Making Mistakes

Embedding errors in Computational Design

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Abstract. Often overlooked in the process of developing an idea– like an imprecise drawing or a poorly built cardboard model- it can be considered that errors are the harbinger of possible future novel work not only by seeing but also making things in a different way every time as a learning process. Moreover, the quality of something original is hard -if not impossible- to determine because it comprises the definition of something into a fixed -hence unoriginal- structure beforehand. Moreover, making mistakes every time we do things enables our capacity to experience insight. Therefore, if the original emerges by the interplay of action and perception, then our capacity for not only seeing but also making in a new and unique way enables the development of a personal style or autographic practice. How the digital can enable our capacity to make mistakes in order to develop original work and a personal style?

Keywords: Digital Design, computational making, artificial intelligence, computational design, digital fabrication.

1 Introduction

Ubiquitous computation and its inexorable use in contemporary architectural design practice raises questions and concerns in relation to how creativity is affected either in a good or a bad way. As general as this assertion might sound, the use of digital design technologies has been a constant topic of discussion as many promises have been bestowed to their use in different times since the invention of Computer Aided Design (CAD) in the early 60s. In addition, denoted as the harbinger of 'better', 'smarter' and 'faster' ways of 'doing what designers do' digital technologies have undergone a constant transformation in the way they have been applied, considered and taught over the years. Moreover, in the last four or five years, questions such as How can machines think creatively? have revived some of the old aspirations and promises of early CAD implementations from the early 1960s. In addition, with the advent and widespread use of machine and deep learning techniques in everyday life, today design is facing - at least in theory- the addition of another 'layer of technology and information' on top of its inherent complexity as a creative endeavor. Therefore, if Minsky's prediction (Wright-Steenson, 2016. ch.1,p.13) becomes true and machines become finally smarter -being capable of outperforming humans- the old debate about the place of creativity, novelty, originality and delight in the emergence of new things is more present than ever. Moreover, this debate confronts two positions between "creative augmentation by automation" versus a more traditional position that defends creativity as unique human characteristic.

If the discussion has inherited some of the same questions and concerns from the advent of CAD, it is valid to frame the discussion in terms of process versus product. In this regard, if the purpose of using technology in design is to eliminate or reduce the amount of complexity in the process, a clear separation between ideation and execution emerges. By eliminating the 'tedious' from the process, so that the representation and execution stages of design can be discretized and optimized as 'error free' processes, the aspiration is to focus on the idea, a final image, a product, and with that the neglect of reasoning in a synesthetic way. In this regard, synesthetic reasoning is the capacity of feeling the material in the conjunction of sensory apprehension and reasoned analysis where the feeling of doing something emerges as an integral process of producing knowledge through all the senses (Paxson, p.118). Moreover, if design is a way of making (Knight, 2015) then making is involved with the production of original 'things' by impressing our uniqueness in our surrounding environment. Hence, the quality of something 'original' is hard -if not impossible- to define because it comprises the definition of something into a fixed -hence unoriginal- structure (Bohm, 1998). As Bohm asserts, the only way to really learn about something new is by trying new things and making mistakes (1998, p6). Furthermore, often overlooked in the process of developing an idea– like an imprecise drawing or a poorly built cardboard model- it can be considered that error is the harbinger of possible future novel work not only by seeing but also making things in a different way every time as a learning process. Making mistakes every time we do things enables our capacity to experience insight. Hence, if the original emerges by the interplay of action and perception, then our capacity for not only seeing but also making in a new and unique way enables the development of a personal style or autographic practice.

This paper reflects about mistakes in the design process that aim to integrate designer's errors as part of the digital design and fabrication process. This paper discusses about the tension between autographic vs allographic (Goodman, 1968) work in digital design, by considering the production of designs as a continuous translation between what a designer perceives, imagines and executes developing what we call 'technique', 'particular sensibility' or 'style' not only about what we do or how we do it, but also 'when' and 'where' we do it. Hence, this paper focuses on discussing the concept of error - or what we associate as a 'mistake'- during the repetition of actions that give origin to original designs. In this regard, the opposition between iconicity vs indexicality plays a fundamental role to explain how digital design is no different than crafts and general arts because it obeys to a particular contingency that challenges the current practice through technologies as the mere application of predefined structures.

2 The "augmentation by automation" enterprise: The sweet promise of the creative enhancer.

The use of digital technology was not new in the field of architectural design with a few examples of successful use during the 1950s[1]. Slowly, computers attracted attention of architects as the practice of the discipline became more complex with the addition of new layers of information, systems and actors to projects. As Wright-Steenson writes *"For architects this meant changes in both the nature of their practice and what they designed. They needed to interface with more systems and handle problems of greater complexity"* (2017, ch1,p9) meaning that building's designs and architects were a part of a bigger network among different actors and fields. As a consequence, not only the designed artifact was a topic of concern inside the field but the new dynamics about how the designed artifact was produced. It wasn't until the invention of Computer Aided Design (CAD) that architects turned to computers as systems that could help to cope with the aforementioned complexity of new architectural projects. As Wright-Steenson(2016) writes "*just as architects turned to computers, engineers and programmers also turned to architecture ... computation, cybernetics and AI researchers reached toward architecture"*(ch1, p10). She explains how through the symbiotic collaboration among these disciplines, architects sought the possibility of creating new workflows for the demanding complexity of design. Also, this allowed researchers in applying their emergent work to obtain tangible results. As a result, in the beginning of the CAD era, Human Computer Interaction (HCI) became a central topic for architectural and engineering researchers, who under the paradigm of cybernetics and artificial intelligence, sought the development of new intelligent systems and interfaces to complement or augment their design workflows. Moreover, Douglas Engelbart's vision of a 'clerk' system considered that because of its information processing capacity, computers could handle anything from mathematical to symbolic problems that require the use of symbolized concepts in direct favor of

[1] Buildings such as Utzon's Opera house in Sidney is one of the first examples of the use of computers in the construction of complex shapes.

architects (Engelbart, 1962, p.5) . In addition, according to Baznajac (1975), the use of computers as a tool for design was taken into 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. Baznajak's addressed exactly the vision of intelligent systems capable of processing large amount of information, capable of dealing with great complexity but most of all, systems that could understand, learn and are capable of embedding designer's knowledge into the system. In addition, this promise was supported by lead researchers in the field of AI such as Marvin minks who predicted by the end of the century computers embedded with a superior intelligence than humans.

To Minsky, by the addition of sensors and mechanical capacities computers could not only create but assemble things - in this case buildings- faster and cheaper than humans. In Minsky's words "*Contractors will have to face automation in construction just as architects will have to face automation of design. Eventually, computers will evolve formidable creative capacity"* (as cited in Writgh-Steenson, 2016. ch.1, p.13). Minsky's prediction became in part a reality installing as one of the main concerns the discussion about the use of computers rendering architects and designers in general obsolete (Wright Steenson, 2016, ch1, p14). Questions about computers developing creative capacities were installed in the agenda of various researchers during the 1960s in places like MIT. Nevertheless, the promise made during the 1960s turned into disappointment and skepticism from early adopters of these technologies after some years, mainly because it came to realization that this type of 'creative intelligence' was based on assumptions and hypothetical models translated from the engineering to the architectural world. This implies that the common belief by the time was that intelligence and creativity were related to problems about information and symbolic processing instead out more embodied, abstract or even obscured human endeavors. Nevertheless, Minsky's predictions of computers as machines that in the future would surpass human limits of intelligence and creativity were rapidly replaced by the mere hope that in the future developments in the area of artificial intelligence would make the enterprise of augmented design through computers possible… we are still waiting.

According to Steve Coons - one of the most important CAD proponents- *"the creation of an idea or a design or an invention is really a learning process. that is, by introspection, experience and association of ideas"* (Coons, 1975, p.28). The designer *"teaches himself, and in the process cannot be traced explicitly even in retrospect"* (Coons, 1975, p28). The idea of super a super intelligence or meta-algorithm to create processes for design was at the moment already know as impossible despite the efforts for constructing that kind of heuristics. These conclusions are tightly related to what more contemporary authors such as Collins refer as 'tacit knowledge' which is the ability to make something not communicated with words or any type of formalization (motor skills metaphor), and the impossibility of pre define how conventions should apply in order to execute predefined rules (rule regress model). In collins words, experimental skills -assuming that design is one- are impossible to transmit to formulaic ones (Collins, 2001, p107).

This revision of the early vision CAD origin leaves two important ideas that I would like to discuss along the following parts of this paper. The first is related to the constant tension between an abstract understanding of design -as a unique creative human endeavor that must remain untouched- in opposition to the engineering vision of design as an 'error free' information processing task -that could be fully automated and optimized to reduce complexity of building design. The second idea is the one related to the development of interfaces suitable to carry along with the promise of 'augmentation by automation' and ensure a fluid symbiosis between man and a the so-called intelligent machine. Finally, what seemed to be the boundary between those two positions about design automation was the definition of creativity and its importance in the design endeavor (Cardoso, 2015).

2.1 Discretizing and optimizing knowledge: Separating idea, representation and design execution.

One conclusion about technology implementations in design was 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. As a consequence, architectural design practice through technology began to show a clear separation between ideation and representation where the former was considered in the domain of the discretizable -as a meta algorithm embedded in a machine as 'knowledge'- while the latter in the domain of the optimizable -as error free information processing related to the tedious and complex part of the design enterprise. This separation emerged from the failure of the creative augmentation by automation when applied for creative endeavors but show very fruitful when applied to representation and information processing tasks. According to Cardoso (2015), the unique theoretical debate that took place after the invention of CAD, and specifically in the CAD project, unfolded two visions about the role of computers in design, one -exemplified by Douglas Ross (p.53) envisioning computers as universal tools for fully automated design -taking care of what was believed as discretizable- and the other one, exemplified by Steve Coons, who imagined computers as “slaves or partners” of the human designer -taking care of the *tedious* and the *optimizable*. In this regard, Coons vision perfectly illustrates the perspective of many of early CAD upholders about creativity, ideation and invention being an inherent human characteristic. As Milne asserts, the moment of insight or innovation that happens in a creative process such as design *“can be described as a sudden and apparently spontaneous re organization of previously dissimilar elements into an integrated whole, which the designer believes is different from everything else he has known before”* (1975, p33). Finally, the consequences of CAD were not only a separation between ideation and representation, but the disembodiment of design. The physical materialization of design was denoted as a clear stage that occur as a consequence of the development an idea -the creative part of design- and later of its representation.

2.3 A new promise, same conflict.

The contraposition between design as discretizable and optimizable versus design as something uncertain, free, ambiguous and abstract determined the clear distinction of the development of an idea, its representation and finally its execution. This trichotomy was reinforced even more with the further development of CAD systems where, as Forrest mentions: *“the D (in CAD) became not design but drafting…”* (as cited in Cardoso, 2015, p.85).

The development of CAD in the following decades was reoriented toward production and industry urgencies and to respond to users’ pragmatic needs (Cardoso, 2015, p86). Nevertheless, along with the development of faster and more capable software -in terms of information processing- during the 1980s and 1990s the debate between creative empowerment through technology versus project management and information processing continued as more layers of complexity were into designs in the same way architecture experienced during the 1960s[2]. Technology in design, by being developed mainly as a processing information system for optimum management and product manufacturing, deviated from the original purpose of augmentation. Nevertheless, as we can see today, personal computing and consumer digital fabrication technologies revived the dream and promise of augmented design and creative empowerment for designers.

[2] Modern architecture project consider at least 3 main categories for dealing with the complexity in buildings when developed using technology. In BIM, apart from the architectural design, MEP or Mechanical, Plumbing and Electrical comprises the main systems that must be considered in the modeling of a project.

Parametric design technologies, building information modeling (BIM), the proliferation of digital fabrication machines, the advent of the maker movement, breakthroughs in the field of AI -with the development of powerful machine learning and deep learning technologies- have captivated new generations of experimental designers. Nevertheless, the trichotomy between idea, representation and execution is still present. In addition, fragmented practices of design make evident the separation between object *being made* and *object to be made*. Whereas the former takes into account the development of ideas in the making, prone to error, imprecision, ambiguity and exploration, the latter -because its unfolding in separate stages- seeks to represent and therefore neglect imperfections, imprecision, infidelities and so on from the process. One might question, how both processes deal with the production of original creative work and therefore new knowledge about designs not only interns of the produced object but the retrospective process that gave origin to it. Whereas the *object being made* position take into account a free exploration of ways of making, the *object to be made* position focuses on the representation of fixed structures to produce an optimum error free result.

3 Digital design as a problem of iconicity vs indexicality.

Attending to Simon's scientific understanding of design as opposed to Schön's phenomenological view of design it is possible to understand the conflict between different definitions of design that are applicable to the inherited debate from the early 60s. While both Simon and Schön see design as the core of all professional training, they both compare practice and teaching of design to other professional fields. In the case of Simon (1988) the idea of design is closely related to problem solving and optimization, similar to statistical decision theory and management science. Moreover, in the presence of an inner and outer environment (alternatives of actions and parameters respectively) a designer can find ways not only to solve problems but to also formulate them. In contrast, 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 his actions in the particular moment where the act of design takes place, producing new meanings and coherence. Both perspectives illustrate somehow the initial conflict of understanding design as structured vs improvised practice. While to Simon, design is goal seeking, problem solving, optimizable, and classifiable, to Schön design is exploration, artistry, situated, and not fixed. By understanding the differences of two opposed but generalized positions about what design is, it is possible to understand design as an activity dealing with the production not of products, but of processes by which new knowledge emerge. Because a great deal of knowledge is tacit (Forsythe,1993, p49), we may not be aware of what we know or what we are doing when performing a task. What we say we are doing, think we are doing, and what we are observed to be doing are not always the same. Because of this, applying structure to knowledge would be a difficult (if possible) task. In addition, Schön states that *"problems of real world-practice do not present themselves to practitioners as well-formed structures."* (1987, p.4). Schön's ideas better relate to the Social Sciences view of knowledge (Forsythe, 1993, p.49) in that problems are "messy" and not "easily solvable", and if they were, it would not be by one solution. When each designer approaches a problem, she chooses and names the things she will notice. Through this naming and framing, she selects details to bring attention to and organizes the information according to her personal objectives giving coherence to the problem and establishing a direction to pursue. Depending on our disciplinary backgrounds, organizational roles, past histories, interests, and perspectives, Schön says, we frame situations differently (1987, p.4). With the varying possibilities of each situation, the hypothesis enforced here is that knowledge is not static or concrete. Hence, we can argue that the original debate inherited since the 60s is one related to a matter of iconicity versus indexicality.

Design is -as other disciplines that deal with creativity or with bringing new things into existence- a material process that responds to many contingent factors. Keane (2005, p.197) through his semiotic perspective of material things, criticizes the use of semiotics as pure meaning communication through symbols, that implies severe problems to understand materiality. He argues that the problem of treating objects as mere illustrations to communicate meaning is an error because privileges meaning -as something fixed- over actions. In this case, the relation to design comes when any effort to fix, verbalize and discretize the design process into structured symbolic representations, constrains the emergence of new knowledge. Design and its inherent materiality relate to a problem of indexicality, advocating for a more practical in contrast to a contemplative posture in relation to activities.

One conclusion about the iconicity vs indexicality view of design is that when situated closer to an engineering perspective, not only culture, history and contextual variables but also meaning are pushed aside. Moreover, with the advent and widespread use of machine and deep learning techniques in everyday life, design practice and arts in general are facing not only the addition of another *layer of technology and information* but another layer of structure. In this case, the use of AI into creative and material processes reinforce the biased and limited view of the world and knowledge as something structured and stable.

If the tendency is to believe that knowledge is fixed and that it can be *extracted* and can be *codified*, we establish that it is neither social nor cultural. We obliterate the option of new things coming into being by looking reality through a pinhole. If Minsky's prediction of intelligent machines for designing is the one reflected in current machine and deep learning techniques, the prediction falls short because it confuses knowledge production with pattern recognition usually in the form of a prediction - mostly in the form of images, reinforcing an occulocentric perspective of the world. The type of knowledge that machines show today emerges from the belief that *Big Data* is a contemporary form of universal oracle - that automated the process of what CS understands as knowledge elicitation. Moreover, contemporary AI in the form of machine and deep learning work based in a fundamental characteristic in which prediction accuracy responds to an optimum procedure of minimizing error by the use of loss functions. As seen before, if we take Simon's definition of design - as goal seeking and problem solving- the application of expert systems formalized as machine learning would suffice to automate the design process. However, we have seen that the intelligence that this type of machines use is based in a very narrow interpretation of reality based on a cognitivist approach where human activity is explained in terms of complex combinatorial.

If design is considered a process of creating new things by being in the world, it can be asserted that being is in the presence of material things beyond a cognitivist perspective where things can be reduced to pure mental representations. Therefore, design obeys to a concept of indexicality where the idea of "bundling" makes reference to the co presence of qualities, as one of the most important effects of materiality. It is asserted that qualities bundled in any object vary according to their salience, value, utility, and relevance across contexts. Finally, objects -with qualities- have the potential of resembling something every time anybody attends to them. It seems the idea of using technology in design it is in fact reduced to the distinction of icon vs index. While icon refers to object's qualities (passive, inert) index affirms that the object exists - although not what that thing is. Hence, knowledge elicitation is produced by being active in the world and with objects, by generating the assemblage, gathering, bundling that we find in Keane's semiotic ideology. Keane stresses that "the semiotic character of material things means that outcome is not settled, not that meanings are undetermined but that their semiotic orientation is in part toward unrealized -future- potential" (2005, p.188). Although not directly, the concept of bundling refers to an inherent characteristic of every creative endeavor. If design is 'something that we do' that is related to our unique human condition as creative individuals, so as *making* is related to how we manifest and impress that uniqueness into our surrounding environment , we can understand that it responds to a way of looking and attending to things always as something different

(Pinochet, 2005. p12). It is the indexical characteristic of design that allows a creator to produce new things and knowledge about how things emerge in the world. As denoted by Bohm (1980), knowledge is produced and transformed in thought. In addition, thought -in the movement of becoming- is the way knowledge achieves its actual and concrete existence, meaning it is essentially a material process (p.50). Finally, the argument is that design is a process of knowledge, situated, inherently material, undetermined, ambiguous and by therefore imprecise. The way it becomes something concrete is by designing, by acting and impressing our unique perspective based on how they resemble something else every time we attend to them, learning new things. This relates to Heidegger's '*begegnen*' (as cited in Dreyfuss, 1990, p.x) in which things encounter or "show up to us" as we act in the world which in the end relates to the his rejection of "explicitness" of thought stating that every decision is based in something not mastered (as cited in Dreyfuss, 1990 p.4).

3.1 Skill, gestures and the production of knowledge.

What finally emerges from the debate is that current design practices face a crucial moment where the use of technology in the production of a design seems unavoidable. In the making process, traditional methods for creation such as sketching, painting, folding, cutting and so on are commonly used, in the professional practice seems almost impossible to produce something using only analog methods. We rely on technology because of its multiple capacities for representing ideas in myriad ways. However, the conflict is that at the light of the problems that emerge from digital design practices such as the *'creative gap'*, the '*black box'* and the *'generic'* (Pinochet, 2016) the distance of a digital design with the materiality inherent to it, leaves very little space for improvisation. The dichotomy between ideation, representation and execution forces the engagement of the designer into a constant translation from idea to physical prototype, promoting the creation of plans for representation that leads to a disembodied process where the performative act of improvisation totally disappears. As mentioned before, the trichotomy inherited from the early CAD implementations into current digital design practices involve questions about the creative act of design in relation to how skill is redefined, therefore authorship and originality. Hence, the question that still remains is how design through technology can transcend the inherited trichotomy since the introduction of CAD to generate autographic -therefore original- work. As discussed, the goal of many researchers and theorists in relation to design and technology still start from questions such as How can machines think creatively? Nevertheless, if we attend to what Carr (2014) argues *"... when it comes to perform demanding tasks, whether with the brain or the body, computers are able to replicate our ends without replicating our means"* it seems that the production of the creative is related to questions about meaning, originality and personal knowledge. By considering Goodman´s distinction of arts (Goodman, 1968) it is possible to classify digital design and fabrication as an *Allographic* one, in which the generic outputs derived from a prescriptive set of rules can generate multiple reproductions -even without human intervention during the process- of a design. Therefore, one question where this paper expands is the one that inquiry in how design and making through the use of digital fabrication tools can transcend its *Allographic* nature into an *Autographic* one, where originality and uniqueness are tightly related to the actions that gave origin to it?

Skill, understood as the learned ability to do a process well (McCullough, 1996, p.3) can be argued to play a fundamental role in the creation of original arts. As denoted by McCullough, skill - mostly represented by the manual- involves sentience, personal worth and the development of an intimate relation with for example, tools (p.7). Furthermore, skill holds a direct relationship with what Polanyi (1967) called personal knowledge, in which informed guesses, hunches and imaginings are part of exploratory acts motivated by what he describes as 'passions', not necessarily stated in formal terms as he asserts *"we know more than we can tell"* (p.4). To Polanyi, a component of discovery is comprised in this type of knowledge. This process of discovery and knowing, exercises a personal judgement in relating evidence to an external reality, an aspect of which he is seeking to apprehend. The development of personal knowledge through practical activity refers to manual engagement with the world where the enaction of gestures play crucial role in the discovery of new things. Hence, it is possible to relate the act of design to the concept of contextual awareness and the idea of feeling the actions as opposed as thinking the actions. One perfect example of material engagement through skillful practice is the one defined by Paxson (2011) as synesthetic reasoning which is the capacity of feeling the material in the conjunction of sensory apprehension and reasoned analysis where the feeling of doing something emerges as an integral process of producing knowledge through all the senses (p.118).

4 From making gestures to making mistakes.

Gestures have the capacity of embracing- beyond mental and intermediate representations- the moment of acting and perceiving. According to Flusser (1991), a gesture could be defined as *"A movement of the body or a tool attached with the body, for which there is no satisfactory causal explanation"* (p.3). In addition, he suggests that a gesture is one "because it represents something, because it is concerned with a meaning" (p.4). This definition of gestures refers to how they are defined in relation to motion not only as an intention -which refers to a backwards understanding process that require to decode the movement in terms of its results and the causal explanation for it

- but with a meaning - which is related to a forward understanding of the unfolding processes, as Ingold (2008) calls, always in the making (p.3). In the cognitive science field, gestures emerge as the manifestation of a continued motor regulation in the action, perception and anticipation cycle. To Maldonato (2014), body movements - gestures- are the result of an interplay between anticipatory(feed-forward) and compensatory(feed-back) mechanisms by which humans' response to determined situations (p.59) not only by reaction but also by anticipation. The body uses feed-forward to prepare for action and feed-back to compensate that movement according to the sensory information coming from our multiple receptors (p.60). Moreover, the efficacy of this mechanisms as an active motor schema improves with experience (p. 60) through the use of what Maldonato calls *'Embodied action'* which is a "*set of sensorial and motor schemas and habits, acting as a system able to recall corporeal perceptions" (p.60).* One can argue that gestures and the uniqueness of them as manifestation of the self, are the result of a constant relationship between Action, Perception and Memory (which emerges from experience and learning).

The uniqueness of every gesture, can be explained by Schmidt's (1975) schema theory based in two concepts: The Generalized Motor Program (GMP) and the Motor Schema (Fig 26). While the GMP provides a motor pattern deposited in memory that possess different characteristics that are invariant in the desired gesture, the motor schema adjusts specific selected parameters of that motor response to adapt to the situational demands. Maldonato (2014) Asserts that because of the relationship of these internal mechanisms, the repetition of a movement - a gesture-will never be identical (p. 61) (fig4). Hence, the uniqueness of a gesture is tied with a component of originality. As asserted by Bohm, the quality of something *'original'* is hard -if not impossible- to define since it comprises the definition of something into a fixed -hence unoriginal-structure. Nevertheless, such originality can be explained from the human ability of learning new things by trial an error since we are children. As we grow, Bohm (1998) asserts, knowledge maintains a proportionally inverse relationship to the ability of seeing new things. This is produced because we are taught to gather knowledge in a more mechanical way, taking away real importance to perception by responding to a social convention that gives a bad connotation to the act of making mistakes (p.5). As Bohm finally asserts, the only way to really learn about something new is by trying new things and making mistakes (1998, p6). This suggest that mistakes are the harbinger of possible future novel work not only by seeing but also making things in a different way every time. Making mistakes every time we make things enable our capacity of experiencing insight. If the original emerges by the interplay of action and perception, it is valid to argue that the capacity of not only seeing making in a new and unique way refers to the development of a personal style or autographic practice.

Maybe the key to overcome the aforementioned trichotomy in digital design is by getting a better understanding of the tools we use and how we impress our uniqueness in the world through technology. The capacity of learning by doing, by being wrong and revealing new things as we make mistakes could be the key to the generation of more reciprocal models of computational making. While this paper has focused in the idea of insight as an unique human characteristic that is crucial to produce new original work, it is important to mention why this paper focuses in the idea of error as the mechanism by which humans can move on into new things. By using digital technologies for design, we lose the capacity of making mistakes and reflect about them in real time. The idea of making mistakes, errors, must not be confused with '*glitch*' or failures that could happen in the execution -for example- of a computer program. While glitches could be interesting mechanisms for producing unexpected emergent results, an error and the mistakes we produced when making something, refers to the synesthetic reasoning process of creation. In that sense, one interesting concept that could lead to a more reciprocal practice in design is the one of embedding. Embedding is a core concept for Shape grammars, a computational theory of shapes and the algebra behind them invented by George Stiny and James Gips in 1972. In shape grammars theory, creativity melds recursion and embedding to calculate in a visual way generating new designs as we see new things. To shape grammars design is about seeing and doing, nevertheless, as asserted by Knight (2015. p.978), they *"have promoted design as an activity that demands perceptual, active engagements with materials"*. If design is a kind of making as asserted by Knight (2015, p.965), the focus of the discussion gets closer to the differences that Pye (1968) establishes between the workmanship of certainty versus the workmanship of risk. While the former could be framed as analogous to what digital design is today, the latter could be framed as what design should become again in order to put back human into the equation. As Pye describes, in the workmanship of risk, the result is continually at risk during the process of making in which judgment, dexterity and care count as essential characteristics in the process (p.22).

Conclusions

As a reflection about the use of technology for design, this paper aims to trace from a historical perspective some of the problems inherited since the beginning of the CAD era that have a clear impact in today's digital design practice. How human uniqueness, history and culture are often obliterated from the design production due to the increasing homogenization of production methods. Our fascination for technological advances and their possible applications in computational design sometimes makes difficult the possibility to look back and reflect about the meaning of things we do. Furthermore, machine learning and its impact in the field of robotics, automation of design processes, and the myriad filters imposed to contemporary designers in the quest for the new and novel, make this topic of extreme relevance. If 'hello culture' is an invitation to devise this new cultural era in the intersection of architecture, engineering, arts and design in general, we must look how the human factor and its imprecisions along with the capacity of insight can bring a new cultural meaning to the things we do. Our capability of being imprecise, is tightly related to our capacity of generating original work. Furthermore, often overlooked in the process of making an idea– like an imprecise drawing or a poorly built cardboard model- making mistakes enable the generation of new things to see, reflect and learn by the production of an error. Maybe, at the light of more accessible and advanced technology in terms of inputs and outputs, we have an opportunity to bring back human into the design process by embedding what makes us different and unique.

This paper started by establishing the consequences of the introduction of CAD in architectural design that generated the separation between ideation, representation and execution. Derived by the constant tension between an engineering vs an artistic view of design, it was established that the debate was inherited throughout the years until present times. Moreover, it established that because of the emergence of this trichotomy, the design practice through technology became disembodied and fragmented as the designer has to go through a series of translations to go from idea to physical object. Furthermore, this installed the discussion in terms of how design through technology is understood under a new debate about iconicity or indexicality. In addition, where the former position accounts for a structured practice of the creative act, the latter accounts for a more performative one. Finally, related to the idea that creativity, original work and authorship emerge from reflective practice, synesthetic reasoning, risk-full workmanship or through the capacity of embedding by seeing and doing, this paper asserts that by embracing the capacity of being wrong, making mistakes and acknowledging errors, could lead to overcome the biased and fragmented practice of design through technology and to propose better computational models to generate original designs that responds to the contingent cultural factors that facilitate its emergence.

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