of our brain: a

computer.

In architecture, pragmatically the “form-giving forces” can be seen as natural factors in any building project, or as an information flow that affects the design process anyway. Pre-determined form is a limitation that has been seen to lead to mediocre or bad solutions – form is not the starting point, it is the outcome. Functional typologies or ideal “pure forms”, for example, do not take into account a variety of factors affecting them, such as environmental, social, economic factors or those affecting individual well-being outside basic welfare. Also, as the designing process is kept open until a relatively late phase, it is possible to consider the changing situations – funding, environmental information, clients/public needs – in a more flexible way than traditionally when the design concept is fixed quite early.

In urban planning, to survive between laissez-faire and top-down control, we must have tools for anticipating the possible future outcomes of different courses of action. It is essential to understand the phenomena, not to predict the future. As non-linear systems are sensitive to slight variation in the initial state, analyzing the causal relations is impossible, but models give a certain understanding of the possible “trajectory” or track the system is on. Acts in the planning and decision-making –concerning the actual city - can be (re-) evaluated in the process by simply altering the emphases.

When the new approaches are successfully applied, a designer may be liberated from depressing and restrictive old concepts, able to handle dynamic forces in a creative and enabling manner. There are different design branches that use computer aided data processing as a tool for capturing the essential features of the complexity. We think the pursuit of a totally auto-generative process is not necessarily the only aim as we try to conquer the unpredictability of the complex. From the ethical point of view, it is more important is to be conscious of the degree of interference in the process in which one is involved, and adjust the responsibility for one’s action transparently according to this. As a developing branch, using computer technology such as dynamic models must not be used for its own sake, but in a process of learning and development of the tool as well as understanding its possibilities. Here We find a wide range of simultaneous approaches fruitful.

In an ethical design process an architect’s role in shaping a design is visible and accountable. As a computer is seen as an equal partner in design with the architect, problems of responsibility may arise. One must, first of all, take responsibility for the choices in the beginning; secondly, for the hidden values of the program; and finally, for the choice and interpretation of the resulting solution. Furthermore, all this must be done transparently. The forms of responsibility could then be classified under two sub-themes: Responsibility for *decisions* and for *information*.

Transparency of the process – including aspects of decision-making and information - terminology and concepts are needed. (Fig.1.)

Responsibility	Transparency
Decisions i. Rules ii. Program/algorithm iii. Interpretation/ evaluation	Process i. Decisions ii. information
Information i. environmental data ii. Scientific principles of interaction (basis for the rules)	Terminology Concepts

Fig. 1. Evaluating Complexity – Ethical Challenges in Computational Design Processes

In other words, the ethical challenges could be: To be transparent and logical in defining the problem, choosing the rules and other relevant factors, as well as to be transparent in programming and choosing/evaluating the final solution. Further, to admit the limitations of the tool and thinking, and taking adequate responsibility for the process at hand, while being motivated by only exploring the tool.

IV. DISCUSSION

We are, as is stated in chaos theory, at a bifurcation of the paradigm, where the next “steady state” is only stabilizing. The challenges of computational approaches in architecture and urban planning are similar to those in other novel technologies, the problems of which are only emerging today. Therefore, the ethical questions arising must be carefully considered alongside the development, evaluation, and use of new methods, despite the most eager manifesting declarations on behalf of “just do it”. As Viny Maas agitates, “...most discussion of acceptance or rejection of data processing device like Spacefighter are a waste of time, because as one discusses other people are making these device.” [53] I would rather say: We need the doing *and* the discussion.

The role of an architect is undergoing a huge reformation process. New methods ignore human intuition in a traditional sense, and the origin of form and design. While multiple actors work together in a dynamic process, the emerging result is no-one’s intellectual property. New tasks like programming, gaining scientific knowledge for setting conditions for the model and evaluating the process will necessitate a whole new attitude towards planning and design praxis in the near future. Nevertheless, while design that is always partly constituted on the non-rational sources of inspiration - metaphor, analogy or spiritual revelation - enters the world of rational science, a new balance between them is needed [50].

On giving up total control, and stepping down from the podium of modern master-mind hero, an architect must re-define the degree of steering and auto-generation allowed in the processes, yet without hiding and letting go of the wheel. Total equilibrium may perhaps not be found here, either, but maybe we should try to seek a sustainable trajectory instead.

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