Design and Make: Translations between the Imagined, the Perceived and the Executed

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ABSTRACT
According to Schön (1987), design is a form of artistry and making, where learning about a specific topic or design emerges through actions (conscious and unconscious) and heuristics. The designer learns how to design by knowing and 'reflecting in action', reinterpreting and re-elaborating actions in the particular moment where the act of design takes place (Schön, 1987). This allows the emergence of not only new meanings and coherences, but also reason and knowledge about the creative act. This article presents the optimistic perspective of early CAD proponents in the early 60s that, supported by cybernetic and Artificial Intelligence theories, had as main goal the development of 'creative enhancers'. This vision is contrasted to the contemporary digital design scenario, discussing the relevance, pertinence and current use of the digital towards the material. Finally, it reveals key aspects of the myriad translations between the imagined, the perceived and the executed, identifying problems and new alternatives for the creative use of what today is ubiquitous and generic in terms of skills available for architects.

THE BEGINNING OF CAD: THE SWEET PROMISE OF THE CREATIVE ENHANCER

In the beginning of the CAD era, Human-Computer Interaction became a central topic for many researchers, who under the paradigm of Artificial Intelligence (Figure 2, p. 43) sought the development of new intelligent systems and interfaces to complement and augment the design enterprise. According to Bazjanac (1975), the use of the computer as a tool for design was taken on consideration by many architects mainly because of the 'sweet promises' made by the upholders of Computer Aided Design, which claimed that computers will 'free' designers from distracting and tedious activities to allow them to spend more time in the design itself. Furthermore, the use of computer-aided models would help designers to predict performance of designs and also accumulate experience and knowledge from the designer, which could be available anytime for new projects (Bazjanac, 1975).

Nonetheless, many of these promises made during the 1960s turned into disappointment and skepticism from early adopters of these technologies after some years, mainly because they realized that this type of intelligence was based on assumptions and hypothetical models translated from the engineering to the architectural world. In addition, while first computer-engineering models were based on procedures and rules that had to deal with numbers and mainly data processing to find a solution, the computer-architectural model had to deal with aspects of uncertainty very difficult to describe explicitly. As Milne asserts, this moment of innovation "can be described as sudden and apparently spontaneous reorganization of previously dissimilar elements into an integrated whole, which the designer believes is different from everything else he has known before" (1975: 33).

In Reflections on Computer Aids to Design and Architecture, *a collection of writings about the first decade of CAD, it is clear that beyond implementation limitations such as high cost of equipment or the lack of more advanced technologies, the overall claim was that computers were not being used in augmenting the design process but instead in mechanical, structural and accounting tasks (Negroponte, 1975). In addition to the 'lack of technology', many of the disappointments that emerged were also related to the incorrect assumption that design was some sort of information processing task (Milne, 1975). Moreover, because computers were fast and efficient in information processing tasks, many of the promises of the early CAD implementations were focused on augmenting the design process by helping designers with tedious tasks such as documentation, project organization or quantity take-offs.*

The idealization of the computer as an equivalent to the human brain and the anthropomorphization of the computer as a partner or surrogate (Negroponte, *1975) was present in many of the projects developed in the first CAD era. As a consequence, this led after many years to disappointments in relation to how current technologies were insufficient to fulfill the early promises and goals proposed by his authors (Negroponte, 1975). The predictions of computers as machines that in the future would surpass the limits of human intelligence and creativity were rapidly replaced by the mere hope in future developments in the area of Artificial Intelligence that would make the enterprise of augmented design through computers possible.*

Some conclusions, according to many authors in the book, were that many of the early promises of CAD were based on representational models of an idealized and mechanized intelligence inspired by AI leaders – such as Marvin Minsky and Gordon Pask – that was impossible to achieve at that time (Negroponte, 1975). According to Coons, "the creation of an idea, or a design, or an invention is really a learning process" that is reached by introspection, experience and association of ideas (Coons, 1975: 28). Moreover, the designer has to "teach himself, and this process cannot be traced explicitly even in retrospect" (Coons, 1975: 28). Thus, the idea of this super intelligence or meta-algorithm to create processes for design was at the moment already known as impossible despite the efforts for constructing these kind of heuristics (Coons, 1975).

Despite the shortcomings and difficulties identified in the first years of CAD implementations, the idea of design as a creative and cognitive process was present in many of the author's contributions to Negroponte's book. The concept of design as a process by which 'innovation' emerges (Milne, 1975), had more relation to a problem of interface between designer and machine that somehow was obscured or pushed aside by the optimistic and misleading promises of CAD proponents and the constant effort to frame design as a set of mechanical procedures and rules. Many of the most successful implementations of CAD related to design and creativity presented in Negroponte's book were the ones related to projects focused in the communication between designer and machine through bodily and perceptual engagement with the designs produced.

As an example, HUNCH (Figure 3, p. 44), a project developed by James Taggart inside the Architecture Machine Group at MIT, was a computational tool that engaged a form of interaction in which the system integrated the creative power of the designer with the computational power of the computer. Negroponte writes:

> *Faithfully records wobbly lines and crooked corners in anticipation of drawing high-level inferences (...). The goal of HUNCH is to allow a user to be as graphically freewheeling, equivocal, and inaccurate as he would be with a human partner; thus the system is compatible with any degree of formalization of the user's own idea (1975: 65).*

Moreover, the system used a stylus as input device, which captured sketching from the user and transformed this input into a digital visual representation (lines or points). The computer interpreted user's input and returned a shape that corresponded to the initial creative intentions of the designer. The logic of the project was based on the combination of the creative power of the designer and the processing power of the computer to store information and process it at a higher level to propose alternatives to design intentions.

Nonetheless, according to Sutherland, the major shortcoming in the early implementations of interactive digital tools such as SKETCHPAD and HUNCH was one related to the antithetical nature of human brain and the computer. Moreover, it was clear that beside the apparent freedom delivered by the interaction between designer and machine to produce a drawing, "an ordinary draftsman is unconcerned with the structure of his drawing material (...). The draftman is concerned principally with the drawings as a representation of the evolving design" (1975: 75). Furthermore, Sutherland asserts that the outcomes form SKETCHPAD were something totally different from what was expected from a computer-produced drawing, which "is dependent upon the topological and geometric structure built up in the computer memory as a result of drawing operations" (1975: 75). It was clear to Sutherland, and later to Negroponte and Taggart, that a computational approach to design – as an intelligent creative enhancer – was difficult to implement because of the differences between the constant evolving logic of the human brain and the structured logic of the computer that demonstrated its incapability to grasp the designer's intentions.

One interesting conclusion about the early implementations of technology in design is that many of the promises were based upon the beliefs and aspirations of those who conceived computers as cognitive machines, which by the implementation of Artificial Intelligence would augment the design process. Nonetheless, the constant efforts of early CAD proponents to frame design into a representational and generic *model for production (Figure 4, p. 46), soon found themselves in contradiction to aspects of the creative process that cannot be codified as a meta-algorithm. Furthermore, it was a general conclusion that design was not an enterprise related to automated information processes or translating the analog into digital, but one related to a much more complex problem, which is hard to define as a set of static rules and symbolic representations.*

DIGITAL DESIGN REVOLUTION?

More than 50 years after the first CAD implementations, many of the questions emerged from the implementation of computers in design, which have been discussed over the past decade, still remain as major concerns in the design field. Furthermore, the discourse of digital design during the 1990s was framed by a blending of theoretical, philosophical, methodological, technical and professional origin (Oxman, 2006). As Kolarevic asserted, "digital technologies are changing architectural practices in ways that few were able to anticipate just a decade ago" (2003: 3). This optimistic perspective about the future of architecture and design, which can be related to the promises and aspirations of technological improvements expected by early CAD adopters, was oriented towards an initial understanding of the geometrical possibilities and limits of digital tools in terms of experimentation and research of geometries. Nonetheless, the fascination for new forms of representation and the emergence of novel geometries did not overcome the initial concerns related to design augmentation in terms of creativity. In addition, the optimistic perspective of proponents of this new digital paradigm replaced the concerns and disappointments of the 1970s.

Furthermore, by borrowing technology from aeronautic and automotive industries, architects started talking about a 'digital continuum' (Kolarevic, 2003) from design to construction by which architects finally were able to expand the boundaries of architecture to unimagined limits. Moreover, thorough CAD-CAM processes, architects were able to surpass the limits of the digital into the realm of the physical. On the other hand, many of the assumptions and breakthroughs derived from the digital revolution in design and architecture since the 1990s focused on formal concerns (What can I design with a computer?) and later on the materialization of those forms (How can I build it?). Hence, one question that remains unanswered is how can designers interact with digital technologies in a more integrated way to generate better designs?

Under the paradigm of information-driven processes, the concerns related to creativity through technology were justified through emergent systems derived from the use of algorithmic logics and parameterization of the architectural form and its relations with the environment through data, and recently by the advances in CAM processes. Moreover, questions related to design augmentation through technology and how architects can interact with machines to generate "better designs" using technology has been obscured. As Andrews (2010) asserts, parametric design is shielded by rhetorical structures to defend the lack of a mature discourse about space and design. Moreover, Andrews argues that because of the "lack of attention to contemporary developments in the modeling of the relations between individuals and their environments" (2010: 151), the parametric paradigm is in crisis. The current model of 'digital design' relies on processes based on representations that respond only to its inner logics. After decades since the emergence of CAD, the goal of design augmentation was never accomplished in the way its proponents intended to. Furthermore, it is possible to argue that the main use of digital tools for design is the one focused on the production and optimization stages of design. At the same time, it is valid to assert that the more 'experimental' group of digital practitioners is shielded under a discursive rhetoric about complexity and artificial behavior based in representational procedures, which show interesting emergent behaviors but not necessarily focuses on the creative and cognitive parts of the process which, in the case of digital design and fabrication, happen before (the ideation), and after (the observed) but not during (the execution).

Nonetheless, this model of interaction seems to neglect new ways of interfacing with machines to engage creativity by relying only in traditional interfaces such as mice and keyboards to generate feedback or establish a dialog with a computer. In addition, if the aspect of materialization is added to the process, the question "How can architects interface with new technologies in software and hardware to engage creativity and cognition in early design stages?" takes more relevance.

FAB 2.0: INSTANT TRANSLATIONS BETWEEN THE IMAGINED, THE PERCEIVED AND THE EXECUTED.

According to Schön (1987), design is a form of artistry and making, where learning about a specific topic or design emerges through actions (conscious and unconscious) and exploration. The designer learns how to design *by knowing and reflecting in action, reinterpreting and re-elaborating actions in the particular moment where the act of design takes place, producing new meanings and coherence (Schön, 1987). Furthermore, this suggests that every creative process is accompanied with a material representation that is a by-product of a constant interaction with our environment. By interacting with our surrounding objects, we learn and produce meaning and therefore reason. As Robinson (2013) argues, reason, that is the power of the mind to think, understand, and form judgments by a process of logic, is actually a proprioceptive circulation of the relationship between mind body and things around us.*

Digital tools (e.g. the computer, 3d printer, laser cutter, CNC milling machine) are commonly used to perform a task (a set of prescribed rules), which can be coded on an algorithm or defined inside a parametric model as a set of topological relations. In contrast, if design is considered as an activity, moreover, a cognitive one, it can be referred as "the way people actually realize their tasks on a cognitive level" (Visser, 2006: 28) by using knowledge, information and tools. Taking this into consideration, the problem identified is the one related to the use of digital tools (CAD-CAM) as task performing machines instead of activity performing machines. In other words, we program our machines to perform several tasks; however, we don't interact with machines to perform an activity in the way Visser claims.

If we consider that design is 'something that we do' which is related to our unique human condition as creative individuals, one can argue that 'design and making' is related to how we manifest and impress that uniqueness into our surrounding environment. Hence, it is valid to assert, beyond the aspirations of early CAD proponents, the possibility to impress that uniqueness through the use of software and digital fabrication machines is still limited. Moreover, because the machine is the one that determines the way something will be made according to predetermined structured procedures (e.g. a Python script, a Gcode, a Grasshopper definition), the actual process of making, exploring and having feedback through seeing and doing – as in analog processes such as drawing or crafting – is insufficient. The question still remains, how to bridge design and making dichotomy through the use of technology engaging architects into more creative processes? Moreover, how should the interaction between these antithetical worlds – the humans and machines – happen in order to generate more insightful and creative design processes not only to represent or optimize, but also to think and learn?

Maybe the answer is that to solve computationally the challenging sensory and aesthetic problems of 'creating' through machines in a similar way to analog processes, we must embrace the concept of interaction. Finally, we must move towards more reciprocal processes by integrating digital tools, not only by focusing in the creation of plans for action/representation, but on models for interaction embracing the perceptual and actional aspects of creation. This could help to reconcile 'design and making' as an embodied activity where the imagined, the perceived and the executed transcend the ever-present tension between historical precedents and the contingency of the moment, to impress our uniqueness onto the material world through the digital every time as something new and unseen. m

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