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Design and the Fourth Industrial Revolution. Dangers and opportunities for a mutating discipline.

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Abstract: The nature of design has always been related to socio-technological forces. In the twentieth century, the first and second orders of design were central in the establishment of graphic and industrial design. In the early years of the twenty-first century, the third and fourth orders of design were related to interactions and environments. This description can be associated with different phases of the Industrial Revolution: the first two phases allowed the transition from a farming and feudal society to an industrial and capitalist one, a third one was related to a post-industrial or services society. The Fourth Industrial Revolution presents the Internet, 3D printers and genetic algorithms as the main technical achievements and green energies as the energy source. It is related to computers, software, artificial intelligence, the Internet of Things and machine learning. These technological forces will create the space for the most important design jobs of the future.

Keywords: Design, Fourth Industrial Revolution, Internet of Things (IoT)

1. Introduction

In different historical periods, the discipline of design has been categorised in diverse ways. A possible manner of understanding the changing nature of design can be explained by transformations. The first alteration was related to the emergence of the *homo faber*, the maker of things, in the Neolithic Age. The second mutation presented the idea of man as the *machine creator*. A third transfiguration is happening now, and it could be characterised as the Age of the *Homo Gubernator*, the "space age of cybernetics and high technology: the systems age, the age of complexity" (Banathy, 1996). Following these ideas, it is possible to understand the sub-areas of design that took shape at the beginning of the twentieth century in professional and academic environments. Fields as *graphic design* and *industrial design* are the result of a time where design consolidated as a modern discipline, and a large majority of design projects produced in the last hundred years can be understood considering these two areas.

To have a clear discernment of the inner logic of the epoch was then – and it is now – highly relevant. For these areas of design it was the second industrial revolution, with its focus on the mass production of goods, and later on, services. Therefore, to study materials and manufacturing processes was a requirement for industrial designers, as it was to comprehend materials and printing production for graphic designers.

The Third Industrial Revolution has been distinguished by the predominance of electronics and information technologies, a process that took place in the second half of the twentieth century. Entering the third millennium, a Fourth Industrial Revolution is building on top of the previous one. It has been characterised by Schwab (2016) as “a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres”.

In this contextual situation, it is appropriate to ask what the dangers and opportunities for design are.

This paper explores the relationship between a software revolution, a framework of paradigms to understand computers, different orders of design, second-order cybernetics, the notion of the Fourth Industrial Revolution, and some of the technological forces that will shape our future in upcoming years. It examines the question of how the correlation between these otherwise unconnected ideas present a crisis for the practice of design.

2. A software revolution and a framework of paradigms for understanding computers

In 2011, Marc Andreessen – the co-founder of Netscape, one of the first browser companies, and co-founder and general partner of the venture capital firm Andreessen-Horowitz – wrote an article in the Wall Street Journal explaining “Why Software Is Eating The World” (Andreessen, 2011). In the article, Andreessen (2011) makes clear that “six decades into the computer revolution, four decades since the invention of the microprocessor, and two decades into the rise of the modern Internet, all of the technology required to transform industries through software finally works and can be widely delivered at global scale”. These forces are permeating under the hood of many industries. Andreessen examples come from bookselling companies, movie distribution companies, music distributors, entertainment companies producing video games, movie production companies, photography, marketing, telecommunications, recruiting, and other enterprises. He goes further and explains “software is also eating much of the value chain of industries that are widely viewed as primarily existing in the physical world” (Andreessen, 2011). The software is the fluid part of the computing equation. To understand this technological context, the idea of a framework of paradigms can be useful.

The fruitful relation between Bill Verplank and Bill Moggridge, a computer scientist and a designer correspondingly, is one among many that can be analysed when discovering the value of design in Silicon Valley (a great resource to see more of these relations between designers and computer scientists in California is the book “Make It New” by Barry Katz). One of their legacies is the notion that the computing revolution can be analysed using a computing paradigms framework. According to them, computers can be understood as a person (giving computers human-like attributes, e.g. AI), as tools (exemplified by the desktop metaphor and the graphical user interface (GUI)), as media (that proliferates with the Internet and with ubiquitous mobile devices). Verplank and Moggridge explain that these three paradigms have been developed already, and they also speak about three other paradigms for the future: computer as LIFE, computer as FASHION, and computer as VEHICLE. Working on these ideas, Hinman (2011) proposes a different group of paradigms for the future:

computer as organic material, computer as infrastructure, and computer as social currency. As organic material, computing power is embedded into the fabric of our lives, with sensors and actuators everywhere, something that could be associated with the notion of the Internet of Things (IoT). As infrastructure, computing technologies are reaching a level similar to water and electricity, built into the environment, a movement that it is clearly perceived with the cloud computing phenomena. As social currency, computing power is used in social environments to create and consolidate social relations, something that we are clearly seeing with social media.

It is highly interesting to see the correlations that can be set between the aforementioned paradigms and the characterization of the Fourth Industrial Revolution that Schwab (2016) speaks about, a world where “engineers, designers, and architects are combining computational design, additive manufacturing, materials engineering, and synthetic biology to pioneer a symbiosis between microorganisms, our bodies, the products we consume, and even the buildings we inhabit”. This operational space claims for a different understanding of design, an area of study not just concern with form giving but with the understanding of systems of systems. Therefore, design can be considered having a correspondence with cybernetics.

3. Design, the age of biology and second-order cybernetics

In the year 2001, Richard Buchanan, a North American professor of design, management and information systems, wrote a characterization of design describing a structure of four orders. According to his interpretation, “the first and second orders of design were central in the establishment of the professions of graphic and industrial design” (Buchanan, 2001). Graphic design presented an interest in visual symbols, the communication of information in words and images, while industrial design showed a focus in tangible, physical artefacts, and material things. We can perceive that there is a correlation between these two areas of design and the Second Industrial Revolution, particularly in relation to the mass production of products. Considered as such, graphic and industrial design were the core pillars of the practice of design during most of the twentieth century.

During this time, the previously mentioned areas were incorporated into academic institutions, giving shape to undergraduate and postgraduate programmes created following the foundational ideas originated first in the Bauhaus and further developed in the Ulm Hochschule für Gestaltung (HfG Ulm). During the years of its brief existence, between 1953 and 1968, the HfG Ulm made an enormous contribution to the world of design education. At its core, it was the notion of bringing together design and the industry, but also exploring other novel areas – such as cybernetics, an area that was incorporated into the reform of the programme of studies conducted under the guide of Tomás Maldonado in 1957. This relation between design and cybernetics still would be an area of relevance in years to come.

According to Buchanan (2001), the third order of design deals with interactions and experiences, in sub-areas that are called interaction design, experience design, service design, or design thinking. To finalise this characterization, the fourth order of design is concerned with complex systems and environments for living, working, playing and learning (Buchanan, 2001).

It is coming out of this analysis that, as we are moving ahead more complex interrelations of systems, the need to understand everything from a systemic perspective is more relevant. The ideas explored by Hugh Dubberly and Paul Pangaro, among others with an increasing interest in the crossover between design and cybernetics, can shine some light on these issues.

In the year 2008, Hugh Dubberly wrote a paper explaining the shift from a mechanical-object ethos – that was heavily associated with the Second Industrial Revolution – to an organic-system ethos (something that nowadays we can associate with the Fourth Industrial Revolution). Dubberly (2008) explains that "increasingly design shares with biology a focus on information flow, on networks of actors operating at many levels and exchanging the information needed to balance communities of systems". According to his understanding, "the shift from the industrial age to the information age mirrors, in part, a shift from manufacturing economy to service economy" (Dubberly, 2008). Something that Buchanan (2001) anticipated on his description of the third order of design.

More recently, Dubberly & Pangaro (2015a) explored the relation between design and cybernetics, considering that "designers of digital systems are faced with the challenges of product-service ecologies". These contemporary ideas are setting the base for a different kind of designer, not primarily concerned with the process of form-giving, but with the understanding of complex systems. Given these conditions, Dubberly & Pangaro (2015a) explain that "form-givers may have the luxury of working alone, but designing systems and designing platforms require teams". We are confronted here with the design of "complex systems and environments" identified by Buchanan (2001) as the fourth order of design.

Ideas that relate design with systems perspectives have been around for a while. During the second half of the twentieth century, the paradigm shift experience in Europe with the growth of the industry and the increment of mass-produced objects, required a definition of the designer's professional identity, as Rinker (2003) explains. Tomás Maldonado then said, "the designer will be the coordinator. His responsibility will be to coordinate, in close collaboration with a large number of specialists, the most varied requirements of product fabrication and usage; his will be the final responsibility for maximum productivity in fabrication, and for maximum material and cultural consumer satisfaction" (Maldonado in Rinker, 2003). The contemporary technological circumstance is bringing another context to consider again a systemic approach.

Understanding that the domain of design has expanded from form-giving to creating systems that support human interactions (Buchanan, 2001; Dubberly & Pangaro, 2015a), a literacy on systems becomes relevant to design. The science that studies goals, feedback and learning – as it is needed in interaction – is cybernetics (Dubberly & Pangaro, 2015a). Given cybernetics, it is required to incorporate subjectivity and the epistemology of second-order cybernetics, "the cybernetics of observing systems as apposed to systems that are observed passively from and objective point of view" (Ebenreuter, 2007). According to Dubberly & Pangaro (2015b), "design is not just steering towards a goal (as in first-order cybernetics); design is also a process of discovering goals, a process of learning what matters (as in second-order cybernetics)". And having second-order cybernetics, there is a requirement for conversation. In that context "design can be seen as a form of conversation in which elements of the design situation are negotiated between two parties to develop a desirable outcome" (Ebenreuter, 2007). As Dubberly & Pangaro (2015a) explain, "design grounded in argumentation requires conversation so that participants may understand, agree and collaborate on effective action". Following these ideas, it is clear that "as a means to facilitate communication and understanding, a second-order cybernetic framework that utilises methods of conversation theory has the potential to provide designers with a greater understanding of a design problem and its resolution" (Ebenreuter, 2007).

The relation between design and cybernetics is not new and has been previously studied (Ebenreuter, 2007; Glanville, 2007; Krippendorff, 2007; Dubberly & Pangaro, 2015a, 2015b). As it has been discussed in this article, it was present at the Ulm Hochschule für Gestaltung (HfG Ulm) in the late '50s, where Wiener lectured in 1955 and Rittel taught classes in operations research and cybernetics (Dubberly & Pangaro, 2015b). It is worth mentioning that for Glanville (2015), "design and cybernetics are really the same thing". He expands on this notion by saying that "conversation is a way of being with someone else, of communicating, in which we don't actually have to claim we understand the same things" (Glanville, 2015), what leads him to affirm that "what designers do is they make errors that are opportunities" (Glanville, 2015). As it was mentioned at the beginning of this article, this could be characterised as the phase of the *Homo Gubernator*, the era of the governor, the helmsman, considering that the Greek word that gave origins to the term cybernetics was *kybernētēs* (κυβερνήτης) and the meaning of this word is to steer, to navigate, or to govern.

What could be new to this equation – making it the main contribution of this article – is the notion that these ideas strongly relate to the Fourth Industrial Revolution, where the lines between the physical, digital and biological spheres are blurring (Schwab, 2016). In the Fourth Industrial Revolution era, the role of design could be more than ever related to the process of discovering goals and learning what matters (Dubberly & Pangaro, 2015b). This could be illustrated with two examples, one related to the creation of forms, the other related to connected technologies, the fundamental elements of the Internet of Things (IoT).

Taking into consideration the creation of forms, an example of the shift that has been produced in the realm of design it is the project Dreamcatcher developed by the software company Autodesk. As they explain, "Dreamcatcher is a generative design system that enables designers to craft a definition of their design problem through goals and constraints" ("Project Dreamcatcher | Autodesk Research," n.d.). This system uses artificial intelligence (AI) algorithms to produce a high number of alternatives given a certain set of conditional rules. The task of the designer, in this case, is not giving the form to a product, but seeding the system and evaluating the results. The final form is the result of an evolutionary process and in many cases, the end results are similar to those found in the natural world as the product of millions of years of evolution (e.g. bones shapes produced with the goal of maximising the strength while minimising the weight).

Having a look at the notion of connected technologies, David Rose, an award-wining entrepreneur, author and instructor at the MIT MediaLab, explores another area that exemplifies this shift. On his book "Enchanted Objects", Rose (2014) examines the idea that there is a set of objects that emerge from "six perennial human fantasies or drives: for omniscience, telepathy, safekeeping, immortality, teleportation, and expression". In his description, "enchanted objects start as ordinary things … augmented and enhanced through the use of emerging technologies – sensors, actuators, wireless connections, and embedded processing – so it becomes extraordinary" (Rose, 2014). In such direction, highly related to the Internet of Things (IoT), to design becomes to create ecologies, systems of systems that evolve and behave in biological terms. It is related to blurring the boundaries between the physical, digital and biological spaces.

These are some of the many possible examples of the type of developments already having a presence in our quotidian reality. Designers have to take an active role in these projects, to avoid the situation described by Cooper (2004), that confronted with a series of crossing scenarios (a computer with an airplane, a computer with a camera, a computer with an alarm clock, a computer with a car, a computer with a bank) noted that "there is a tremendous difference between designing for *function* and designing for *humans*" and "asking engineers to fix the problem is like asking the fox to solve the henhouse security problem".

It can be said that we will see more ideas in these lines happening in the near future, considering that some of these technological forces are part of what Kelly (2016) describes as "the inevitable".

4. The Fourth Industrial Revolution and the inevitable

The industrial revolution, a constant process of changes that started in the eighteenth century, had been characterised as presenting different phases. Some authors as Rifkin (2013) had noted that internet technologies and renewable energy "merge to create a powerful new infrastructure for a Third Industrial Revolution", while others as Schwab (2016) indicate "the Third used electronics and information technology to automate production" and "now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital and biological spheres". As Prisecaru (2016) notes, "whether it is or not the third or four industrial revolution, this new cycle is based on Internet and green energies, the first allowing easy access to information and easy trade for goods and services and the latest diminishing energy impact on the environment". It is clear that the elements present in the discussion are quite the same.

The profound impact that the Internet had on the world at large is still in an early stage and our societies will see more profound changes in the upcoming years than those experimented in the recent past. Notions behind this networked structure are giving the foundational basement to a movement that will change the infrastructure of energy, from fossil fuels to renewables, transforming the buildings into green microplants to collect renewable energies, adding storage capabilities, using the technology of the Internet to transform the electricity network into an Internet of Energy and passing this into electric vehicles and fuel cells, "which may buy and sell green electricity on a smart, continental, interactive grid" (Prisecaru, 2016). This notion is very much related to the previously described paradigm of "computers as infrastructure" (Hinman, 2011).

In recent debates in international forums such as the Davos meeting of the World Economic Forum held in 2016, ideas about the Fourth Industrial Revolution, introduced by the WEF Chairman Klaus Schwab, have been the central point of the discussion. Particularly, when it is considered that the Internet of Things (IoT), with its billions of devices interconnected, "will transform the world enhancing the labour productivity, making transport more efficient diminishing the energy needs, supporting dealing more effectively with climate change" (Prisecaru, 2016). In this case, this concept can be related to the computer paradigm that presents "computers as organic material" (Hinman, 2011).

As this process presents a "gradual release of labor force from physical activity and mental efforts afterwards in favor of more striking creativity" (Prisecaru, 2016), the role of a kind of design not locked to the idea of form-giving would be relevant, particularly considering the passage from a mechanical-object ethos to an organic-systems ethos explained by Dubberly (2008).

These concepts have been well described by Kevin Kelly, an American author that has been writing about technology and the future for several decades. On his last book, "The inevitable", Kelly explains twelve forces related to technology that will shape our future in the next thirty years. To describe this process, he uses twelve *present participles*, "the grammatical form that conveys *continuous action*" (Kelly, 2016), as this is related to a constant flux that "means more than simply 'things will be different.' It means processes – the engines of flux – are now more important than products" (Kelly, 2016). As we have argued in this article, designers will be less related to products and form giving to be more related to organic systems in constant flux. These ideas are clearly related to the aforesaid notions of design in the age of biology (Dubberly, 2008) and to the blur of the physical, digital and biological spheres, characterised as the Fourth Industrial Revolution (Schwab, 2016). Kelly employs these actions – Becoming, Cognifying, Flowing, Screening, Accessing, Sharing, Filtering, Remixing, Interacting, Tracking, Questioning and Beginning – explaining that they all are overlapping forces. They are the result of a process where "the strong tides that shaped digital technologies for the past 30 years will continue to expand and harden in the next 30 years" (Kelly, 2016). As such, "in the intangible digital realm, nothing is static or fixed. Everything is becoming" (Kelly, 2016).

5. Conclusions

Throughout this paper, I argue that there is a strong correlation between the software revolution explained by Andreessen (2011), the computer paradigms framework proposed by Verplank and Moggridge and expanded by Hinman (2011), the four orders of design proposed by Buchanan (2001), the notion of the age of biology unfolded by Dubberly (2008), the ideas presented by Krippendorf (2007), Glanville (2007, 2015), or Dubberly and Pangaro (2015a, 2015b) about the correlation between design and cybernetics, the different phases of the Industrial Revolution reported by Schwab (2016) and the forces that Kelly (2016) presented to us as the inevitable. These correlations can create enough momentum to produce a significant change in the nature of design.

The British design theoretician Bruce Archer, in the foreword of Klaus Krippendorff's book "The Semantic Turn", explains that "after the design profession embraced Sullivan's 1896 principle, *Form Follows Function*, the celebration of mass producible forms by the Bauhaus in the 1920s; the affectation of 'streamlining' adopted when design aligned itself with marketing in the 1930s; the influence of operations research in the late 1940s; the practice of minimalism by the Hochschule für Gestaltung (HfG) at Ulm in the 1950s and 1960s; the predominance of the systems approach in the 1970s; and the concern with concurrent engineering in the 1980s and 1990s are at best advances in design thinking that pale by comparison to the paradigm shift in design we are now witnessing" (Archer in Krippendorff, 2006). Krippendorff (2006) explains, under the postulate that "design is making sense of things", that "design has to shift gears from shaping the appearance of mechanical products that industry is equipped to manufacture to conceptualizing artefacts, material or social, that have a chance of meaning something to their users, that aid larger communities, and that support a society that is in the process of reconstructing itself in unprecedented ways and at record speeds".

According to Manzini (2015), a hundred years ago the practice of industrial and graphic design emerge in the context of a "technological innovation and industrial development". In a new century, design could become the new culture and practice needed in a context where social innovation has the potential to change the world. There is a clear need to change and become a widespread activity, "permeating the multiple nodes of the unprecedented sociotechnical networks in which we all live and operate" (Manzini, 2015).

The Fourth Industrial Revolution, with the amalgamation of the physical, digital and biological spheres, presents a crisis to otherwise stable areas of design practice. In the Chinese language, the sign for "crisis" (危机) comprises two meanings: danger and opportunity. The discipline of design particularly as it has developed during the twentieth century, confronted with the crisis created by the Fourth Industrial Revolution, has the possibility of embracing a process of change and mutate again.

Leaving along different contextual situations, there will certainly be professionals – "artificial organ designers", "cybernetic directors" or maybe "fusionist" ("The Most Important Design Jobs Of The Future," n.d.) – in charge of the three characteristics of design that, as Glanville (2015) explained, Vitruvius left for us: *firmitas* (well constructed), *utilitas* (functional) and *venustas* (delightful).

References

Andreessen, M. (2011, August 20). Why Software Is Eating The World. *Wall Street Journal*. Retrieved from http://www.wsj.com/articles/SB10001424053111903480904576512250915629460

Banathy, B. H. (1996). *Designing social systems in a changing world*. Retrieved from http://dx.doi.org/10.1007/978-1-4757-9981-1

Buchanan, R. (2001). Design Research and the New Learning. *Design Issues*, *17*(Number 4).

Cooper, A. (2004). *The inmates are running the asylum*. Indianapolis, IN: Sams.

Dubberly, H. (2008). ON MODELING Design in the age of biology: shifting from a mechanical-object ethos to an organic-systems ethos. *Interactions*, *15*(5), 35–41.

Dubberly, H., & Pangaro, P. (2015a). Cybernetics and Design: Conversations for Action. *Cybernetics and Human Knowing*, *22*(nos. 2-3), 73–82.

Dubberly, H., & Pangaro, P. (2015b). How cybernetics connects computing, counterculture, and design. *Hippie Modernism: The Struggle for Utopia. Walker Art Center, Minneapolis MN*, 1–12.

Ebenreuter, N. (2007). The dynamics of design. *Kybernetes*, *36*(9/10), 1318–1328. https://doi.org/10.1108/03684920710827328

Glanville, R. (2007). Try again. Fail again. Fail better: the cybernetics in design and the design in cybernetics. *Kybernetes*, *36*(9/10), 1173–1206. https://doi.org/10.1108/03684920710827238

Glanville, R. (2015). How Design and Cybernetics Reflect Each Other. Retrieved from http://systemic-design.net/wp-content/uploads/2014/08/Ranulph_Glanville.pdf

Hinman, R. (2011, January 2). Emergent Computing Paradigms. Retrieved from http://rosenfeldmedia.com/the-mobile-frontier/emergent-computing-paradigms/

Kelly, K. (2016). *The inevitable: understanding the 12 technological forces that will shape our future*. New York, NY, USA: Viking Press.

Krippendorff, K. (2006). *The semantic turn: a new foundation for design*. Boca Raton: CRC/Taylor & Francis.

Krippendorff, K. (2007). The cybernetics of design and the design of cybernetics. *Kybernetes*, *36*(9/10), 1381–1392. https://doi.org/10.1108/03684920710827364

Manzini, E. (2015). *Design, when everybody designs: an introduction to design for social innovation*. Cambridge, Massachusetts: The MIT Press.

Prisecaru, P. (2016). Challenges of the Fourth Industrial Revolution. *Knowledge Horizons. Economics*, *8*(1), 57.

Project Dreamcatcher | Autodesk Research. (n.d.). Retrieved November 27, 2016, from https://autodeskresearch.com/projects/dreamcatcher

Rifkin, J. (2013). *The third industrial revolution: how lateral power is transforming energy, the economy, and the world* (1st Palgrav Macmillan paperback ed). Basingstoke: Palgrave Macmillan.

Rinker, D. (2003). “Industrial Design is not an art” – Tomás Maldonado’s Contribution to the Creation of a New Professional Identity. In *Ulmer Modelle – Modelle Nach Ulm*. Ostfildern: Hatje Cantz.

Rose, D. (2014). *Enchanted objects: design, human desire, and the Internet of things* (First Scribner hardcover edition). New York, NY: Scribner.

Schwab, K. (2016). The fourth industrial revolution. World Economic Forum Geneva. Retrieved from https://foreignaffairs.org/articles/2015-12-12/fourth-industrial-revolution

The Most Important Design Jobs Of The Future. (n.d.). Retrieved January 20, 2016, from http://www.fastcodesign.com/3054433/design-moves/the-most-important-design-jobs-of-the-future

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