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Parameters VS Algorithms: The New Urban Paradigm

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Abstract

This paper focuses on two contemporary architectural and urban movements – Schumacher's Parametric Design and Watanabe's Induction Design. Both the Parametric and the Induction design are in tight relation with the currently active Complexity paradigm and self-organization concepts, and are distinctive for their intense use of specific morphogenic software. Thus, they themselves serve as powerful instruments in the process of creation of the new millennium urban Utopias.

Induction Design acts as an extension of the brain and gives precise solutions (entirely based on specific assessments and calculations) to numerous complex architectural, urban and environmental problems. Parametric Design, on the other hand, could be described as an extension of the hand and its primary task is to organize and to articulate the increased complexity of the modern society by setting strict rules for morphogenesis.

As both trends operate on all levels, from interior design to urban planning, we cannot help but wonder if any of them has the required qualities to become the next great style and to establish the new design paradigm.

The author has conducted a study of the two trends, which includes exploration of their emergence, history, socio-cultural and scientific context, principles and methods, and thorough examination of multiple examples of their application. As a conclusion from the study and the comparative analysis, the author proves that despite their apparent similarities, the Parametric and the Induction Design have not just different characteristics, programmes, methods but also face different problems and thus provide different solutions.

Keywords:

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Introduction

From ancient times the desire for understanding the Universe led the humanity towards technological innovations, scientific breakthroughs and changes in the societal structure. The influences of the socio-cultural and politic paradigms are easily traced even in the field of architecture and urban planning. Studying the effects of the scientific paradigm though, is more obscure and requires solid interdisciplinary background. In this article the author examines how the last paradigm shift affected architecture and urbanism, and acted as a basis for the formation of new styles.

The second half of the 20th century started with the complications of the post-war crisis and the 1960's came as years of great change when the unthinkable suddenly became possible. The technological outburst, the new art trends, the new lifestyle fashion and the modern computational potentialities hauled the future and its problems to the present. Computers made calculations, considered impossible before. Cosmos was not that far away anymore and actually became part of the daily environment. The machines and their seemingly limitless power, the postmodern philosophy, the complexity paradigm, the concept of fluid dynamics, the development of the fractal and algorithmic theories laid the foundations of the computational theory and design. These tools were so overpowering that soon they reverberated in the arts, engineering sciences, architecture and urbanism.

These changes, along with the thirst for identity after the crash of the International style, led to the replacement of the old modern buildings with a variety of shapes, colors and styles, based on and mixed with specific national elements. The sterile crystals of Modernism and the anonymous silence of the post-war years were forsaken. The science, which has always been humanity's most powerful instrument, extended its new Computational Design branch, that served as a great inspiration and pushed the urban utopias in new directions.

Definition, Background and Types of Computational Design

The term *Computational Design* has two basic meanings. The first one is related to the development of computer sciences, while the second one refers to products and processes, articulated, modified and governed by digital means. The author pays attention to the second meaning and considers it is reasonable to talk about it as *Computer Inspired/Aided Design* (CIAD).The realm of CIAD extends from the fields of computer sciences and human-computer interaction, through digital fabrication and tangible interaction design, up to mechanical engineering and product design. It represents new approaches, attempting to equip the designers with tools, more suitable for the new digital world.

The code, translating programmer's will to the language of the machines, is CIAD's most powerful instrument. In the architectural art though, it represents the rules that dominate all stages of architectural production. Throughout its history, the architecture has always been shaped by changing

codes and constraints and thus it has never been free of code, and neither were its elements.

The roots of CIAD can be found in the 17th century when the calculus was defined as separate branch of mathematics, used for describing and explaining various natural phenomena. The next big steps were made by Alan Turing and John von Neumann. Turing gave exact shape to the algorithmic and computational concepts. His theoretical work on Turing Machine was considered a cornerstone in computer sciences. Neumann, on the other hand, worked on 2D self-replicating automaton, that could be examined as further step in the development of Turing's work. Turing and Neumann actually managed to visualize patterns of otherwise invisible algorithmic processes. Among the scientists who shaped the new paradigm were Richard Feynmann (introducing the concept of swarm nanobots, operating on simple-set-rules); Stanislaw Ulam (studying the principles of crystal growth using simple 2D lattice network); Aristid Lindenmayer (developer of L-systems for simulating and modeling plant growth); and John Conway (developer of "Game of Life" cellular automata). The author considers the works of Stephen Wolfram (exploring complexity problems based on cellular automata and developer of Mathematica software), Robin Liggett and William Mitchell (developers of "TopDown" CAD software); and John Maeda (launching Java based design pedagogy on gizmo-centrism and accentuating the simple algorithmic beauty in aesthetics education) to be of great importance, too.

From architectural and urban point of view of great importance is Christopher Alexander's [6] analysis on urban structures in terms of simple algorithms and connectivity. Later he proposed a program decomposing algorithmically complex design tasks into simple sub-problems and recomposing them into the fittest design.

Every paradigm shift leads to changes in technology and mentality. Each new style has its formal and conceptual interpretation. Keeping in mind CIAD's historical context, we may state that major changes from metaphor to practice model were emerging. From just a source of visual inspiration, the natural interrelated dynamic processes became analyzable and easily digitally simulated.

The author distinguishes two CIAD types, accordingly to two main approaches: *top-to-bottom* form-making process (morphogenetical CIAD) and *bottom-to-top* form-finding logic (morphodynamical CIAD). Morphogenetical CIAD has formal approach. Distinctive for its transformation of 3D patterns by applying iterative spatial logic and continuous, yet discrete, material organization, it is inspired by Biological concepts and mimics natural forms. The author suggests naming this CIAD branch Parametric Design, since its processes and resulting forms are described by varying parameters. Morphodynamical CIAD has more conceptual approach, based on solving particular problems, rather than solving morphogenetical issues. It mimics natural processes by disentangling and redescribing them by various algorithms. Since it operates through the logic of algorithmization, the author suggests calling this branch of CIAD Algorithmic Design.

The Parametric and the Algorithmic Design consist of various sub-styles. Each of them is shaped by different criteria (structural, economical, environmental, etc.) used during the design process. Some of Parametric Design's sub-styles are Biomorphic Design, Blobbytecture, Biomimetics, Minimal-surface Design and Schumacher's Parametricism. Among the examples of the Algorithmic Design are: Evolutionary Design, Algorithmic Porous Patterns, Multi-agent System Design and Watanabe's Induction Design (which will be called Inductionism, from now on).

Overview and Goals

Thomas Kuhn [2] stated that each paradigm not only changes the perception of the world, but also requires new tools and programs for accumulating as much knowledge as possible and solving as many problems as possible before beginning the struggle with the inevitable emerging paradoxes. The avant-garde styles represent some of these new tools and articulate Kuhn's process of retooling, in their quest to satisfy the new social and environmental demands of the contemporary society.

Parametricism and Inductionism are refracting the status quo through CIAD's prism. They offer the needed retooling, and thus are classified as avant–garde movements: they are evaluated analogously to the scientific paradigms, provide new conceptual frameworks and formulate new aims, methods and values. Parametricism and Inductionism are bright representatives of the Parametric and the Algorithmic Design. Their instruments are specially developed computer programs and scripts. Both of them have solid theoretical background [5], [9] in which goals, governing principles and specific methodologies are introduced. Both styles emerged in the early 1990's. They operate in the same design range, from interior design to large scale urban projects and are still evolving. Parametricism and Inductionism though, were born and developed in different parts in the world. Thus, in order to understand better their concepts and methodologies, we have to reconsider their historical and socio-cultural background, as representatives of Western and Eastern cultures.

The foundations of the Parametricism were laid by Patrick Schumacher in the beginning of 1990's. The trend emerged from the innovative use of CIAD as an articulation of the increasing complexity of the social processes and its roots are in animation, advanced parametric designed systems and modified scripting methods. In Parametricist Manifesto, Schumacher [9] declared the trend to be the next big style after to Modernism. He claimed it succeeds the *temporary movements* such as Postmodernism, Deconstructivism and Minimalism. As each of these trends represented a major change either in the development of the society, the comprehension of the surrounding world, or the development of different building constructions forms and techniques, the author considers this statement as rather radical.

Many tasks are set in front of Parametricism and one of them is to apply the swarm formation to a cluster of buildings in order to from continuously changing field in which non two buildings are the same, yet are still lawful continuities cohering with the structure multiplicity. Unlike in Complexity Theory, the decisions are made *top-to-bottom* and are strictly defined by particular principles. According to Schumacher, Parametricism's primary task 'is to organize and articulate the increased complexity of the post-Fordist society'. The author believes Parametricism should be examined according to Gordon Pask's [8] holistic principles.

Inductionism was established by Makoto Sei Watanabe [5], in the early 1990's as a research and development project. Its evolution can be divided into four main phases. The first phase was mostly devoted to trials, while the second one was related to developing a set of specific computer programs. Phase three represented the actual application of the Inductionism's principles during the design and the execution of Iidabashi Subway Station project in Tokyo. The last, fourth phase, is still ongoing project and could be described as the stage of refining the Inductionism's tools and programs in order to meet emotional needs, and subjective conditions and requirements. Inductionism is working with algorithmic structures, representing abstract patterns that are not necessary associated with experience of perception. It could be also examined as Metabolism's successor, especially since it operates according to the principle that architecture should be able to develop like living organisms develop. Another part in Inductionism's background is played by Michael Batty and Paul Longley [1] who speak about the process of "breeding cities", using fractal growth instruments and self-organization principles. Also Manuel de Landa [3] suggested the designers have to stop looking for the form itself, 'but on the process of decision making'. Accordingly to Complexity Science concepts, the decisions in the process are made *bottom-to-top*. Watanabe declared that the goal is not to create forms that interpret Lorenz attractors, fractals and chaos theory concepts, but to use these concepts as a contribution to the design. Since the closeness to nature does not come from the similarities of forms, but from development of similar systems and specific conditions, the goal is avoiding the imitation of forms, but recreating its mechanisms. These principles along with CIAD's scientific background make Inductionism *conceptual* rather than *formal* style. It is not about using the computers to create a large amount of proposals with unusual forms from which to choose, but to solve particular problems by generating proposals, satisfying specific conditions. Thus, it is necessary to study the trends of development, to preserve the existing diversity and, in the same time, to obey the 'mini-max rule', of which Watanbe speaks [5]. Thus the primary task of the Inductionism is not to discover form, but to discover ways of providing better solutions to problems, while offering imagination freedom, ways of breeding cities.

Tools and Principles

Both Parametricism and Inductionism use the computers as a brute force and as main tools for generating proposals, yet there are a few differences in their usage.

Parametricism's specific tools and techniques are employment of animation, simulation, variety of form-finding methods, parametric modeling and scripting. Its unique feature is Schumacher's design frame of strict positive and negative heuristics. The positive heuristics represent the *must-do-s* and relate to parametrically malleable forms, gradual differentiation at varying rates, systematical correlation and inflection, etc. The negative heuristics are the *must-not-do-s*, the taboos. They are very explicit and refer to evasion of rigid geometric primitives, simple repetitive elements, juxtaposition of unrelated elements or systems, etc. It is important to note that the *must-do-s* and *must-not-do-s* refer to the formal physical characteristics. The overall clarification of functional relations and intertwining of all urban layers are left exclusively to the designer's personal objective and subjective concerns.

Parametricism's five basic principles are defined in its Manifesto [9]. The first is *parametric interarticulation* which pushes the designer from single system differentiation towards multiples sub-systems association. The second and the third principles are respectively *parametric accentuation* and *parametric figuration*. They ensure the enhancement of overall sense of organic integration by deviation rather than by adaptation, and a specific complex visual configuration in which multiple latent readings are present. The last two principles are *parametric responsiveness* and the application of *parametric urbanism*. They represent the desire for in-built capacity, allowing the environment to be adaptable, and explain how the urban massing describes a swarm formation. Urban effects and facilitation of field orientation are achieved by applying these tools along with the structural modulation. Thus the main goal of achieving deep rationality and full integration of the built is fulfilled.

Unlike Parametricism, which uses scripting methods as application to CAD software, the Inductionism's tools are specially developed programs for resolving particular problems.

In the majority of architectural and urban approaches, the designer's task is to study the context, to discover all possible interrelations and to interpret and simplify them in order to produce optimal solutions. Alexander [6] points one of the problems of current practices - the loss of information due to simplification and reductionism. As the true nature of things is best expressed in terms of connectivity and the tiniest event could lead to major changes, we must not abandon even the slightest trace of connection, especially during the study of complex urban systems. Watanabe develops two big groups: the first one is the simple *Program series* (Constellation, Tree, Dinner table, Particle flow series, etc), while the second one is large scale *NeoInduction serie*s (Neo Sun God City, NeOn Demand City, KeiRiki, Privacy series, etc.).

Inductionism's principles differ from Parametricism's ones. The principle of *non-reductionism* is hard to follow, since analyzing a city depends entirely on conventional reductionist methods. The second principle is *diversity*, of which Watanabe says 'It is easy to say that we need to handle diverse objects with respect for their diversity, but much harder to execute'. The solutions provided by Inductionism are not uniform and their specific feature solving the problems while preserving the diversity, achieved by utilizing the computer's ability to perform enormous amount of calculations. Instead of completely different, the structural elements could be almost identical, which is actually close to Schumacher's taboo of simple repetition. *Bio-minimalism* is another principle, constituting the use of proper quantity of appropriate materials on the right places. It is not the same as architectural minimalism and it does not produce simple but diverse forms. The principle of *Arbitrariness and Randomness* represents the sharp distinction of what is to be designed and not.

While Parametricism is distinctive with its *must-do-s* and *must-not-do-s*, Inductionism stresses on two types of restrictions and conditions. The first type is *hard conditions* that should be 100% satisfied and are related to restrictions of space or imposition of each component's conditions. The second type, the *soft conditions*, represents the designer's intentions, which should be met in general. They refer to the extension and the density of the given space. The author considers the *hard conditions* define the overall algorithms, while the *soft conditions* set the varying program parameters.

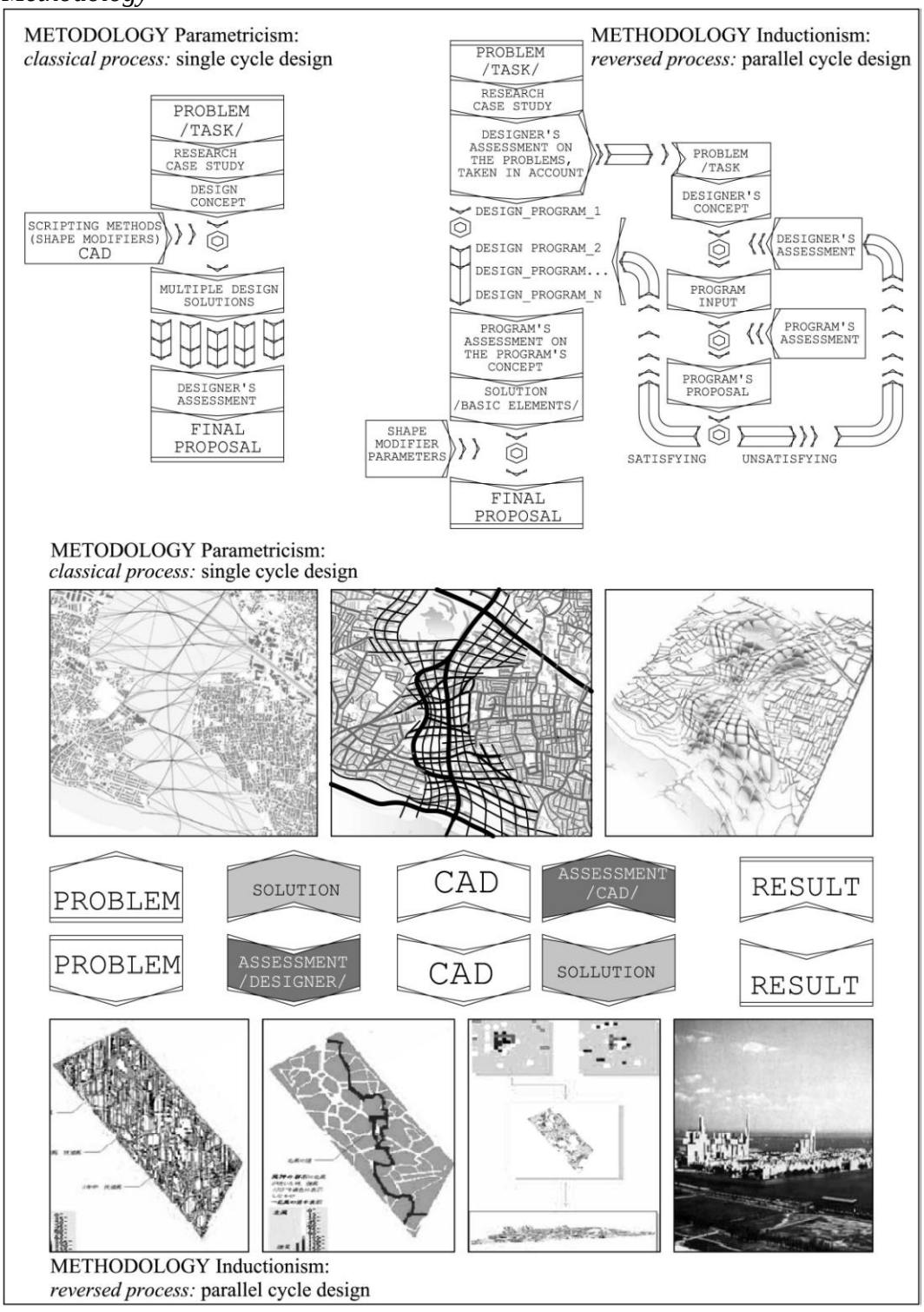
Methodology

The contrast between Parametricism and Inductionism lies in their methodology (see Figure 1).

Parametricism's methodology is very similar to the *classical design process*. The new moment is the role of the heuristics and the generation of multiple proposals, from which the designer chooses one. Basically the process follows several steps: starting the project; examining the territory; pointing problems; conducting case study and designing the concept; forming preliminary solution; using CIAD for generation of multiple solutions; designer's assessment on the final concept; finishing the process. The designer is involved throughout the whole project, from creating basic concept, assessing the final project up to adding the final touches.

Inductionism's methodology is more complicated. The design process consists of two parallel cycles of data input and assessment (by the designer and by the program). The author deduces this is a *reversed* design process, as the designer's assessment is made in the beginning, while the final proposal is assessed by a program. The role of the designer is in the process of developing the programs and setting the hard and soft conditions.

Figure 1. *Comparative Analysis: Parametricism's and Inductionism's Methodology*



Problems, Analysis and Application Examples

Like every major architectural or urban style, CIAD has a few problems that are either common or specific. One of the common problems is described by the question 'Do all CIADs look the same way?'. The author's opinion is that although many CIAD projects share similar conceptual or visual characteristics, each of them is shaped by different methodologies and tools. Each style has different concerns and problems and solves them in different way. Thus the produced outcomes are unique.

Another problem is the risk of losing identity. The author believes it concerns every global paradigmatic style. After the collapse of the International style and the outburst of the critical regionalism, handling this issue became crucial for establishing a style, claiming to be the next paradigm. Parametricism is mostly influenced by the swarm behavior concept, yet the society is not ruled entirely by this principle. Each society and its cities are governed by divergent behavioral algorithms, they consist of layered socio-cultural influences and tend to react in different ways to similar problems. In Parametricism, due to the strict heuristical visual frame, the results may look similar. Michael Leyton [4] describes the shape as a memory, and so we may conclude the heuristical frame leads to decrement of the societal memory. Inductionism, on the other hand, does not have this problem, since each project is solved by specially designed programs, refracting the *public parameters*. The shell of the structures does not obey fixed rules and could be shaped accordingly to the local characteristics.

Another common issue is Pask's [8] holistic frame. He defines four main features: dynamic nature of the city as a contextual background for individual buildings; conceiving structures in the context of temporal extension; structural existence as a part of intention; structural arousal from the context of the territory. The author believes that in order to understand and operate under the holistic approach, all four of these features should be met. In the case of Parametricism, the author finds only three of the four conditions to be met, since the last one, 'structural arousal from the context of the territory' is not fully fulfilled. In the case of Inductionism, all four requirements are met.

Problem, specific for the Parametricism, is related to the incorporation of computing tools in the process of architectural and urban design, while CIAD is still operating under the old paradigm. Parametricism and its heuristics can be examined as an attempt to overcome the postmodern visual concerns. Negative heuristics formulate structures that prevent relapse into old patterns that are not fully consistent with the concept. Positive heuristics offer guiding principles, allowing the work to fast-forward in a particular way. By this Parametricism aims to take over the scenography of Postmodernism, yet constantly falls back into *formality*.

Cities are complex entities, governed by evolutionary dynamics principles and their systems and sub-systems are being constantly repaired and rebuilt. In the process of evolution, the cities have collapsed and expanded in uneven episodes of flourish and decay, which naturally led to changes in physical

organization. Schumacher [9] states that one of the concepts of the Parametricism is 'Crystallizing into a solid new hegemonic paradigm for architecture'. Crystal is a solid material whose constituent atoms, molecules or ions are arranged in an ordered pattern extending in all three spatial dimensions. This definition is very close to the definition of a city: uniform structure, a solid urban organism, whose constituent cores, grids and building blocks are organized and extended in all three spatial dimensions. Like the cities, crystals are also 4D structures, changing and evolving with time obeying very strict rules of growth. How this concept of crystallization resembles Parametricism's specific look? From the dawn of civilization, the people constantly opposed the nature, by developing certain type of order to withstand the sense of chaos. People self-organized in tribes and small communities, and formed settlements answering their basic needs. The primary functions of the settlements were to accommodate, to ensure safe conditions for prolonging the life of the tribe and to secure the existence of future generations. One of the most important factors was the presence of water. Cities emerge and expand by *crystallization principles*, and are shaped by societal swarm behavior, dynamic flows of traffic, food, goods and information distribution, and influence radiating urban cores. The author perceives Parametricism as a metaphor of urban flows, eroding differentiated by swarm logic crystal fields. It aims to construct new field logic that operates via synergic correlation of multiple urban systems. Its power is used to cope with the rapid succession of design changes and ability to produce variations of a single building, or to generate versions of building components for repetition of elements, which actually places the process of assessment in the end of the design process.

About Inductionism, Watanabe says it begins with studying the issues of the project and examining the present conditions from multiple points of view, after which comes the process of choosing a specific and only possible line, that determines the planning process, the surfaces, the forms and even the materials. The line needs to be useful, to solve conditions, posed by the project, and *must feel good*. Then the processes of describing, programming and compiling takes place. It is about higher quality and better efficiency. Another difference with Parametricism is that the forms are result, rather than starting points. Inductionism is not a conclusion, but links in a continuously changing project.

From all studied Parametricist and Inductionist works, in this paper the author analyzes two projects, bright representatives of the two styles.

The first one is the Parametricist Kartal-Pendik Masterplan, Istanbul, developed by Zaha Hadid Architects (2006). The new urban network is based on Otto Frei's studies on minimal path networks, yet they are not fully taken in account and on top of them bended and twisted orthogonal grid is overlaid, creating a rhythm of urban peaks is in accordance to the process of widening and narrowing. The grid is replacing the traditional T-crossing based urban network with contemporary X-crossing based grid. Schumacher defines the project as ordered complexity, replacing the monotonous chaos of existing structures that mark the unregulated contemporary city expansion and as a

result, an elegant coherently distributed cityscape is created. Yet it completely contradicts the existing urban tissue and order, shaped by millennial social interactions. For this reason, the author considers the fourth of the Pask's requirements is unfulfilled. This project is more like transition from the present-past to the present-future and is more distinctive for its power to accentuate both local and the global properties.

Bright example for Inductionism is the project On-Demand City, started in 1995. It is a programme for *conceiving a city* in which optimal connections between functions and their specific places are ensured by few separate programs. A few cycles of distribution modification and assessment are made until the hard and soft conditions are satisfied. The outcomes of the program are tangled in one unbreakable whole, fulfilling all of Pask's conditions. Due to the big quantities of elements, an urban matter clustering, diverse patterns, and urban centers and sub-centers are emerging. Thus, the city could be perceived as an accumulation of matter and events, a process of change, an existing urban media of networks. While Paramtreicism introduces ordered complexity, Inductionism is a quest for secret order not cancelling out the disorder, but justifying it and injecting it with meaning.

Conclusions

The differences between the Parametricism and the Inductionism can be found in their inspiration, principles, methodology and application:

Inspiration: While Parametricism is inspired by fluid dynamics, differentiated fields, filled with fluid media (liquids in motion, radiating waves, laminar and turbulent flows) refracted by Complexity Theory, Inductionism is inspired by the process of cellular growth and obtaining optimal microclimate, refracted through the prism of computations and cellular automata algorithms.

Principles: The big difference is between Parametricism's *must-do-s*/*must-not-do-s* and Inductionism's *must-do-s*/*should-do-s*. The author concludes these principles resemble the levels of urban adaptability.

Methodology: The radical divergence, explained in Figure 1, is the place of the designer's assessment and solution in the overall process. Parametricism keeps the *classical design process*, while Inductionism has *reversed design process*.

Application: In the two examined projects we witness contrasting outcomes, based on different goals, problems and methodologies.

In conclusion, Parametricism is not the best option for design problems which are under- or over-constrained, or where the design variables are more obscure and hard to determine. It is more suitable in areas where the matter is engineered form itself. Inductionism is best applicable for design projects, where the variables are more obscure and hard to determine, yet its visual impact is not that breathtaking. On a round-table meeting Watanabe (2013) said: 'City is a mixture of too many individual wills' as the best explanation why the swarm logic behavior would never fully work. Thus the design does

not mean something created willfully, rather than something born from willfully specified conditions.

The urban utopias are closely related to the scientific ones. They all aim to provide perfect living standards. Utopian towns may never be truly global, may never change the social and moral conventions or allow anonymous existence, yet may an utopian model still emerge under the current conditions? After the development of Complexity theory and realizing the importance of the dynamic balance in our world, more and more another term is taking place: *extropia* [7], an open evolving society allowing individuals and voluntary grouping to form institutions, social forms and settlement they prefer, without bounding to particular technologies, policies or styles. Since science has already proved that "static" actually means "dead", what is actually the aim of the next urban paradigm? The author believes both Parametricism and Inductionism step out of the old perception of the perfect world and strive for the new dynamic perfection. The societal problems and our known physical world still are handled by the computers only with rough approximation, the technology is still developing, the society is on the edge of the quantum computational paradigm, and the next extropia seems to be nearer. In order to achieve stable urban programme, we need to keep some of the utopian requirements: common problems to solve, new aesthetical characteristics, preserved diversity, accentuated socio-cultural and historical contexts. All five issues should be present, yet each style so far handled only four of them at a time.

The author believes that the next Urban Paradigm is still under construction, and for now we can only explore small bits of it. To see it in completion, we should take advantage of various current trends in different fields, expand our knowledge further, reach the ultimate dynamic balance and make the great shift from Utopias to Extropias.

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