Abstract

Analog and digital media not only inform each other but also inform the discussion and production of architecture.

1 Introduction

Nietzsche had argued, sitting half-blind in front of his typewriter, that his new writing tool was “working on his thoughts.” Today, sitting in front of a computer, one may have similar suspicions—how is this new tool working on one’s thoughts, and thus on one’s architecture? Computation and computer technologies of representation have impacted the modes of conceptualizing architecture as much as they have impacted the modes of production. Traditional modes of presentation and representation have become challenged and at the same time—often stealthily—are re-inscribed into almost every routine of architectural production.

2 Enlightenment Architecture—The Modularization of Representation

Of these traditional aspects of representation, the modular and the so-called Cartesian Grid, have been the most dominant features of any interactive computer software. At the Paris École Polytechnique in 1799, the mathematician Gaspard Monge elaborated a descriptive geometry radicalizing elementary geometry. Monge’s invention was a three dimensional spatial construct that allowed him to map complex geometries and their relations in space through orthographic projections onto reference planes (Figure 1).

Based on Monge’s coordinate system, fellow École Polytechnique professor, the architect Nicolas Louis Durand, developed a notation device for architecture. While Monge’s abstract grid was a notation machine combining mathematical calculation with visualization—two otherwise entirely distinguished methods—in order to map and thus capture complex curved trajectories, Durand’s method reinterpreted Monge’s abstract coordinate space by literalizing its grid units into building units, into architectural modules. The imaginary grid was transformed by the hands of Durand into a physicality, an architectural determinism that unfolded along the grid’s predetermined lines and represented along its orthogonal projection planes (Figure 1). Contemporary architectural drawing conventions still prefer those representation techniques Durand institutionalized today known as section, elevation, and floor plan.
Durand’s rationalization of architecture into a combinatorial coordinate system lead to a new comprehension of buildings as types (building categories) and element-types (element categories, constituting a building). In the spirit of the Enlightenment, Durand disassembled architecture into basic irreducible components, classified them into a taxonomy and synthesized them according to rules (Durand, 1802-1805). The weakness of the approach was the subordination of any other aspect of architecture to the syntax.

Durand’s method can be seen as a first step towards a modularized and standardized architecture—usually associated with modernism. The encyclopedic treatment forced architecture not only into a rectangular-coordinating straight jacket, but also established basic types for basic building programs. Yet most importantly the method established the so-called Cartesian grid as a planning aide for architects, a choice still informing the profession as much as the building industry.

3 Modern Architecture: The Industrialization of Representation

While the technical means in Durand’s time had not yet developed to capitalize on the taxonomy and modularization of architecture, the situation changed dramatically when production industrialized in the nineteenth century.

Besides new social and political requirements architecture had to fulfill, new production methods were also needed. Techniques of fabrication that were introduced allowed and required a further rationalization of building components. The ways architects thought about architecture, how they designed, and finally produced architecture changed. The work by Louis Sullivan and Frank Lloyd Wright in the USA at the end of the nineteenth century are early results of these technological developments. In the 1920s, Walter Gropius had also begun to incorporate these changes in his work and pedagogy in Germany.

The large-scale construction kit Gropius proposed in 1922 is of major importance, as he linked the new logics of mass-production to those of building architecture. (Figure 2a) A flexible set of exchangeable cellular components could be arranged into different houses. (Figure 2b) The need for dimensional precision and control was achieved with the drawings of section, elevation, and plan popularized by Durand. Nevertheless, even more explicit in describing Gropius’ design strategy were the use of isometric drawings.

Isometric: representation for industrially-produced components

While traditional projection techniques provided plans, sections, and elevations yet never an impression of the actual three-dimensional object, isometric drawings achieved both: the precision of the previous drawings and a direct legibility of the entire object’s proper measurements in non-distorted, three-dimensional space. (Figures 3, 4) In the vein of industrialization, precise, accurate, and unambiguous technical drawings could be achieved (Farish, 1822).

Figure 1: Jean-Nicolas-Louis Durand’s (left) and Gaspard Monge’s (right) approaches in comparison.

Figure 2a: Walter Gropius, large-scale Construction Kit 1922-1923

Figure 2b: Walter Gropius, Models of Standard Houses 1921-1923.

Figure 3: Optical-grinding engine model. This is perhaps the first machine drawing rendered in 30 degrees isometric. 1822
The Bauhaus incorporated axonometry and isometry in the curriculum of design and architecture as the drawings for the Haus am Horn and Gropius’ director’s office from 1923 show. (Figures 5, 6) The technique began to literally in-form the conceptualization of space and design within space, as the isometric projection allowed space to be considered as a three-dimensional coordinated cubical room in which design was inscribed along its imaginary coordinate points and lines. The lamps in Gropius’ director room exemplify this attitude as they are suspended at first in the coordinate system of the axiomatic representation and later within the office’s space.

A new aesthetic

Besides a new spatial imaginary based on new precise drawing techniques, a new aesthetic representing the industrialized production of objects was developed. Much attention was given to the representation and production of the artifact, the original within this production process. The prototype was a product, often still crafted by hand, and yet already anticipating the machine’s operations and limitations. With the machinic production of objects, uniformity, and precision marked by a rigor of fabrication began to predominate the aesthetics of objects and their representational aesthetics.

The prototypes for these forms were “cleanly constructed and true to materials,” as Behrens already wrote in 1910, when he emphasized the necessity for bare forms of industrially produced objects, stripped of excess ornament, made impersonal, and baring signs of their production. (Behrens, 1909; Buddensieg, 1979; Schwartz, 1996). Gert Selle prepares a more nuanced reading of the form of typified objects. According to him, “the objective form is a function of production-economy and product-aesthetic,” or alternatively the machine aesthetic. (Selle, 2007) The object assembles a look that suggests a certain production process, without necessarily being the result of it. The prototype of the object is here not just as a physical model to be reproduced. Rather the industrialized, mass-producing process itself informs the prototype, as it needs to be at once anticipated and expressed in the object’s form.

4 Modular Coordination: A New Representation Technique For Automated Industrial Architectural Production

After the Second World War, the industrialization of building attained new momentum given the worldwide housing shortage. Much hope was placed in the automation of processes of production and assembly. The adoption of numerically controlled processes of manufacturing elements or entire building components required rethinking the logic and precision of designs and their construction processes. With Konrad Wachsmann’s work, a radical extension of Durand’s nineteenth century project, thinking in modular systems and systematic precision began to dominate architecture. This was closely related to the introduction of a new logic of thinking and notating: modular coordination (Figure 7, 8).
Wachsmann’s modular coordination opted for a complex coordination of the entire building, which no longer begins from the standpoint of isolated individual elements and functions.

“The processes of industrial fabrication have not only created new concepts of production, but have also inspired new opinions about the function of the components and about the meaning of building overall. Well-founded facts have been put into question. “The principle of the decomposition of the building into functions that are independent of one another has been supplanted by the necessary coordination” (Wachsmann, 1959).

The coordination of individual building components and their production and assembly is given the greatest importance. (Figure 8) Computer-controlled automation, according to Wachsmann’s speculations, was to bring the design and production of a building under complete control and heighten differentiation. The architect not only designed the building but also the processes of its automatic production. It was then that construction and assembly with computers was anticipated. Where besides plans and sections, the Bauhaus had advocated axiomatic drawings (Gropius, 1923), now flow charts and punch cards were added to the repertoire to explore new means of notation for capturing design and construction in a format legible to machines. (Industrialization was, in Wachsmann’s view, not a technical aid in the mass production of artistically designed appliances but the direct source of the appliances’ design. Wachsmann assumed that instead of designers it would be the principles of industrialization and the logics of automated production processes that would inform future designs and consequently future human environments (Wachsmann, 1962).

5 Computer aided rather than generated design

This development gained momentum in the 1960s when limited computers became available—to architects and artists. There was a recognition that interaction with the new tool was anything but intuitive: data entering the computer had to be scripted, and often collaborations between architects and programmers became necessary. In a tedious process, the translation of the architectural discipline’s century old know-how into the logics of computation took place, and often for the first time needing to be numerically or algorithmically inscribed.

To increase the interaction between designer and computer, in 1961, Ivan Sutherland worked at the console of the TX-2 computer at the Lincoln Labs of MIT to develop what he called Sketchpad with the technology of the light-pen developed in the 1950s for the defense project Whirlwind. (Figure 9) The easily modifiable TX-2 computer had a CRT screen and enough memory to hold 280 000 bytes. Sutherland intended to sketch rather than to program that which would appear on a computer’s monitor. A first success was reached when a cross appeared on the computer monitor which could be recognized by the light-pen as the reference and starting point of the drawing. Moving the light-pen in relation to this initiation point allowed one to ‘draw’ lines in reference to what was being represented on
the computer screen. Yet only programmed functions entered the computer and thus were available for interactive use with the computer.

Curves remained a major challenge to the program, and were limited to those based on arches. These technical limitations would literally inform and ultimately limit the designs. Only rationalizable geometries would enter the computer, and there were limits to what was representable through the computer monitor’s technology.

Even though Sketchpad’s constraints were to a large extent ensuring the success of the program and planting the seeds for interactive computer graphics programs to come, it also set an agenda for how the computer was used as a drawing aide and how certain geometries could be more favored than others. The choice of the medium was not only a choice about how design was represented but also of what design was about, and by extension how we may think about design. Since the repetition of pre-determined geometries was much less time consuming than inventing new ones, the computer reinforced the repetition of the same as more effective. The medium’s potential for new design generation and presentation strategies was no longer used inquisitively; instead traditional drawing techniques in section, plan, and elevation were brought into the digital realm in line with the discipline’s well established procedures.

This development was not necessarily linked to the computer’s logic of operation, it was rather a matter of choice by the users, or perhaps more precisely of the software companies that provided the users with interactive Computer-Aided Drawing programs. These all provided a blank, grided interface as starting point, the so-called Cartesian Coordinate System, into which the designs could be notated. Digital Architecture was literally coordinated along the lines of the coordinate system.

The principles of Sketchpad and computer aided drawing tremendously expanded the interaction between architects and the computer. Yet they also severely limited the comprehension and conceptualization of the medium and its genuine processes. This was partially because the programs did not require programming skills from its users. Industrial engineering and design in the automobile and aerospace industries, and gradually later Architecture, profited from this development. (Figure 10) The computer-illiterate architect Peter Eisenman began in the US to explore with the founder of 3D software FormZ, Chris Yessios, the generative potential of computer software. (Rocker, 2008) Besides experiments in shape grammar and Boolean operations, triangulation in particular began to literally in-form Eisenman’s architecture, becoming even its signature. Nevertheless, they never took advantage of the underlying processes of computation, a circumstance that has only changed since the late 1990s when architects were increasingly more invested in computation and coding.

6 Parametric differentiation: mass-customized architectural production

After the computer and its interactive software had been re-accessed for their generative potential, the limits to software had become apparent to architects. By the end of the 1990s, computation itself and the mathematics of differential calculus gained greater relevance to design. This development was partially triggered by a younger generation of architects reading Deleuze’s interpretation of Leibniz, establishing a new logic of the “integration of differences within a continuous yet heterogeneous system.” (Lynn, 1993, 8) It was in 1686 when Leibniz, a well-known politician and philosopher, propagated his idea of differentiation, a method that could calculate and thus comprehend the rates of change of curves and figures.
Besides its initial practical applications in ship and bridge design, Leibniz’s differential calculus had also philosophical implications as it allowed the comprehension of nature as a ‘continuous variation,’ as a ‘continuous development of form.’ In Deleuze’s reading of Leibniz, differences were hereby no longer thought of in terms of separate entities, but rather in terms of a continuous differentiation according to contingencies, a process Deleuze termed folding. (Lynn, 1993, 11). Perhaps most notably, architectural form designed with software based on differential calculus changed “from fragmented polygonal rectilinearity towards smooth continuous spinal curve-linearity, [...] subverting both the modernist box and its deconstructionist remains.” (Rocker, 2006) Much attention is given to Leibniz’s differential calculus and its ability to fuse the hierarchy of parts and whole to produce a deeply modulated whole as well as infinitesimal variation among parts. The implication of Leibniz’s mathematics for architecture is explained by Eisenman:

“Leibniz turned his back on Cartesian rationalism, on the notion of effective space and argued that in the labyrinth of the continuous the smallest element is not the point but ‘the fold’ [...] In mathematical studies of variation, the notion of object is changed. This new object is for Deleuze no longer concerned with the framing of space, but rather a temporal modulation that implies a continual variation of matter. The continual variation is characterized through the agency of the fold: ‘no longer is an object characterized by an essential form.’” (Eisenman 1993, 24)

Eisenman depicts here what I first termed versioning in 2003—thinking of design no longer as a single entity characterized by an essential form but rather as a series. (Rocker, 2003, 2006). Each design-event is characterized through continuous similarities rather than clearly defined differences. Differential calculus enabled a divergence from the Modernists’ mechanical kit-of-parts for design and construction.

Differential Calculus presents a challenge if not a catastrophe—for architecture’s planometric means of representation, which simply cannot cope with the spatial complexities characteristic of the fold. With the new means of presentation, new realms of architectural thought and production become possible, as the designer is liberated from the constraints of traditional models of presentation.

Young architects obsessed with the possibilities of differentiation most often reduce the concept to mere surface effects, at best symbolizing rather than taking advantage of the computer’s power, the tireless looping—its ability to perform millions of operations in a single second, and to constantly shift and recalculate functions continuously. A disciplined groundwork of order underpins the system driving the versioning, giving rhythm to a powerful Turing Machine at the heart of the digital aesthetic. It is not just “the curve” which characterizes computed form, but the parameterized curve—the folding and shifting of the two-dimensional curve across a third dimension. Not even the curve alone, but also its derivatives and inflection points—the core of calculus-based mathematical analysis—is that which informs digital form-making at its deepest level.
Architecture is viewed neither as fragmented nor contradictory, but rather as an integrative, intensive whole. With computer-controlled manufacturing techniques, infinitesimal variations and “one-of-a-kind customized variety” (Lynn, 2004) became possible. But was the possible also plausible? Many of the results were often grotesquely dysfunctional, uninhabitable, continuously differentiating spaces, which were at best rigorously generated. In architecture, the continuous differentiation of an imagined continuity resulted in little more than an exhausting and now exhausted exuberance of form, which seemed to have finally found its end.

More recent inquiries begin to critique such formal and tool-reliant efforts. There is an increasing alertness to the opportunities and to the deficiencies, engendered by dependency on the tools and the processes they allow for. This alertness is paralleled by an increasing interest in the power of computation for a critical analysis and synthesis of design. Parametric architecture has thus recently involved projects developed to revisit traditional architectural types. (Figures 12, 13, 14)

While parametric tools have been previously most often used quantitatively and syntactically, they should now be revisited for their qualitative and semantic potential. One could perhaps argue that representation guides the experience and understanding of architecture. Eisenman writes that the moment in which “space does not allow itself to be accessed through gridded planes” (Eisenman, 1995) is the moment in which the architect realizes the process of imaging was always already present in the process of design and its realization, and thus inscribed into the material substance of architecture.

With this liberation, parametric design should be more strategically reinvested in the disciplinary virtues of architecture, challenging them from within. Versioning—not rote but motivated—can aim to go back to history and the essential problems of architecture, such as typology and classical and post-classical approaches to part-to-whole explored by earlier generations of architects using tools such as the Cartesian system and axonometry. Versioning is then itself an essential part of the age-old architectural problem of part-to-whole. It is not about the “continuity,” nor is it about “the repetition of discrete elements for mass-production,” but it is rather nuanced mass-customization essential to a constant recalibration of the relationship between tradition and innovation, knowledge and imagination, presentation and representation, the analog and the digital.

References

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Credits:

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Figure 12: Rocker-Lange Architects, Explorations in parametric Types, Hong Kong Tower Types 2010, Matrix.
Figure 13: Rocker-Lange Architects, Explorations in parametric Types, Hong Kong Tower Types 2010, Elevation.
Figure 14: Rocker-Lange Architects, Explorations in parametric Types, Hong Kong Tower Types 2010, Models.