

ES Parametricismo, heurística y creación conjunta en las artes del diseño

EN Parametricism, heuristics and co-creation in the arts of design

ITA Parametricismo, euristica e creazione congiunta nelle arti del design

FRA Paramétrisme, heuristique et création commune dans les arts du design

POR Parametricismo, Heurística e Cocriação nas artes do design

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Parametricism, heuristics and co-creation in the arts of design

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ABSTRACT (ENG)

In 2008, architect Patrick Schumacher, from Zaha Hadid Architects, proposed an architectural manifesto for the 21st century, extendable to other arts of design and even to other areas of technological and artistic activity in which the human factor is associated with creation: Parametricism. In the subsequent debate, problems such as those of a new style as produce of digital technologies, and the totalizing claims of a design theory based on Niklas Luhmann's postulates on his General Systems theory, have been repeatedly discussed. In this article, the topics of the Parametricism manifesto associated with the human factor and creation in design in the current technological environments, have been extrapolated to its plausible revision from the heuristics discipline perspective and to a possible re-definition of the co-creation concept in the arts developed by the Informal Art Movement of the mid-xx Century.

KEYWORDS: *parametricism, heuristics, unconventional computing, Unikat product, autopoietic machines.*

RESUMEN (ESP)

En 2008, el arquitecto Patrick Schumacher de la firma Zaha Hadid Architects, propuso un manifiesto arquitectónico para el siglo XXI, que puede extenderse también a las otras artes del diseño e incluso a otros campos de actividades tecnológicas y artísticas, en las que el factor humano está asociado con la creación: el Parametricismo. En el debate subsiguiente, problemas tales como aquellos de un nuevo estilo como producto de las tecnologías digitales, y las pretensiones totalizadoras de una teoría del diseño basada en los postulados de Niklas Luhmann en su teoría general de sistemas, han sido discutidos repetidamente. En este artículo, los temas del manifiesto del Parametricismo relacionados con el factor humano y la creación en el diseño dentro de los actuales entornos tecnológicos han sido extrapolados para su plausible revisión desde la perspectiva de la disciplina heurística y para una posible redefinición del concepto de

creación conjunta en las artes desarrollado por el Movimiento de Arte Informal de mediados del siglo xx.

PALABRAS CLAVE: *parametricismo, heurística, computación no convencional, producto Unikat, máquinas autopoieticas.*

RIASSUNTI (ITA)

Nel 2008, l'architetto Patrick Schumacher dell'azienda Zaha Hadid Architects, ha fatto una proposta architettonica per il secolo XXI la quale può anche essere estesa alle altre arti del design, persino ad altre attività tecnologiche e artistiche in cui l'agire umano va preso per mano della creatività: il parametricismo. Diversi dibattiti hanno seguito questa proposta, tali come i problemi associati ad un nuovo stile prodotto dalle tecnologie digitali, anche le pretensioni totalizzanti di una teoria basata sui postulati di Niklas Luhmann, teoria generali dei sistemi. La relazione che segue ricava i manifesti del parametricismo in rapporto con il fattore umano e la creazione nel design nell'ambito attuale della tecnologia per revisionarne il loro carattere plausibile dalla prospettiva della disciplina euristica e anche per una possibile nuova definizione del concetto della creazione congiunta nelle arti sviluppato dal Movimento di Arte Informale, verso la metà del secolo xx.

PAROLE CHIAVE: *parametricismo, euristica, computazione non convenzionale, prodotto Unikat, macchine autopoietiche*

RÉSUMÉ (FRA)

En 2008, Patrick Schumacher, directeur du cabinet Zaha Hadid Architects, proposait un manifeste architectural pour le 21^e siècle, le paramétrisme. Celui-ci peut être étendu aux autres arts du design, voire à d'autres domaines d'activités technologiques et artistiques où le facteur humain est associé à la création. Le débat auquel a donné lieu ce manifeste a permis d'aborder et approfondir différentes questions, notamment la définition d'un nouveau style comme produit des technologies

numériques et les prétentions totalisatrices d'une théorie du design fondée sur les postulats de Niklas Luhmann dans sa théorie générale des systèmes. Dans cet article, les thèmes du manifeste du paramétrisme liés au facteur humain et la création dans le design dans les environnements actuels ont été extrapolés pour leur plausible révision depuis la perspective de la discipline heuristique et pour une possible redéfinition du concept de création commune dans les arts développés par le Mouvement de l'Art informel du milieu du xxe siècle.

MOTS-CLÉS: paramétrisme, heuristique, informatique non conventionnelle, produit Unikat, *machines autopoïétiques*.

RESUMO (POR)

Em 2008 o arquiteto Patrick Schumacher da firma Zaha Hadid Architects propôs para o século XXI um manifesto arquitetônico extensível também às outras Artes do design e até mesmo a outras áreas de atividade tecnológica e artística, nas quais o fator humano está associado à Criação: o Parametricismo. No debate subsequente, problemas como os de um novo estilo como produto das tecnologias digitais, e as declarações totalizantes de uma teoria do design baseada nos postulados de Niklas Luhmann de sua teoria geral dos sistemas têm sido repetidamente discutidos. Neste artigo os tópicos do manifesto paramétrico associado ao fator humano e à criação no desenho nos ambientes tecnológicos atuais foram extrapolados para sua revisão plausível a partir da perspectiva da disciplina heurística e para uma possível redefinição do conceito de cocriação nas artes desenvolvidas pelo Movimento Informal de Arte de meados do século xx.

PALAVRAS-CHAVE: *parametricismo, heurística, computação não convencional, produto Unikat, máquinas autopoieticas.*

INTRODUCTION

Heuristics, as an adjective, means “serving to discover.” It is a behavioral process not unique to the human species, through which we discover how to solve problems (the unknown). What makes heuristics different from the analytical-logical process for solving problems of thought is that living biological species (autopoietic) also develop heuristic problem solving procedures (their adaptation to the environment). In the case of the human factor, heuristics generally discuss human behavior (the human factor) in the face of problems (to be solved). In the specific case of computational heuristics, this equation is developed with an automated machine or artificial autopoietic machine (adaptive software or optimization and behavioral or decision models), which solves problems by itself... (or at least helps to search possible solutions). Pioneering works in the twentieth century on heuristics began in the mid-1980s when the field of artificial intelligence emerged in computational science. Some people thought about applying heuristics to computational science as a way to develop artificial intelligence (AI). This is understood in current computational technology and computational science, as well as in mathematical logic and the philosophy of today’s science; however, it has not been widely studied until 2008, when Patrick Schumacher, an architect of Zaha Hadid Architects, proposed in his *Parametricist Manifesto* these themes to be discussed as a new way of making architecture, which he named a new style, particularly, in the arts of design, where, as illustrated by the case of the rise of the use of adaptive software, such as the Grasshopper in architecture, and embedded in the multiple optimization software used in various associated technological fields related to arts design.

Today, the considerable differentiation and possibilities in the universe of design arts involves the use of heuristics in the way they have been used by mathematicians to solve problems or by psychologists in their studies of decision models in case of great complexity, in which it

is not possible to review each of the variables involved in its solution. This universe of great complexity arises from the differentiation of the design product in a digital universe in which the phenomenon of mass customization and technological individuation, produced with serial, but adaptable, technological platforms, has grown.

Heuristics are generally seen as a guide of decisions against problem situations (related to the human factor), and this relation is particularly duplicated in computational heuristics by its translation to algorithmic procedures in the machine—for example, as a model of evolutionary decisions or adaptive software. Romancya and Pelletier (1985) propose two aspects to define heuristics related to the human factor: a space of solutions by fallibility procedures (experimentation) and its feature of being a guide of decisions. In the field of arts, and regarding the human factor (the artist, the designer, the architect, the musician, etc.), the idea of re-exploring the concept of co-creation comes from the result of inquiring about heuristics (generally) and computational heuristics (specifically), which was proposed by artists of the mid-twentieth century, in the so called “informalism movement” (or the informal abstract, which also has projections in the Deleuzian debate of the Fold in the design in the late 90s). It was a way of understanding, from a perspective of the arts, the relation between the topological field of metaheuristics (where the human factor works, i.e. the artist, the designer, the architect, etc.) and the subordinate heuristics, in which artificial autopoietic machines performs (adaptive software, optimization heuristics or heuristics of decision models or adaptative toolbox) in their interaction with the physical world, that is, in a process of machine creation (assigning some human content to some appropriate artificial material, but by a machine). In the case of the Informalism of the 50s, co-creation was conceived as a reduction or folding of the human factor versus the material (a subjective factor, capable of creating a new one produced by interaction with the material, instead of its appropriation to an idea or Formal subjective). The resulting artistic work or the resulting design was cooperative with the tectonic properties of the material or with the physical laws, which were not subjected but magnified as a cofactor of creation. In the case of the contemporary digital universe, co-creation shifts to the idea of a heuristics of the human factor, supported by the artificial autopoietic machine, as the co-creator, in the same sense in which the material was assigned a leading or interactive role in the formal development of the work in the middle of the 20th century (Dubuffet, Tapes, etc.). Moreover, a heuristic program is the digital mechanization of heuristic behaviors or procedures in a

computer, according to Feigenbaum and Feldmann, cited in Romanycia and Pelletier (1985). This is what is defined as computational heuristics.

Since the 1990s, differentiation has been strengthened by developments in CAD design and the raising of the internet, which link design and market and consumption in a new way: first appears the product-consumerism (the mix of several forms of products independent of the producer) and finally the user, who creates individual content based on technology platforms specially developed for so. The do it yourself is born. Today, consumer categories such as lifestyles or brands do not longer apply, which preceded the current era of mass customization. A way of referring to the century of technological development between the Bauhaus Manifesto of 1919 and that of Parametricism of 2008 (Patrick Schuhmacher, 2008) would be the transformation of mass consumption to individualized consumption but also massive. The Parametricist Manifesto, on the other hand, explicitly focuses on the problem of co-creation—or, in this case, co-design—in the space and design arts, in the presence of the human factor in the machine processes in the era of mass customization. The Parametricist Manifesto collected these themes in 2008, although they were limited to architecture by its author. The global design represents the ideals of universality of the mass culture of functionalism and serialism of the twentieth century, but the constant changes and modifications of prototypes contradict this universalist principle. There is an important difference between customization and personalization in software. Customization requires the user to develop a process; personalization involves an interaction between the software and the user. Another approach raises that personalization may be just a

personal nomenclature. For example, addressing a generic letter to a person. Here is another category: individuation. The process developed for a singular individual and its qualities and properties are conceived from the beginning. In the current era it is possible to produce mass customization and mass individuation. The technology is behind. It is never visible in the usability of software or personalization. The technology through 3D printing and virtual reality allows to develop unique objects or *Unikaten* (the German term used to designate unique objects underlining the uniqueness of it, extrapolated by Thilo Schwer (2014) to label individuated unique end design objects in current mass consumption technologies).

In pictorial informalism of the 50s of the xxth Century, tectonic material is deliberately used by the artist as a co-creator of the 'work', be this the case of a 'painting'. The concept of informal refers to how the apparent randomness of the art work, which actually obeys models of physical forces of complexity in the way the liquid or paste of the colors is distributed on the 'painting' surface is not framed by an idea 'of composition or' form 'by a subject (the painter). In Figure 1 A), in Dubuffet's *L Harloupe*, the co-creation process is indirectly activated by the granulation of the color material on the surface which interacts with the act of the artist to demarcate the resulting edges and replicate the resulting construct on the surface(s) of the 'painting' or area of intervention of the artist -the human factor or creative force. In Figure 1 B) In the 90s in Architecture and the Visual Arts resumed the ideas of the Informalism of the 50s with experimentation of the delezian 'Folding': the informal abstract, as opposed to the reductionist abstract of the avant-garde of the early twentieth century, should capture the virtual complexity of the tectonic forces that are

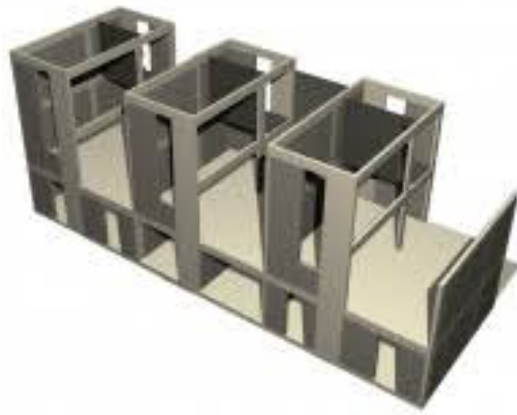


A



B

Figure 1. Art examples. A) From Dubuffet Foundation© by L. Harloupe, 1961 (<http://www.dubuffetfondation.com>). B) *Archi Folds Multifunctional Textile Amsterdam Boon Archi Fold*. From Studio Samira by Ossip van Duivenbode, 2017 (<https://competition.adesignaward.com/>)



A



B

Figure 2 Architecture examples. A) Monterrey (Santa Catalina), Project of Elemental Architects, by A. Aravena, G. Arteaga, H. García Huidobro, 2010. B) The basic Core planned design by the architects. Self built additions by residents during the habitation process. Project of Elemental Architects, by A. Aravena, G. Arteaga, H. García Huidobro, 2010. Photography by R. Ramírez.

part of the series of state changes of any given event or material. The Human Factor interacts through heuristics (in this case non-computational) with the virtual forces of the material updating these in one or several changes of state. In Boon Archi Fold the folds of the materials update the tectonic forces of the materials (cardboard or aluminum) in a series of results or moments explored by the artist without any previously given composition idea. Mainly in the so called emerging countries, since the 60s different methodologies have been applied by architects and urban planners to low income housing settlements 'co-design' and co-planning for progressive development

over long periods of time in which the tectonic principles of the Informalism paradigm may be also recognized in the process of property and spatial tectonic development. In Figure 2, the 2010 Santa Catalina Housing Project, Mexico is an application of co-design and co-planning by the architects in an incremental or progressive development housing model. In this example, a reciprocal co-design model is implanted as the 'inhabitants' in turn also submit their own tectonic experimentation with materials and room planning to the spatial boundaries imposed by the architect's design. In this process of reciprocal co-creation, a case in which the *human factor* (the architect or designer)

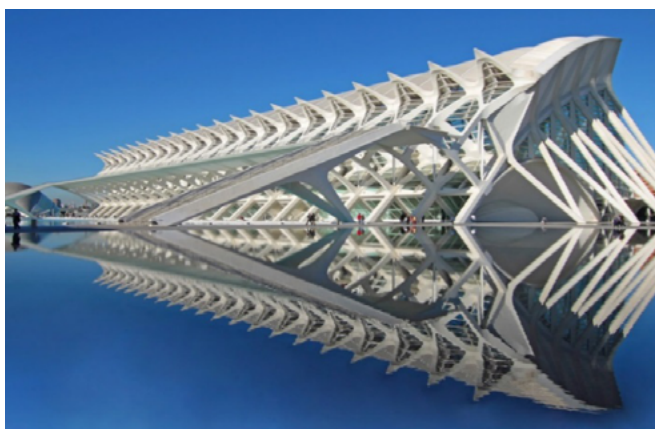


Figure 3. City of Arts and Science, Valencia, by S. Calatrava, 1998 (<https://www.arch20.com>).



Figure 4 Example in New Media Installations. Hylozoic Ground Relational Geometries, Installation of the Ohrstedt Studio Knob. Participation of Canada in the Venice Architecture Biennale 2011, by P. Beesley. Photography by Pierre Charron, 2011.

interacts directly with the object only in its initial phase and the feedback is reciprocal in the interaction with the dwelling inhabitant itself and his possible tectonic 'material' choices. *Preforming* is a concept that allows to review important works of some structuralist architects of the twentieth century, many belonging to the so-called "High Tech" trend of the 2nd half of the twentieth century. Based on a thorough work of analysis of the structural forms of nature, initiated by Buckminster Fuller in the 30s and 40s tectonic aspects such as the behavior of the material in relation to geometric shapes, interacts with the ideas or subjectivity of the human factor (the designer). In this case the design is not imposed a priori from social or economic ideas as in the case i.e. of the Bauhausian functionalism design School. In Figure 3, Santiago Calatrava's City of Arts and Science Valencia building example, the functional use is defined as cultural institutional, but the development of the triangular cells in the 3 axes allowing a ship-shaped volume to be extended on the longitudinal axis plays a predominant role in the design output. Computational Heuristics are applied in the design and development of very complex automated or autopoietic hardware and software in some current art and architecture installations. The Artist or Designer intends explicitly to work with emergent environments and objects. In Figure 4, Hylozoic Ground Relational Geometries Installation of the OHRSTEDT STUDIO KNOB, the collaborative work developed by architect and sculptor Philip Beesley is made up of hundreds of thousands of light components manufactured digitally equipped with microprocessors and sensors assembled manually, which are to be moved and breathed activated by the presence of users in exhibition room.

METHODOLOGY

The methodology used in the research work on computational heuristics included a) a first stage of documentary historical exploration of the use of the concept of Heuristics from the period of classical Greek philosophy, during which the term was coined as such, until the implementation of this concept in mathematics and computer science during the twentieth century. b) Based on the documentation obtained on the use of heuristics up to date, the topics relevant to the discussion of this concept within the debate of the design arts proposed by the parametricist manifesto of Patrick Schumacher at the end of the previous decade were selected: the heuristics in decision models regarding the human factor and heuristics in their relationship with mathematics in algorithmic computational technological processes. c) In the 3rd stage, this very specific discussion is extrapolated from the Computational Science and contemporary Psychology to the discussion of the

Informalism movement in the visual arts and in the architecture and its re-interpretation as a new co-creation paradigm in the design arts in general in contemporary times.

DISCUSSION: COMPUTATIONAL HEURISTICS AND PARAMETRIC 'STYLE'

The concept of differentiation—Luhmann's formulation (1987)—is adopted by Schumacher (2010) in his book to mean computational procedures of self-customization and self-regulation, with which he had previously detected the symptom of parametricism as a new relation of the human factor and its design, mediated by the intervention of programs and software that allow it to reach results that are beyond the intrinsic capabilities of the human factor: added in this article is an element that relates to the book "The autopoiesis of architecture", which is an attempt to create a unified and comprehensive theory of Architecture, in which parametricism is included as the last chapter of the Volume 2 of this book. The argument falls in that parametricism continues the autopoiesis of architecture, which is the closed self-referential system of communications that constitute the architecture as a subsystem in contemporary society. Parameters are just a way of defining the presence that the human factor has in one of the stages of confrontation with the material, in this case the physical agents of spatiality, as conventionally defined in tectonics; but also the ones corresponding to what may be labeled as paratectonic should be included; the cyber space, represented by that space boundary that today means internet, even more in moments like the exhibition CA 2015 Las Vegas, in which they have launched Internet of Things (IOT) like the following phase of development of Internet, as ubiquitous information systems, i.e. spatially located, in order to further deepen in ubiquitous mobile computing. Considering the design based on the grammar of parameter scripts, the aesthetic result is simply the expression of this procedure, which is referred to as the performative procedure. The power to have written codes completely decides the aesthetic terms of the architecture and come to redefine the architecture as a whole.

The Luhmann's concept of systemic differentiation, extrapolated from the theory of the organism, in which a recurrent differentiation allows the functions of the system of the organism to be composed as its subsystems, whereby the feedback environment of these is the organism itself, is also extended by parametricism to a programmatic conception of architecture in the idea of style. Addressed in the Parametricist Manifesto as a system of control of an environment and feedback of a system extrapolated to the solution of the programmatic

crisis of architecture after modernness of the idea of the autopoiesis of architecture and its reference made to a new style or a way of doing things is finally expressed in a category of design defined as *unikat*, which consists of a serial product, built with digital technology to mass produce, but with a single or unique character at the end design product.

Implicit in the considerations of a new style, the Parametricist Manifesto generally includes the topic of heuristics and specifically computationalist heuristics... An *implicit* recognition of structural shifts in the logic of thought as a human procedure and specifically in the shift of the human factor versus the technological interfaces and the position of the creative or created in the man-machine relation.

The term parametricism implies the notion of parameters, which implies fluctuations and shift of boundaries or terms of reference, of emerging design products by the double fluctuating interaction of the human factor, which is also apart from the final product of the design by computationalist heuristic models and by the correlative evolution they assume in this formal process (this for the case of parametricism and, in the process of mutations of tectonics for the alternate case of the adaptive architectures, technological interfaces), such as software based on cellular automata, in the case of formal design software, such as Grasshopper for parametricism and info-computationalism, that is, naturalistic computation for the corresponding to adaptive architectures.

This formal reference is associated in parametricism—in the terms of style—with organic forms, by differentiating the purist and minimalist referentiality of platonic formalism, which was associated with the industrial technological social program of mass production of the modern international style: the minimum... the basic... the massive. From the *Unikaten* of parametricism, also associated with a technological social program of what is diverse, unique, individual and autonomous, comes the formal referentiality of the recursive and complex: this emphasis on differentiation. The amplification of deviations rather than neutralization and compensation is related to the difference between exploratory research design and problem solving.

The solution of problems is the engineering side, the technical parametric side. In contrast, when spoken of parametricism as style, it means talking about playing with the potentials still unknown of these techniques, but with the direction clearly established by parametric heuristic principles.

The revaluation of the best way of using the design product develops a new profile in the twenty first century with the Schumacher's Parametricist Manifesto of 2008, which in its formulation includes one of the technological and sociocultural processes associated with this shift in the economic system of the capitalism in the late twentieth century: the genesis in the current technological era of the so-called tayloring, i.e., the adaptation/appropriation of mass production of products from the industrial technological era to the usability characteristics of these products by social and cultural groups, and already in the current digital era to the individuation of the technological product or the redefinition of industrial serialism from plural to multiple, morphogenetic or singular, by the effects of an industrial technology defined as mass customization. The new *Unikaten* is a result of 3D CAD modeling and printing technologies and the web 2.0 era (user generated content). In the fifties of the twentieth century, when an oversupply of industrial production occurred for the first time in the history of western capitalism, there was a twist to a process of legitimizing this overproduction and supply of unnecessary products with brand content—lifestyle—which distorted the essentialist functionalist postulates of Bauhaus and Walter Gropius of 1919 of ergonomic and social efficiency.

This historical precedent was the basis of the trend towards progressive differentiation in the industrial mass production of western capitalism at the end of the twentieth century and, hence, of design. On the other hand, in the late of the 1970s, the postmodern environment (post-functional and critical) proposed ecological, culturalist and anti-fordist approaches as a continuation of this differentiation process. Today, this process has gone from being superstructural—that is, mostly linked to the processes of consumption in the mass media of communication of the twentieth century, such as television and cinema and specialized magazines—to define the foundation itself of the product of contemporary design. Since the 1990s, differentiation has been strengthened by developments in CAD design and the raising of the internet, which link design and market and consumption in a new way: first appears the product-consumerism (the mix of several forms of products independent of the producer) and finally the user, who creates individual content based on technology platforms specially developed for so.

Co-design or co-creation is the result not only of the investment supposed in the change of the product-consumer, but also much more. As of the twenty first century, computational heuristics, both in optimization applications and in decision models, computational heuristics or subordinate heuristics of design are presented as a manifestation, the most recent one of the

co-creation approach tested in the twentieth century in various arts, through the informalism of the fifties (in plastic arts,) in architecture in the preform, trends that came to the end of the twentieth century, especially in architecture, with the Folding Trend in Design of Peter Eisenmann and Greg Lynn. Thilo Schwer (2014) explains based also on Luhmann how he applies this constructivism to systems theory and social systems—and design. Radical constructivism is applied through the concept of autopoiesis: the cybernetic circle, feedback of the environment as input of the subsequent feedback, and its life and unity kept by it; but extrapolates this category to society. The systems are also social and are of communication and psychic. The design product is differentiated from these.

CONCLUSION

With the new potential of computational design and digital technology, designers can shift and re-structure the design process to achieve a more flexible model/system to address the increasingly complex nature of today's design-related issues. The new parametric style (understood as a new way of doing) proposed by the Schumacher's manifesto is a new style of design applicable to engineering products, material tectonic construction, electromagnetic tectonics, material or virtual consumer objects, etc., and directly expresses the social autopoietic processes described by Jonas of progressive differentiation, but also the new definitions of the human factor and the machine factor from computational heuristics. Schumacher proposes a new style in architecture (and design) by the transversality that emerges from considering design and not only the man-object relation as part of the feedback circle (according to Jonas (1994), a Theory of Design as a 'product' or the conventional Theory of Design arises from this new style). Therefore, to revise the design, technology and the human factor, but in addition to the above, also a feedback circle parallel to the human-machine relation, understanding this also as an autopoietic relation; the adaptive or self-productive software that in the view of computational heuristics also design and also make decisions. The parallelism of both feedback circles, thus defined, is exactly what allows proposing the paradigm of co-creation—present in the twentieth century arts from the informalism of the fifties—as a way of understanding

or defining the role of the human factor in relation to systemic autopoietic processes, both in relation to social functions and in relation to the machine factor.

REFERENCES

- AMARAL, F. N. & Haesler, E. H. (2005). A Logic-Based Formal Model for (Meta) Heuristics. *Monografias em Ciência da Computação* (06/05). Retrieved from ftp://ftp.inf.puc-rio.br/pub/docs/techreports/05_06_amaral.pdf
- ARAVENA, A., Arteaga, G. García, H. (2010). *Project of Elemental Architects*. Monterrey, Mexico.
- BEESE, P. (2011). *Hylozoic Ground Relational Geometries, Installation of the Ohrstedt Studio Knob*. Participation of Canada in the Venice Architecture Biennale 2011.
- CALATRAVA, S. (1998). *City of Arts and Science*. Valencia, Spain. Retrieved from <https://www.arch20.com>
- COOPER, B. S. (2008). *What Makes a Computation Unconventional? or, there is no such thing as Non-Turing Computation* University of Leeds. Retrieved from <https://arxiv.org/pdf/1303.2507.pdf>
- DODIG-CRNKOVIĆ, G. & Giovagnoli, R. (2012). Natural/Unconventional Computing and its Philosophical Significance. *Entropy*, 14, 2408-2412
- DUBUFFET, J. (1961). *Dubuffet Foundation*. Retrieved from <http://www.dubuffetfondation.com/>
- GIGERENZER, G. & Gaissmaier, W. (2011). Heuristic Decision Making. *Annual Review Psychology*, 62, 451-482.
- HVASS, P. & Magnus, E. (2010). *Tuning & Simplifying Heuristical Optimization* (doctoral thesis). University of Southampton, Southampton, United Kingdom.
- JONAS, W. (1994). *Design-System-Theorie: Überlegungen zu einem systemtheoretischem Modell von Design-Theorie*. Bielefeld, Germany: Herausgeber Siegfriedmaser.
- KATSIKOPOULOS, K. (2011). Psychological Heuristics for Making Inferences: Definition, Performance, and the Emerging Theory and Practice. *Decision Analysis*, 8(1), 10-29.
- LUHMANN, N. (1987). *Soziale Systeme: Grundriß einer allgemeinen Theorie*. Frankfurt, Germany: Neuaufgabe.
- ROMANCYA, M. & Pelletier, F. (1985). What is a Heuristic? *Computational Intelligence*, 1(1), 47-58.

SCHUMACHER, P. (2011). *The Autopoiesis of Architecture: A New Framework for Architecture, Volume 1*. London: John Wiley and Sons.

SCHWER, T. (2014). *Produktsprachen: Design zwischen Unikat und Industrieprodukt*. Bielefeld, Germany: Transcript Verlag.

STUDIO Samira (2017). *Boon Archi Fold*. Retrieved from <https://competition.adesignaward.com/>

URIBE Mendoza, B. (2018). Heurísticas Computacionales y Co-creación en las Artes. *Revista Internacional de Edificación*, 1(1) (in print).