On Ornamentation—A Digital Perspective

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Digital technologies of information and communication are transforming the way man understands and intervenes in the world. Indeed, our culture reveals important changes occurring at many levels in our society, which inevitably affects the discipline of architecture. Engaging the challenges of our contemporary reality, new means are defying the building industry from design to fabrication. This paper looks at the cultural and technological conditions that are shaping architectural practice, addressing the question of ornamentation in the digital age. Finally, two projects developed by ReD (XURRET SYSTEM and MORSlide) will serve to highlight concepts and design techniques, illustrating how digital techniques can lead to new conceptions of the ornament.

DIGITAL CONTEXT(S)

Reality

Today we experience an almost digitalized reality or "stereo-reality"[1] where our living condition relies increasingly more on the (immaterial) representations than in the (physical) things themselves. The digital expansion of human awareness and intervention towards the extremely small (nano scale) or the extraordinarily big (planetary scale) clearly reveals how we now perceive a "digitally mediated" nature, which we can not totally perceive with our senses[2]. Obviously, this introduces ambiguity in our empirical and intellectual conception of reality, both of which have always inspired and informed ornamentation. While traditional decoration was developed through imitation of the natural or abstract approaches, today's digitally conceived ornamentation tends to blur these two conventionally opposed tendencies. For instance, if we look at a digital raster image of a landscape in a computer screen, the apparently objective representation of nature is, instead, a matrix of identical squares with specific color tones, like any other digital image. By offering a scale-less environment, digital media stimulates design explorations that embrace simultaneously mimetic and abstract languages. With its powerful qualities as an interpreter of a calculated reality, the computer offers a hybrid environment to think and develop ornamentation in fundamentally different ways.

Design Technology

The evolution of CAD reveals a growing interest towards the study and application of the potential of the digital, giving ways to explore and control increasingly complex and non-standard geometries. Within the current landscape of digital design approaches, parametric and generative techniques suggest a more flexible design process, given that architects are no longer concerned with designing a single object, but a structure of information that drive the emergence of a multiplicity of possibilities.

In parametric design[4] one can develop a single digital model with variables and constraints, and derivate multiple –adjusted- versions from different data inputs. Similarly, generative design systems[5] operate with a wide number of possibilities, which evolve from design constituents and populations, according to defined rules. The influence of these digital techniques reveals interesting opportunities to pursue an ornamental intention that explores design variation and differentiation[6].

Fabrication technology

The integration of CAM[7] technologies in architecture is offering viable possibilities to materialize complex geometries and shapes that deal with great levels of variation. Brought in from other design-related fields, CAM tools link the data of a digital three-dimensional model to Computer Numerically Controlled machines (CNC) through programming instructions. This fact represents that manufacturing distinct elements are as easy as if they were all geometrically identical, producing them despite the complexity of their shape. By superseding the limitations imposed by industrial standardization, CAM shifts traditional systems of mass production towards mass customization. Today, decorative elements - like any other building component- can be customized through and mass-produced, which challenges the traditional views on time and economic limitations associated to ornamentation[8].

EXPERIMENTS ON PROGRAMMABLE ORNAMENTS

As a research and design practice, ReD investigates digital technologies to critically identify and explore their conceptual, material and broader implications in architecture. Through independent work or active collaborations, this architectural studio has developed several projects around the subject of ornamentation, like XURRET System[9] and MORSlide[10].

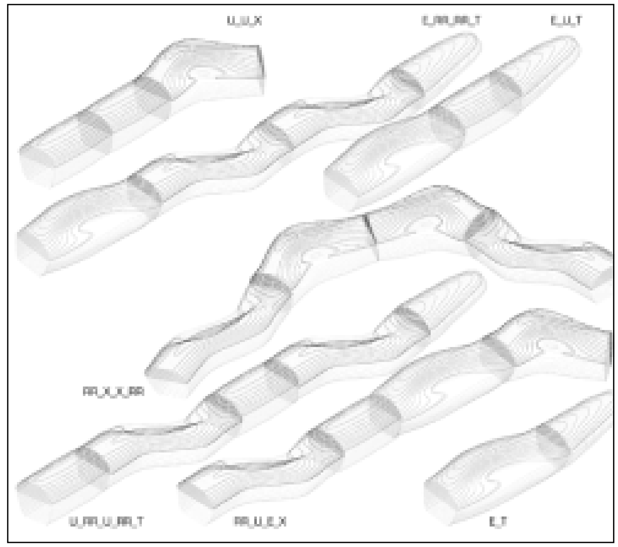
XURRET System

XURRET System is a seating structure or bench, designed for the Barcelona 2004 Forum of Cultures. Due to the formal complexity of its shape and ornamental intricacy, ReD was called to implement a digital production process to link design, development and fabrication[11]; as well as to elaborate the designer's ideas and bridge them to final mass production.

The project consisted of 5 parts, able to be connected one after the other in multiple ways to create an array of seating combinations, which would vary in length, orientation and overall shape (Fig. 1).

Beyond its irregular form, the designers had envisioned the bench to be covered by a "filiform texture"; an analogy taken from the image of a leaf with extremely visible veins. The original renderings showed a repetitive mapping -a tiling of an image- where the leaf texture had been copied all over the surface of the bench. Producing a pattern without differentiation, this strategy seamed to be incompatible with the idea of continuity and organicity that the designers were aiming for. In fact, resolving simultaneously the combinatorial and detail aspirations of the proposal, highlighted the true challenge of the project: how do you form a normalized kit of parts that has the ability to create an apparently endless and irregular field?

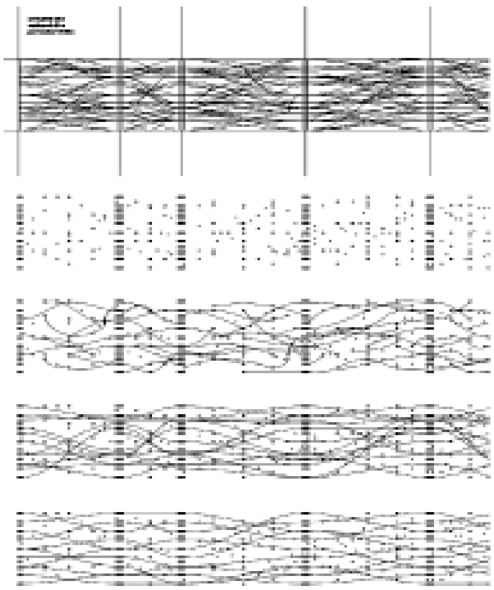
Figure 1. XURRET System consisted of 5 parts, engineered to be combined and connected one after the other in multiple ways, generating endless arrays of seating possibilities.



In the XURRET System, form and ornament would have to be engineered so that -no matter what the combination of parts would be- the overall result would look continuous and differentiated. Ornamentation was a strategy to blur the boundaries between the parts and thus highlight the unity of each assembly. Guaranteeing a condition of tangency between the elements -affecting both shape and texture- became the critical task of the digital model.

Parametric design was used to develop an interactive process that linked the topology of the parts with a 2D drawing or map, which followed the principles of the filiform concept. This drawing was programmed as a set of curves controlled by parametric key-points: some spatially constrained to assure the continuity of curves from part to part,

Figure 2. Parametric pattern based on the principles of the "filiform" concept where different groups of curves were controlled by the position of specific key-points.



and additional ones with greater "freedom""(Fig. 2).

By adjusting their parameters, one could modify aspects such as the density and curvature of the threads or the width of the areas required for enforcing tangency conditions. Simultaneously, this motif was vectorilally mapped at 1:1 ratio onto the parts, and used as extrusion paths to generate tubular veins with parametric circular sections (Fig. 3). All together allowed testing the aesthetic effect produced by varying thickness and degree of prominence on the surface (Fig. 4).

This associative parametric construction –a programmable system- would permit changes at any step of the process without the necessity of redrawing anything; by computing all possible filiform arrangements, their corresponding mappings and their tubular attributes simultaneously, one could generate and explore multiple versions and constantly evaluate the results.

Furthermore, this model merged design with fabrication information; not only it supported the possibility of exploring several solutions, but also served as the data source to drive CNC machines. Taking advantage of this CAD-CAM link, the development of the project extended into the production of 1:1 scale physical prototypes in high-density polyurethane foam, used to create the final molds for concrete casting(Fig. 5).

Figure 3. The "computed" pattern was mapped at 1:1 ratio onto each elements surface, and used as extrusion paths to generate its tubular veins.

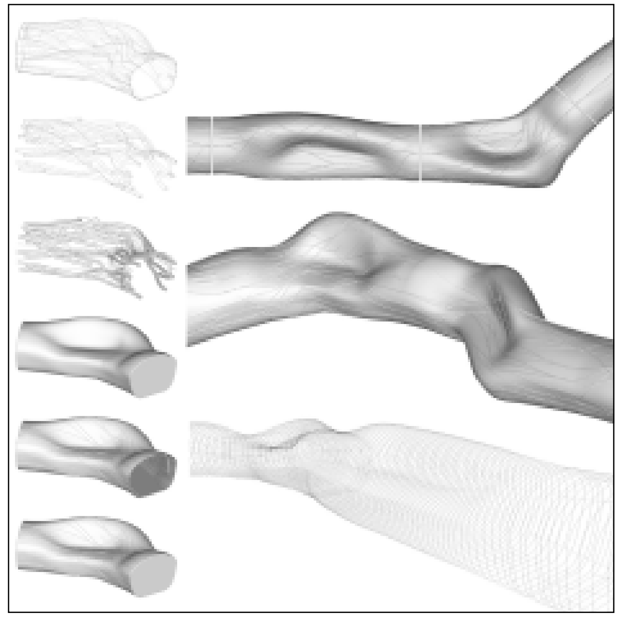
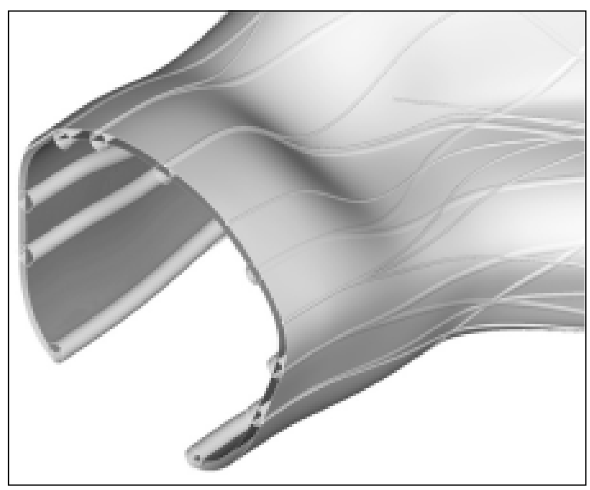


Figure 4. Texture effects could be adjusted and evaluated through parameters, which controlled how tubular veins emerged by intersecting the surface of each element.



The XURRET System experience shows how a final ornamental effect emerges from a programmable design environment, which combines mimetic intentions with the abstraction of mathematical rules, in a continuum between conception and manufacturing. The final built components are monolithic and made from a single material –concrete- that blends structure and surface, volume and texture, form and ornament (Fig. 6).

Figure 5. CNC production of 1:1 scale physical prototypes in high-density polyurethane foam, which were used for creating the final molds for concrete casting.

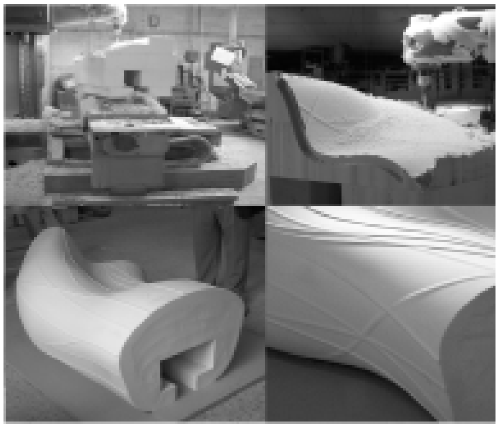
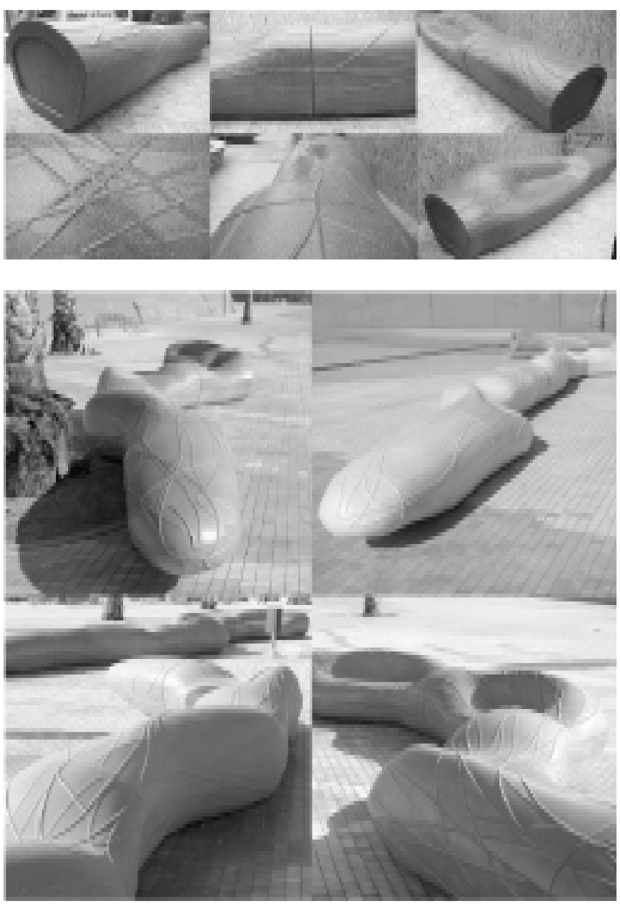


Figure 6. The final XURRET System components are monolithic and made of concrete, blending structure and surface, volume and texture, form and ornament.



MORSlide

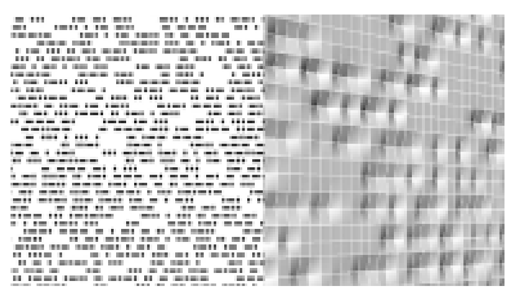
MORSlide is a system of surface panels and sliding doors, which was designed as a continuous enclosure or “wrap” around the wet core -kitchen and bathrooms- of an apartment remodeling in Barcelona. By hiding the programmatic subdivision behind it, this wrapper created a larger box, which can be read as an inserted object into the space. Visible from everywhere -the entrance, corridor and living room- it turned into the most significant design component of the renovation, and offered a suggestive opportunity for ornamental exploration.

ReD explored a decorative motif that, beyond fulfilling aesthetical, spatial and technical concerns, addressed critical research interests given that it took advantage of digital fabrication technologies to challenge standardization principles.

Given the existing (and quite random) distribution of door openings, the design overlooked the rhythm or proportions of individual panels that composed this box. Conceptually, MORSlide contemplated all possible positions of the 4 different sliding doors, aiming for an uninterrupted skinning effect. It produced a visual flattening of the complete surface into a field that could be re-arranged in infinite configurations through a “stretch-able” texture strategy. The design challenge was to find a decorative motif that would emphasize continuity across the physical limitations of standard rectangular panels.

Like a digital binary system, Morse code is a powerful language based on an extremely narrow vocabulary. Space, point and dash are the three basic symbols that offer endless combinatorial possibilities[12]. Beyond the construction of words, sentences and meanings, a Morse-coded text creates a for-

Figure 7. A Morse-coded text creates a formal pattern with a strict horizontal organization, while generating an apparently unplanned, randomly distributed field. For the MORSlide it was used to generate a 3D faceted digital surface.

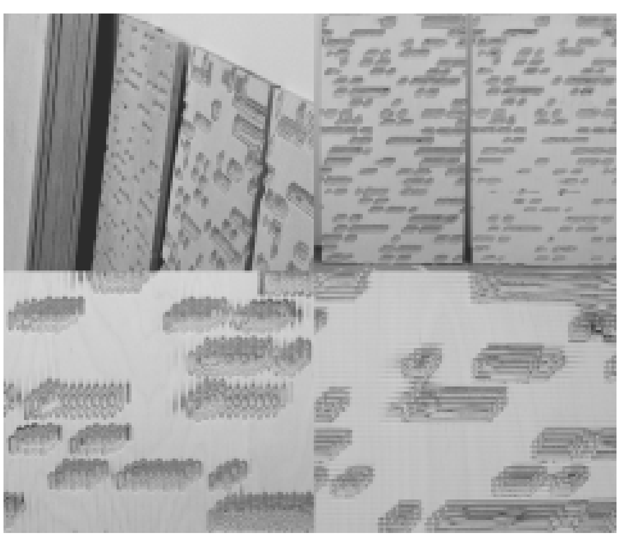


mal pattern with a strict horizontal organization, while generating an apparently unplanned, randomly distributed field. Most importantly, the superimposition of any portion of a Morse-coded text over another did not affect its overall appearance as a motif of points and dashes (Fig. 7).

In the MORSlide project, the application of a similar strategy was appealing because it successfully resolved the questions of difference and continuity, given the different proportions between wall surface and door openings. In linguistical terms, the sliding or displacement of a door "computed" different symbolic constructions by hiding and/or revealing parts of the original inscription. From a design point of view -no matter what the wall-door layout would be- the resulting surface always looked continuous, with a pattern performing as a re-configurable field. As a whole, MORSlide is a wall system where each panel -despite their almost identical shape- was differentiated with a unique ornamental texture, yet interactively diffused with others into a global, dynamic decorative theme.

Given the domestic nature of the project, it was critical to find a customized production process to integrate design and fabrication while fulfill economic and time constrains. Subtractive CNC machining provided viable means to produce variable relief effects on flat panels. It enabled the exploration of multiple ways of engraving the Morse-

Figure 8. Subtractive CNC machining provided viable means to produce variable relief effects on flat plywood panels.



coded pattern into the thickness of standard plywood panels (Fig. 8). The final 3D texture was the result of testing the visual effects emerging from graphic-to-surface translations while considering curve-to-faceted modeling possibilities and producing several material samples machined with sharper or smoother incisions at 1:1 scale.

Considering this, the MORSlide project explored the interaction between digital tools and specific material qualities to deploy their potential as a design opportunity. Indeed, milling a faceted surface into plywood produced –by exposing the colors of the wood laminations- an additional pattern that superimposed onto the more abstract and digitally modeled 3D texture. Moreover, the trajectory of the mill was set up to run continuously across

Figure 9. Photos of the apartment with the MORSlide System installed. Details of the final ornamental effects.

the panel, leaving a trace that further contributed into the cinematic aspect of the door sliding (Fig. 9).

CONCLUSION

Digital Ornamentation

In this cultural and technological context, digital tools suggest a way to think about an ornament that is no longer a designed entity but a programmable one. Integrating indeterminacy as a positive value for design inquiry, the ornament extends beyond its compositional principles to be driven by information data. When merging aesthetic and mathematical qualities within computational environments, digital ornamentation[13] can simultaneously beautify and improve a specific task in the building, extending its visual qualities towards functional performance[14]. Furthermore, with the integration of CAM technologies in the production process, digital ornamentation can be extensively and interactively engineered from design to material fabrication15. By engaging mass customization, decoration can also be oriented towards individualization, a concern that is a sign of our contemporary cultural condition.

NOTES

1 William Mitchell's *City of Bits* reflects how many aspects of our life have been transferred into the virtual world. The necessity to be present in both worlds is generating a "duplication" of reality in the realm of computer networks, a phenomenon that Paul Virilio calls "stereo-reality"

2 However, this experience is technically constrained given that perception varies according to the quality of communication and information processing technology (i.e.: image resolution or transmission speed).

3 Refering to Wilhelm Worringer's doctoral thesis Abstraktion und Einfühlung, Markus Bruderlin (2001, p.18) identifies "two basic artistic drives: that towards empathy, as embodied in the imitation of nature, and that towards abstraction (...) as a deeper-rooted instinct" in the history of ornamentation.

4 Parametric design, also known as associative geometry, is a digital modeling technique that comes from software developed for mechanical engineering, widely used in industries like automotive, aerospace and product design.

5 Shape grammars and evolutionary computation (based on genetic algorithms) are examples of generative design systems that integrate the computer as a creative medium to develop architectural design.

6 Following A. Picon (2003, p.314), one could argue that through computer programming –parametric or coding-, the ornament becomes a kind of event, which is no longer a static and finite entity but is part of a family of potential possibilities. In other words, recalling Pierre Levy, with these digital processes the ornament becomes a virtual entity ready to be actualized.

7 CAM stands for Computer Aided Manufacturing. For further reading on the introduction of digital fabrication technologies in architecture see M. Male-Alemany and J. P. Sousa (2003).

8 The economic advantage of implementing CAD-CAM systems in ornamental production is a strong argument against Adolf Loos' observations. At the beginning of the XX century, one of the references that Adolf Loos (1998, p.171) used to culturally reject ornamentation was the excessive cost of manual labor needed for ornamental production. CAD-CAM systems are totally changing this view, because they offer an economic, precise and flexible industrial mode of production.

9 XURRET System is an original design by Spanish architects Abalos & Herreros. Re|D was involved in the numerical production of 1:1 scale prototypes for ESCOFET, S.A., the concrete company responsible for mass-producing the design.

10 MORSLIDE will be first tested in the FERRE-ALEMANY Residence in Barcelona, a renovation project designed by Marta Malé-Alemany and co-produced with Sarah Collado.

11 Given the information provided by Abalos & Herreros, this process evolved chronologically as follows: an initial 3D modeling of the parts; the CNC production of a volumetric prototype to test different combinations and spatial occupation; the generation of a digital model of a 2D parametric pattern; its 3D mapping on the surface of each part; the development of "controlled" textural effects with tubular veins; and a final CNC fabrication of the resulting prototypes. In short, it represented a continuous process from virtual information to materiality, which allowed evaluating the design while testing the product at 1:1 scale, simultaneously.

12 With these 3 basic constituents Morse code has the capacity to define *words*, build *setences* and construct *meanings*. Indeed, this extremely structured symbolic system was a very appealing tool to be explored for the "reconfigurable field effect" desired in the MORSlide project.

13 Digital ornamentation here is not understood as virtual or electronic decoration, but it refers to the digital design and manufacturing approaches towards the material production of the ornament.

14 It is important to notice that ornamentation has always been linked to functional purposes. Since Vitruvian "venustas" recommendation, this can be traced in the

words of characters like Leonne Batista Alberti, John Ruskin, Louis Sullivan or Gottfried Semper. However, according to Ronald Schmitt (2002**,** p.7), the “European modernists limited their definition of function and rejected ornamentationto”, a tendency that would last to our present days.

15 See the concept of “Hyper [D-M] Process” (design-manufacturing) elaborated by the authors in their research paper presented at the eCAADe’03 Conference.

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