A Manifest for Digital Imperfection

Artistic style is an important aspect for creative practice. However giving away some computational control over digital design and fabrication is necessary in order to engage designers in a higher-risk practice that enhances attention, creative decision making, and product ownership.

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"Science is an endless search for truth. Any representation of reality we develop can be only partial. There is no finality, sometimes no single best representation. There is only deeper understanding, more revealing and enveloping representations."

—*Carl R. Woese* [1]

The very basis of the current computational paradigm is the assumption that analytic representation is key in developing practical systems to solve technical tasks. The foundations of computer science are rooted in discrete (and Boolean) mathematics, where binaric machineries and computational systems define whether an input—or function—belongs to a given set, whether a problem is solvable or not, whether a solution to a given problem can be applied to a different problem, and what is the optimal way to solve such questions. Similarly, in many other fields of technology, engineers are using continuous mathematical tools to understand, analyze, predict, and simulate real-world phenomena; to decide whether a signal represents a symbol; and to build reliable machinery that delivers expected results. Furthermore, modern (quantum) physics contributes statistical observations of uncertain reality, suggesting additional non-deterministic methods to interpret the world and conceptualize new quantum technologies.

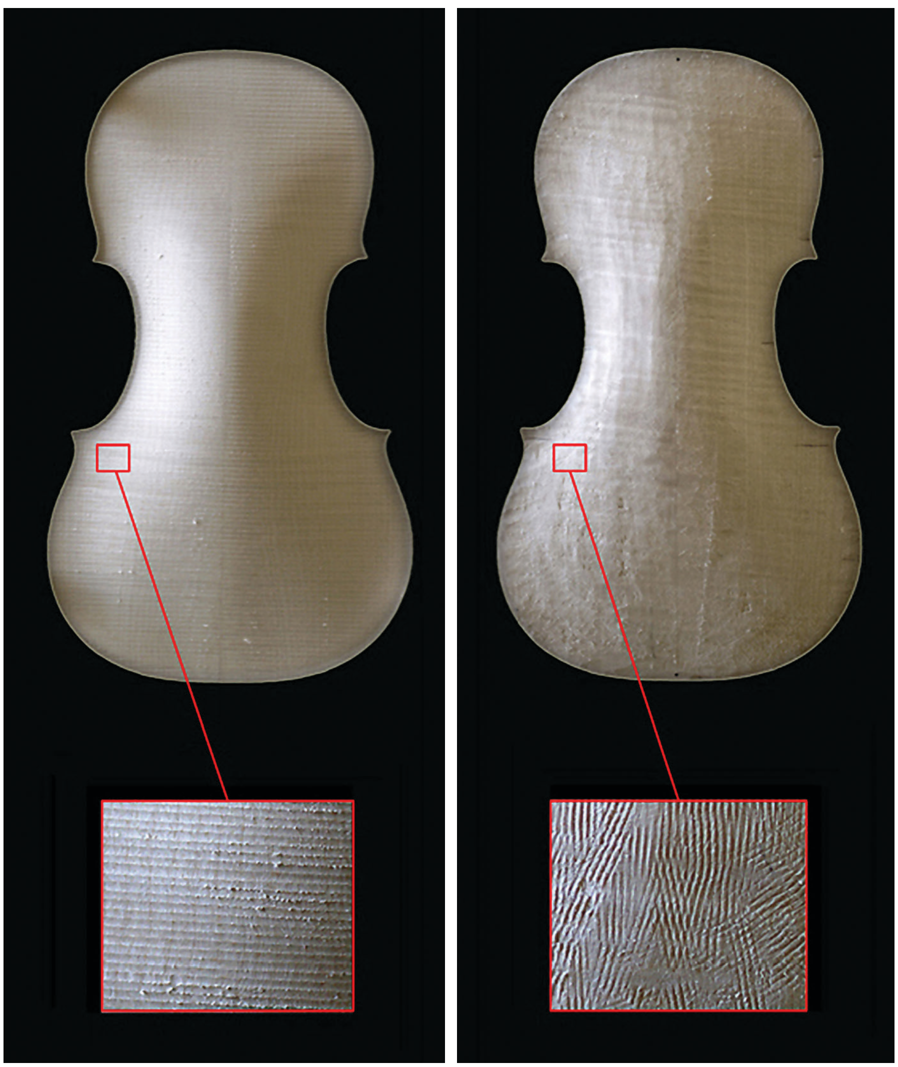
While the computational sciences and analytic representations undoubtedly leverage very powerful tools to understand the world and develop advantageous technologies, they are not free from weaknesses and limitations. While some negative phenomena of the Information Age can easily be observed (cyberbullying, early-age exposure to sexual content, and so on), other issues such as the difficulty of representing cultural values mathematically are less visible. Many scholars have already articulated the risks digital agency presents to computer-aided society [2]. In this article, I highlight an additional limitation in the current computational design and fabrication paradigm in relation to design style—whether generated by computer-aided design (CAD) or computer-aided manufacturing (CAM)—and suggest a revision of the way we conceptualize computers for creative outcomes.

THE PROBLEM OF STYLE IN COMPUTATIONAL DESIGN

In many fields of computer science, researchers successfully identify individual users by features extracted from their recorded performance (such as gait tracking and recognition). Moreover, computational methods have contributed to the evaluation of creative style within computer graphics (CG), where researchers have developed tools to extract the identifying

Figure 1. The Hadza hunters in Tanzania mark their arrows with unique personal patterns.

Figure 2. Violin back plates made from maple wood. Left: A back plate produced with a digital milling machine, rendering a uniformed pattern on the wood. Right: A back plate made by the author using hand tools, showing a complex pattern that reflects the variability of techniques being used.



characteristics of artists' styles. For example, in *Image and Video-Based Artistic Stylisation*, CG researchers list methods for "Stroke-Based Painterly Rendering" (chapter one), "Artistic Stylization by Nonlinear Filtering" (chapter five), "Artistic Rendering of Portraits" (chapter 12), and more [3]. This body of work considers style as a static quality. Changes in personal style over time have not been mapped, and the relationship between style and time-varying motoric skills (the relationship between subjective creative intention and technical abilities) have not been studied.

But what is creative style? In archeology and anthropology, the study of material culture has motivated detailed evaluations of variability in human techniques and methods for making artifacts. Starting with the early 20th century work of the German-American anthropologist Franz Boas [4], the study of artistic style within the humanities is an important part of research into material culture. Kroeber has described style as "a self-consistent way of behaving… selected out from among alternatively possible ways… selective with reference to values" [5]. Work by Wiessner suggests the style of craftspeople in traditional practices reveals social information and expressions of personal identity [6]. In anthropology, it seems to be a consensus that personal style is unique—the characteristic signatures of individual makers identify them among other makers, yet the signals communicating this variability are culturally dependent (see Figure. 1). These maker-signatures are not always evident to the observer, and the relationship between style and skill is not entirely clear.

On one hand, creative style has been the subject of many studies. By creative style, I mean the formal variations in artwork or design that transmit information about personal and social identity. This is a variation on Wiessner's definition of style as a "formal variation in material culture that transmits information about personal and social identity" [6]. However, individual style in carrying out creative and expressive motoric tasks (using a free-hand practice, usually by a skilled person) has not been studied in depth with quantitative methods within computer science. Most work in computer science seeks a working algorithm to achieve acceptable results when implanting formal variations in artwork or design (such as brush strokes qualities and patterns, color distribution, and so on) outside their original creative context. Examples include products meant to stimulate the eye with signals that remind us of a well-known artist, or that fit current standards of aesthetics [7].

For instance, the painting style of Vincent Van Gogh can easily be identified; the now-popular artist used distinct expressive techniques in his work. However, the collective memory of these historical works is biased toward iconic examples or even toward some cognitive morphing between them. Thus, a Photoshop (or Google DeepDream) filter designed to stylize your photos as if they were painted by Van Gogh may satisfy users, yet bear little resemblance to the portraits Van Gogh would have created today had he lived to the age of 163. An artist's style is never frozen in time; it reflects the context of the work. Imagine, for example, what would have motivated Van Gogh to dedicate a work to you, and how would this initial motivation influence the preliminary conditions of his work?

The dangers of the current CG trend are hidden deep in the intangible qualities of the creative practice, not all of which are easy to define. Perfection, homogeneity, and uniformity of shape and texture do not, by themselves, carry cultural signals—these signals are produced and consumed by people. A uniform texture may demonstrate accuracy, but does not carry a great deal of information, while a complex texture can reveal much more about the designers and their cultural context (see Figure. 2). Similarly, a perfect model of a virtual idea does not tell us anything about the fabrication process, but an imperfect reproduction embeds a story within the artifact. However, the economic influence of computational machinery convinces us that computers need to play an important role in creating cultural artifacts for design and art. Recently, researchers have invested in developing a variety of software agents that "takes input from designers, then 'evolves' new designs on its own," since "designing products [traditionally] is costly and time-consuming" [8].

Instead of aiming to simulate style or imitate it, we should use this complex quality to close the gap between digital designers and digitally fabricated artifacts.

To summarize, research in both computer science and humanities falls short in its contributions to the development of new, style-oriented expressive design tools. Although CG researchers study neither style nor aesthetics from a humanistic perspective, they develop tools to transplant a certain distribution of visual elements outside of their original context in order to generate a desired emotional reaction. Archaeologists and anthropologists, on the other hand, study style in its cultural context, but do not develop new tools for creative production. Nor have they studied in depth the dynamic evolution of individual style over time.

STYLE, TIME, AND MEANING

People change over time: Their motoric skills change, their intentions change, their styles change, and their cultural contexts change. A creative practice ties abilities with intentions, but what are these abilities and intentions? Is the metaphysical separation between abilities and intentions, skill and style, and matter and form useful when we study creativity? If so, can we study creative intention without developing a psychoanalytic model of the artists and their cultural contexts?

Obviously we can develop a convincing digital style generator, which we can use to gain a profit in specific economic contexts. Nevertheless, such developments do not reveal important questions about style—they only generate a simulation, by implanting out-of context signals to synthesize a reaction meant for a different context. Alternatively, we can choose to rely on Kantian philosophy, reject the duality between abilities and intentions, and focus on the empirical interaction between human and matter. However, even that direction won't make the analytic comprehension of style or its analytic representation more feasible.

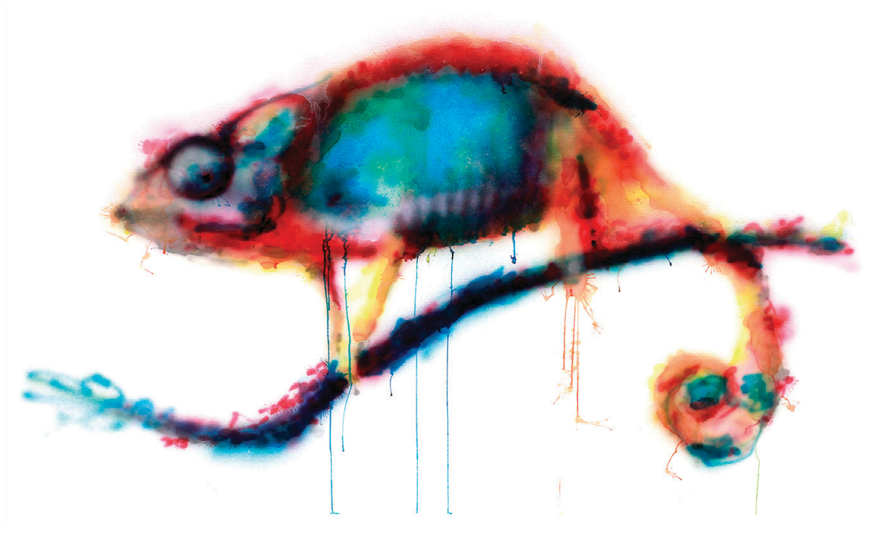
Visual design is the art of conveying symbolic meaning within an artifact, rather than solving an optimization problem. While some aspects of machine and interface design can be defined as engineering problems, design is not a branch of engineering. It deals with underlying cultural signals of aesthetics and meaning, with the aim of emotionally engaging people with the subject of the design work. A good interface design guarantees users will succeed in completing a task, but it will also impact their emotional reaction to the product.

The cognitive and affective aspects of design are interwoven [9]. Some of the dependencies of this relationship fit well into computational sciences, while other aspects do not. Still, recent trends in digital design and fabrication introduce computers, with their analytic problem-solving manner, to the whole spectrum of the design process. Thus re-imagining design as an engineering challenge and implementing continuous control on the whole creative chain—from autonomous design generators to digitally controlled fabrication machines.

Today, the vision of big-data beautifiers (styling products based on well-observed retail trends), which rely on a low degree of personal preference, influence design paradigms and impact research in both industry and academy. But it is a problematic vision. While digital technologies have altered the design practice, allowing for powerful CAD and CAM tools, they overshadow some design qualities rooted in cultural meaning and material context.

Hence, I argue for a revision of this trend, advocating for digital imperfection in computational design practices as a way to conjure a struggle between creative skill and personal style—a

Figure 3. A watercolor painting of a chameleon using an augmented airbrush [11], which allows novices to experience the manual art of spray painting.
Unlike an automatic printer, here the virtual simulation guides the physical process, allowing for a new experience with a singular physical style.



struggle that will contribute to an unpredictable yet meaningful product. This is not a Marxist critique on mass manufacturing and the alienation it creates between labor, society, and human nature. It is a manifest for imperfection and openness: An imperfection that can engage the designer in an ongoing performative search for balance between the controllable and the uncontrollable in design and nature. A search to balance forces and interests, rather than simulating aesthetics that will generate predictable product acceptance. A manifest for preventing the virtual agency from over controlling all aspects of physical matter.

FROM IMPERFECTION TO CREATIVITY

The question of style in computational design can be considered as a question of agency. Artists and designers develop their personal styles in a melting pot, where skill, aesthetics, environmental influences, and design objectives mix together and influence each other. When we outsource responsibility for style to an automaton—by implementing a simulation of the styles of skilled artists out of their original context, by expecting the computer to beautify work based on programmable aesthetic criteria, or by using a digital machine to build artifacts—we are giving up on human engagement and decision making. We are, in fact, giving up on part of the human creative spectrum.

Nevertheless, while computational agency dominates modern production lines and design tools, there is still a space to encourage the development of digital design tools that engage a broad range of users in creative practices. Although many digital tools aim to ease design and fabrication, I argue openness, unpredictability, and imperfection in creative tasks help to engage the designer in an intense experience that has a higher potential to generate subjectivity and meaning, and support artistic expressive statements and ownership (see Figure 3).

One example of such an interaction is the FreeD device [10], a hand-held digital milling device that is monitored by a computer, while preserving the maker's freedom to manipulate the work in many creative ways (see Figure 4). Relying on a pre-designed 3-D model, with the FreeD the computer springs into action only when the milling bit risks the object's integrity, preventing damage by slowing down the spindle. The rest of the time, it allows complete gestural freedom.

A user study of the FreeD device reveals how synergetic cooperation between human and machine preserves the expressiveness of manual practice [10]. This quality of the hybrid territory evolves into design personalization. Moreover, the study shows signs of correlation between the early manual style of the participants and their style while using the digital device (see Figure 5). Based on interviews with the participants, who are all designers, the authors report this correlation is gained by engagement in the practice of making while facing challenges that appear during the work, or ideas evolving while using a carving tool. As such, it could not have been realized before the fabrication process. This form of involvement allows performance of personal style within a digitally monitored fabrication task

Figure 4. The FreeD in action.

Figure 5. Five users execute the same design using the FreeD.

Figure 6. A castle model fabricated using the FreeD, and the tool path of the device being used by the author in making this castle. We tend to develop technologies focusing on the final results rather the process itself, yet the process contains a rich information about subjective creative decisions.

that helps compensate for the user's lack of carving knowledge without automating the process.

Zoran et al. suggest a hybrid interactive system will be beneficial for open-ended processes, allowing makers to define the amount of computational control they use. Beginners may need guidance to simply complete the task at hand, while developing their techniques as part of the investigation. On the other hand, skilled makers may require higher-level control, allowing the computer to reproduce their skills or manually seeking different objectives, such as introducing random qualities to the process. The image of human–computer synergy is subjective and should be open-ended and variable if it is to support real creative engagement.

The FreeD enables users to interpret and modify a virtual model during fabrication, keeping the user's subjective tool path as a signature embedded in the texture of the physical artifact. Because the FreeD allows design manipulation to be integrated within a tangible carving experience, the nature of this work more closely resembles the process of traditional craft than other forms of digital fabrication, while still providing digital risk management and quality assurance. By introducing traditional approaches to the digital making of artifacts, Zoran et al. hope this intimate collaboration between people and computers will pave the path for a new type of interaction.

Building upon prior art such as the FreeD, I hypothesize personal style in expressive manual tasks can signal rich information (see Figure 6). Moreover, this time-varying information depends on the task itself, while also revealing identifying characteristics of the observed subject. I believe these identifying characteristics can be carefully extracted from records of creative performance, using properly tuned models. More specifically, we should study which characteristics of creative style depend on elements of the creative performance, such as the morphology of the task, its social context, the mental model, and the user's experience, and which time-varying characteristics are unique to the user and appear in all of her or his work. Instead of aiming to simulate style or imitate it, we should use this complex quality to close the gap between digital designers and digitally fabricated artifacts. And also aim to enhance expressivity and unpredictability, which can arise in less controllable or "perfect" virtual design environments.

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Biography

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