# Architectures of the Digital Realm: Experimentations by Peter Eisenman | Frank O. Gehry

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*"'If you please, draw me a sheep,'[1] said the little Prince, thinking not about a real sheep, but a virtual one."[2]*

In the past and the present we witness confusion regarding the real and the imaginary, the real and the virtual, as well as confusion regarding the architecture of the digital with those architectures the digital medium is capable of generating.[3] It is in this context that my paper attempts to situate the architecture of the digital realm.

Two questions come to mind: First, what role is played by the real and the imaginary, and how do both, in close cooperation, constitute contemporary architectural theory and practice?

Next, in what sense can and should we speak of a *pictorial turn*—and could a too-intensive focus on digital imagery perhaps obscure rather than illuminate our view of the role of digital media in architecture?

## A Pictorial turn?

In 1994 the art historian W. J. Thomas Mitchell coined the term *pictorial turn*,[4] suggesting that images largely dominate our culture. The *pictorial turn* thus refers to and replaces a conditional change in society that Richard Rorty had called the *linguistic turn* in 1967,[5] a moment when reality seemed only to exist within and through the use of language. Rorty argued that any analysis of reality is linguistically determined, and even further, that reality is simply structured like language, that—in short—reality is nothing other than a system of signs. In this vein of thinking, language no longer was conceived as a depiction or representation of reality, but seemed rather to be constitutive thereof.

30 years later, Mitchell's phrase suggests that images rather than language seem to be constitutive of reality. A *pictorial turn*, according to Mitchell, is not to be confused with: "A return to naïve mimesis, copy or correspondence theories of representation, or a renewed metaphysics of pictorial 'presence': It is rather a post linguistic, post semiotic rediscovery of the picture as a complex interplay between visuality, apparatus, institutions, discourse, bodies and figurality."[6]

Obviously, new forms of visual simulations and illusions based on computational calculating powers are predominantly held responsible for the *pictorial turn*. Vision—as much as the imaginary or the real—became hereby suddenly understood as a historical construct inseparable from shifting representational practices and the media from which they derive.

Taking Mitchell's argument a step further, we can already witness that with the introduction of the digital medium into architecture a significant shift in the means and modes of representation has occurred and thus has begun to alter how we theorize and practice. This book is one of the symptoms.

Nevertheless—is the change we are witnessing in our profession a change caused by the proliferation of digital images? Or is the change caused by the fact that the architect has begun to seize the reins of power, which are located behind the images themselves, in the representation of the data and the translation process (that is, the algorithms) as they convert this data into vectors and surfaces?

More recently architects are taking advantage of the new ability which the digital medium offers of redefining the customs and mechanisms that dictate their craft—that is, they can retool the tools that work on their thoughts.

## Media: informing agencies

Nietzsche had argued, sitting half-blind in front of his Hansen typewriter, that his new writing tool was "working on his thoughts."[7] 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 architectures? What are, in other words, the media-specific processes: Are they the "picture technologies" of the software, or are they the algorithms of the "computer" which lie beneath?

It seems all too easy to equate the proliferation of digital images with the proliferation of the digital medium—since the digital medium's genuine mode of operation can be based on the presence or absence of a single sign as Shannon showed, in reference to Turing's Universal Machine.[8]

Even though it is common to speak about 0s and 1s, these symbols nevertheless obscure that on an operational level the machine's state is simply either activated: 'on' or inactivated: 'off', a condition which is anything but pictorial. And yet, the presence of the digital image depends on the presence or absence of discrete states.

Even though Shannon ascribes the universal machine computer to nothing but the presence or absence of a state, it is precisely for this reason that the computer is the first medium capable of imitating all other media, as the media theoretician Friedrich Kittler has pointed out: "There are no new media, but one new medium, named the computer, the newness of which […] is that it can be all machines, and thus all media."[9]

If media constitute the real, then the digital medium—as it emulates all other media—constitutes not one but a multitude of realities![10]

Anything—regardless of whether it is text or image—only 'exists' in the digital realm in terms of numerical operations. Here the image—no longer bound to the visible—'exists' only numerically encoded rather than substantially inscribed—as was previously the case with the analog technologies of photography, cinematography and radiography. The numerically coded image becomes visible only after it has been translated and displayed on our displays. Pictures as they evolve and dissolve on our iconic 'desktops' are visualizations—at best, representations—of numerically encoded information, obstructing rather than enabling a view into the medium's essential operations, which have long since withdrawn into the black box.[11] Consequently the perception of the computer's operation relies on a multitude of different representations: 1's and 0's are just as "arbitrary" as the image. In fact, nothing a computer produces is meaningful unless it is interpreted in some way—even when data is viewed numerically, there is always a level of interpretation.

Most discussions regarding the *pictorial turn* are at best only linked to the digital medium's desktop effects. Certainly they have nothing to do with the digital medium's genuine operations. Conceptualizing the latter and its consequences for architecture remains a challenging task.

## Digital techniques: constituting worlds

In this moment, when digital techniques constitute worlds according to their measure, one may wonder about the consequences for architecture traditionally considered—as Peter Eisenman puts it, "the epitome of material reality."[12]

Along these lines Eisenman—himself a computer illiterate—began to develop in 1988 a design for Carnegie Mellon University[13] critiquing the omnipresent systems of knowledge such as computers, robots and other technologies. These knowledge-based systems required, according to Eisenman, a re-conceptualization of architecture: "While architecture was previously preoccupied with the overcoming of nature, it now has to cope with the increasing complexities of knowledge-based computational systems."[14]

For the formalist Eisenman, the consequences become apparent in increasingly complex forms with n-number geometries. It is thus for him that the Boolean cube is the perfect structural model depicting this condition: "The Boolean cube is a complex structure which lies between purity of a platonic form and the infinite and unlimited form of non-Euclidean structure. Because the form is based on the infinite doubling and reconnection of itself it is an unstable and infinite N-geometric figure, yet frozen singularly these forms exhibit the properties of platonic forms."[15]

It seems more than symptomatic for Eisenman the architect that he can only begin to cope with abstract non-formal computational processes through a geometric structure. Despite the disputable relevance of Eisenman's model of computation in the form of an n-dimensional cube, it nevertheless exhibits an early attempt to conceptualize the computer's genuine operations (fig. 1, 2).

Studying the implications of computation from another vantage point Eisenman wonders how the digital medium has affected our perception and consequently our realizations of architecture: "The electronic paradigm directs a powerful challenge to architecture because it defines reality in terms of media and simulation, it values appearance over existence, what can be seen over what is. Not the seen as we formerly knew it, but rather a seeing that can no longer interpreted. Media introduce fundamental ambiguities into how and what we see. Architecture has resisted this question because, since the importation and absorption of perspective by architectural space in the 15th century, architecture has been dominated by the mechanics of vision. Thus architecture assumes sight as being preeminent and also in some way natural to its own process.

It is precisely this traditional concept of sight that electronic architecture questions. The tradition of planimetric projection in architecture persisted unchallenged because it allowed the projection and hence, the understanding of a three-dimensional space in two dimensions."[16]

Eisenman, who had already earlier in his career toyed with the confusion of the real and its representations—buildings looked like models, axonometric models functioned like drawings[17]—expected in the late 1980s the digital medium to even more radically challenge traditional forms of representation and comprehension in architecture.

Consequently, in 1989 Eisenman's office began to explore the precursors of the 3d modeling software Form*Z[18] and their potential to challenge the status quo in architecture—a project that was perhaps ill-fated from the beginning, given that this

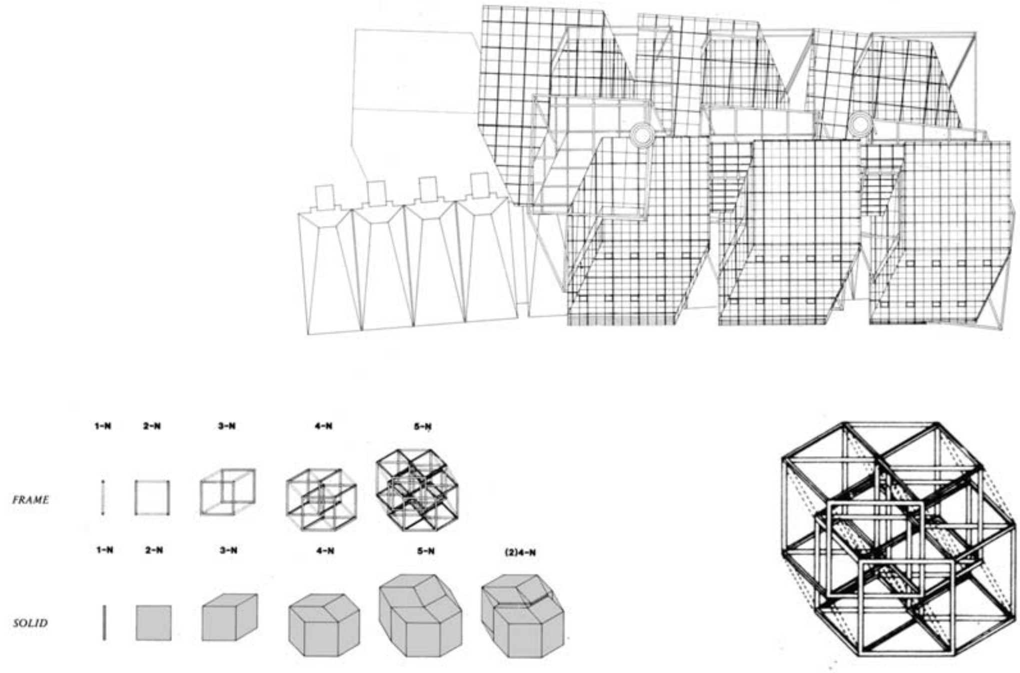



*Fig. 1: Peter Eisenman: Carnegie Mellon Research Center, Pittsburg Pennsylvania, 1988, Diagrams and Roof plan*

*"Each Building is made up of three pairs of 4-n Boolean Cubes. Each pair contains two solid cubes with 40' and 45' members and two frame cubes with 40' and 45' members. These pairs are continuously and progressively spaced so that they fall out of phase with one and another while remaining within a 5-n relationship." (Peter Eisenman)*

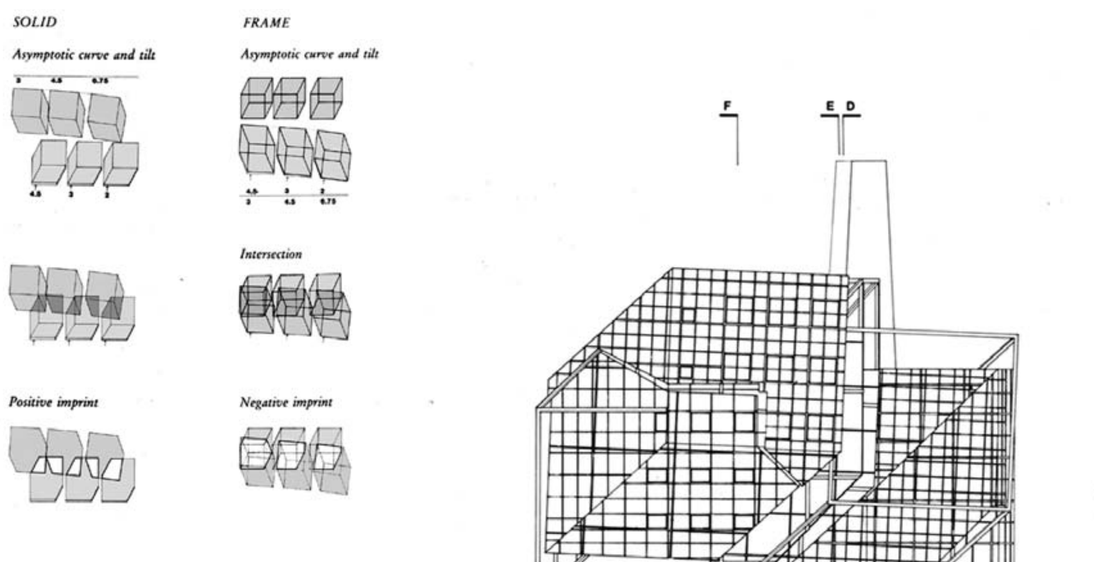



*Fig. 2: Peter Eisenman: Carnegie Mellon Research Center, Pittsburg Pennsylvania, 1988, Diagrams and East Elevation*

software stabilizes rather than destabilizes a rational comprehension of space.

Standardizations such as the Cartesian grid form the unquestioned ideological substrate of most architectural software—often unnoticed by the 'user', these ideals inform images and forms by evoking inherited norms and schemata. Digital discrete images, for example, are characterized through uniform subdivisions, a fine Cartesian grid of cells known as pixels. Unlike non-digital photography, however, the digital image only approximates a smooth gradation in its grid, breaking a continuous surface into discrete steps.

The omnipresent Cartesian grid becomes also inscribed in 3-dimensional models, as the user cannot but use the Cartesian coordinate system to consolidate the profession's standardized modes of representation (plan, section, elevation). Surrounded on all sides as we are by standards, it seems all the more necessary to remember that these are nothing more than arbitrary constructs, open for change.[19] But who are the authors of change—the architects or the software developers?

Perhaps it was this or a similar question, which resulted in the cooperation between Peter Eisenman, who knew next to nothing about computers, and the Form*Z software developer and professor of architecture Christos Yessios. The uneven couple was searching for an alternative representation and thereby comprehension of space, through testing the potential of software.

The roots of Form*Z go back to Yessios' doctorial thesis of 1973, entitled: *Syntactic Structures and Procedures for Computable Site Planning*,[20] for which he developed a language that automated space planning, based on the use of shape grammars. The generation of form through pre-given shapes capitalized on Noam Chomsky's generative grammars.[21] Throughout the 1970's, the linguistic method dominated Yessios' development of this computer language, including the transformational laws that could—within a given set of design parameters—derive optimal spatial configurations.[22]

While the beginnings of Form*Z elaborated freely on the crossroads of language and image, later Yessios concentrated his efforts on establishing a cognitive framework that could be shared commonly by the profession and thus become more sellable but also more conventional: "Following the canonical paradigm of form making, an array of pre-defined platonic shapes provides designers with the starting point for a series of controlled transformation to generate geometries whose limits are set by the individual imagination."[23]

Obviously, the designer's imagination was equally informed by the software's possibilities as well as by the overall design process—a circumstance that would soon become all the more apparent in Eisenman's work.

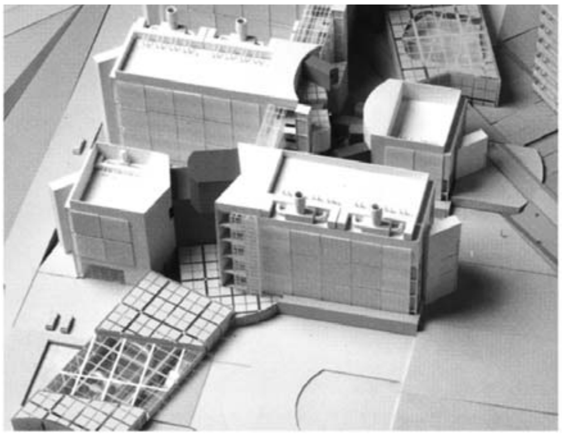
Eisenman did not become more directly involved in discussions regarding computation—or perhaps more precisely, regarding the use of interactive software—until 1984. Three years, later Eisenman and Yessios taught a joint studio, around the problem of designing a biological research facility for the J. W. Goethe University of Frankfurt, Germany. Eisenman aimed hereby at an: "Architectural reading of the DNA processes by interpreting them in terms of geometrical processes. At that time we departed from the traditional representation of architecture by abandoning the classical Euclidean geometry on which the discipline is based in favor of a fractal geometry."[24] (fig. 3, 4)

While Eisenman determined the program and the overall design agenda, Yessios and the students scripted the new design tools, which were the products of Eisenman's imagination. The computer was hereby less used as a drafting machine than as a generator to explore and generate form as Yessios remembers: "The group quickly agreed (or was persuaded by Eisenman) that the problem was not one of arranging spaces and securing appropriate and sufficient linkages. It was rather a problem of designing the generative process."[25]

The procedural logics of Eisenman's earlier designs matched those of the software developers. Nevertheless, only those aspects and processes of design could enter the computer which were computable, which could be transposed into code. Consequently design processes had to be adjusted to accommodate the limitations and the constraints of the machine, on the other hand the machine allowed the generation of unpredicted designs, a circumstance which turned the designer into the author of a given set of rules rather than the author of a unique design.

Right after this early experiment Yessios—and the same can be assumed for Eisenman—was left with the impression that: "At this time, we do not fully understand where it might lead us. We do not even fully understand the potential of what is already in place. Actually the potential appears to be virtually infinite. It is leading us to compositional schemes, which we could never have conceived on our own, but the computer is able to unfold for us. And yet, we programmed the computer; we told it what to do. This is not as paradoxical as it may sound. It certainly underlines the potential of the machine as a 'reinforcer' of our creative processes."[26]

Eventually some of the custom-made tools became part of the first Form*Z, released in 1991, that thought to challenge conventional techniques of representation and design: 3d void modeling[27] replaced 2d drafting. Computational reinforcement received then, shortly afterwards, Eisenman's design for the Emory University Center for the Arts, in Atlanta Georgia (fig. 5).



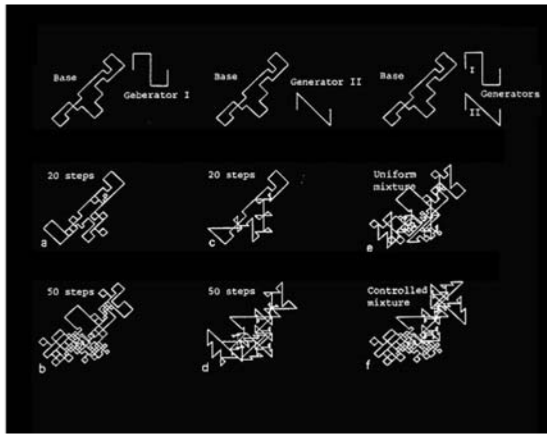
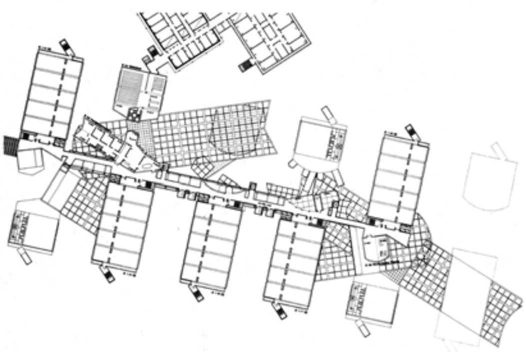



*Fig. 3: left: Peter Eisenman: Biological Research Institure, J. W. Goethe University of Frankfurt, Germany, 1987, Model Picture; right: Peter Eisenman: Biological Research Institure, J. W. Goethe University of Frankfurt, Germany, 1987, Application of generators in the co-taught studio Eisenman/Yessios*

*"The fractal, as a generative system, consists of an initial state of a shape (the base) and one or more generators. The generator, from the practical point of view, is a production rule: replace each and every line segment of the base with the shape of the generator." (Chris Yessios)*



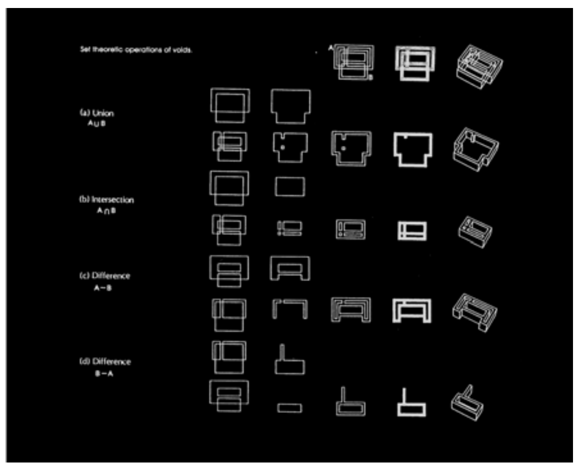



*Fig. 4: left: Peter Eisenman: Biological Research Institute, J. W. Goethe University of Frankfurt, Germany, 1987, Plan Level II. The design's basis shapes were 'borrowed' from biology's symbols and generated with the computer based on fractal geometry; right: Chris Yessios: Set theoretic operations of voids, Form*Z, these operations should play a significant role for Eisenman's conceptualization and generation of design throughout the 1980s and early 1990s*

Constructed between 1991 and 1993 it was Eisenman's first design using Form*Z and it was the first design in which the software clearly left its marks: Boolean operations merged volumes together, previously folded, while triangulations ensured the complex surface's planarity. A whole new way of working was invented, resulting in a wire frame model, that was, rather than a structure conveying gravity, a pattern describing the design's emergence, and manifesting the underlying logics of the software's operation. The entire design emerged as a data set, from which drawings could be extracted. Ever since, the conventions of drawings have dwindled in importance (fig. 6, 7).

A few years later, in 1995, Eisenman conceptualized these 'M Emory Games': "Our work imposes a conceptual memory on the volumetric massing of an object, and in doing so attempts to subvert icons of presence, the building mass itself, with a striated network of what could be described as lines of memory. Little of the iconicity of these lines of memory comes from the traditional forms of iconicity in architecture, such as function, structure, aesthetics, or a relationship to the history of architecture itself. Rather, the iconicity of these lines comes from a writing that is indexical as opposed to iconic. An index is something that refers to its own condition. In this sense its iconic role is more one of resemblance than it is one of representation. […]"[28]

The Emory project resembles an *index*[29] of the operations conducted in Form*Z. In this respect,

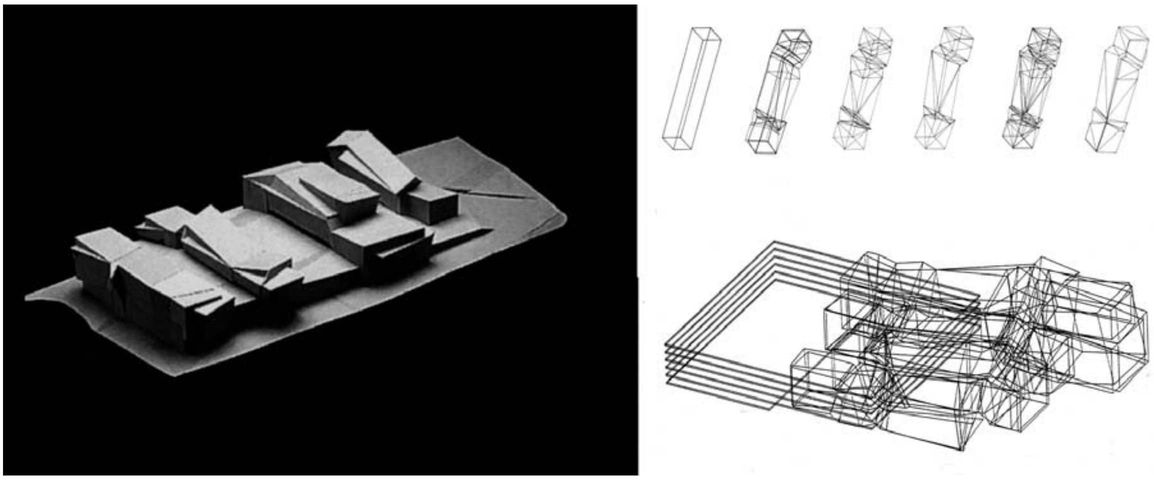


*Fig. 5: Peter Eisenman: Emory University Center of the Arts, Atlanta 1991–1993, Folding bars, Form*Z, Chipboard Model*

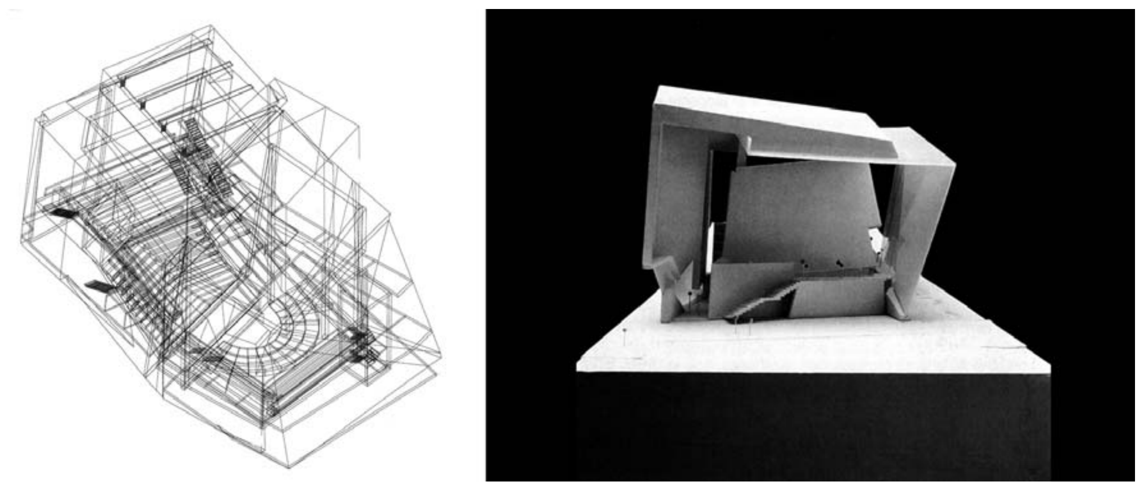


*Fig. 6: Peter Eisenman: Emory University Center of the Arts, Atlanta 1991–1993, Folding auditorium, Form*Z, Chipboard Model*

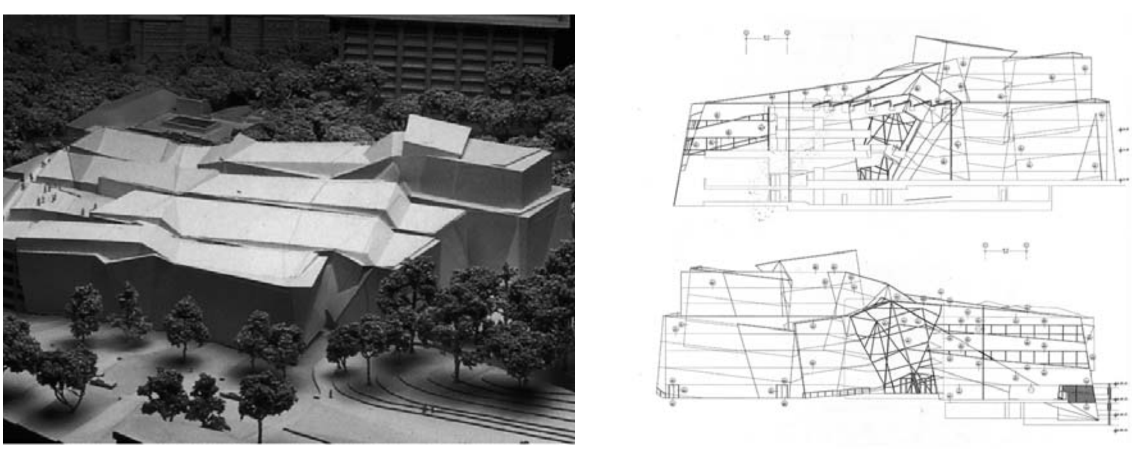


*Fig. 7: Peter Eisenman: Emory University Center of the Arts, Atlanta 1991–1993, Folding Model, Folding Section, 2D AutoCAD*

the design indicates primarily the process of its own generation, which centered around the possibilities of challenging inherited comprehension of space through the design of 'folding bars.'

## Differential calculus: Folding architectures

Gilles Deleuze's book *The fold: Leibniz and the baroque*[30] began to spread its influence through out the US American architecture scene in 1993 when it was first translated into English. In the same year Greg Lynn had already published *Folding in Architecture*,[31] countering Deconstructionism's ideas of the discontinuous and heterogeneous and favoring instead the continuous, the differentiated. One of the key advocates of *Folding in Architecture* was Eisenman.

What was the fascination that emanated from Deleuze's reading of Leibniz?

For Lynn, a young architect working with the latest software based on differential calculus, Deleuze's reading of Leibniz propagated a new logic, that of the "integration of differences within a continuous yet heterogeneous system."[32] It was in 1686 when Leibniz, propagated his idea of differentiation with "*Nova Methodus pro Maximis et Minimis, Itemque Tangentibus, qua nec Fractas nec Irrationales Quantitates Moratur, et Singulare pro illi Calculi Genus*."[33] Leibniz invented with differentiation a method that could calculate and thus comprehend the rates of change of curves and figures. Differential calculus was soon applied for the graphing of physical phenomena of movement or the graphing of curves for the construction of ship and bridge designs.[34]

Besides its practical application, Leibniz's differential calculus had also philosophical implications as it could analyze and thus allow 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*.

*Folding* in Architecture stands according to Lynn for a flexible organization in which dynamic relations replace fixed coordinates as the logics of curvilinearity depicted by Leibniz's differential calculus underlie the system.[35] Perhaps most notably, with software based on differential calculus architectural forms changed "from fragmented polygonal rectelinearity towards smooth continuous splinal curvelinearity, […] subverting both the modernist box and its deconstructionist remains."[36] (fig. 8)

Thus, at the first glance, Eisenman's triangulated architecture of the early 1990s had—at least superficially—next to nothing to do with either *folding*, or curvilinearity or Leibniz's differential calculus. And yet, its author insisted at length on the dramatic implication of Leibniz's mathematics for architecture, explaining that: "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'. If this idea is taken into architecture it produces the following argument. Traditionally, architecture is conceptualized as Cartesian space, as a series of point grids. […] 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.' He calls this form of an object 'object event.'"[37]

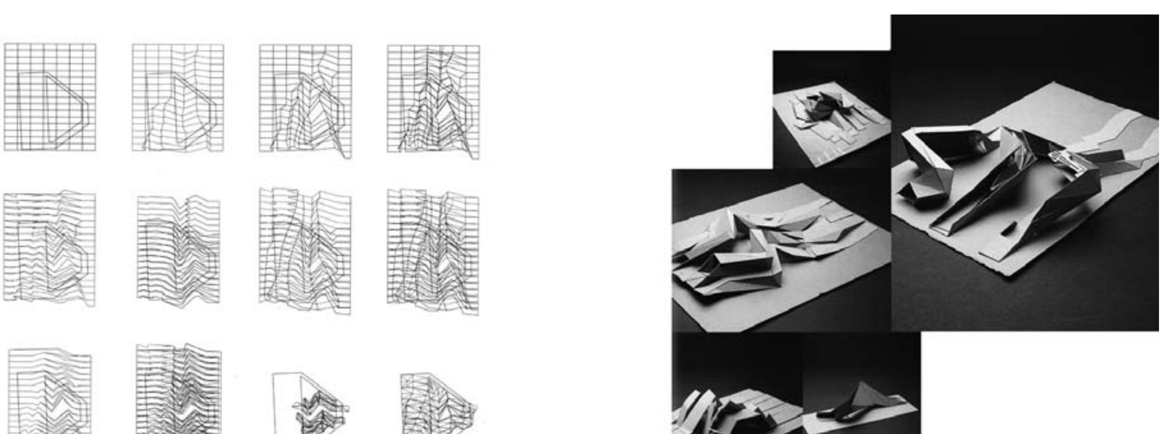


*Fig. 8: Peter Eisenman: Church 2000, Rome, 1996–1997. Triangulated folds entered the physical model production: Triangulation had turned into Eisenman's signature style—which was applied independent of any software's operations. The virtual house (1997) will be Eisenman's first project breaking away from triangulation using differential calculus.*

Eisenman depicts here what I first termed *versioning*[38] in 2003—thinking of design no longer as a single entity characterized by an essential form but rather as a series. Each design-event is hereby comprehended as a unique intricate version of a whole series of possible designs—all characterized through continuous similarities rather than clearly defined differences. In this sense, *folding* could have been interpreted by Eisenman as the divergence from the Modernists' mechanical kit-of-parts design and construction technique. Instead, Eisenman, discussed *folding* in topological terms: "A folded surface maps relationships without recourse to size or distance; it is conceptualized in the difference between a topological and a Euclidean surface. A topological surface is a condition of mapping without the necessary definition of distance. And without the definition of distance there is another kind of time, one of a nomadic relationship of points. These points are no longer fixed by X, Y, Z co-ordinates; they may be called x, y, and z but they no longer have a fixed spatial place. In this sense they are without place, they are placeless on the topological ground. […] Here the topological event, the dissolution of figure and ground into a continuum, resides physically in the fold; no longer in the point or the grid."[39]

*Folding* becomes one out of many possibilities out of Eisenman's repertoire of challenging figure-ground relationships and of changing the order of space, as it draws attention to that which is commonly overlooked: the coordination of space and architecture. *Folding*, the process of differentiation based on Leibniz's differential calculus, turns in Eisenman's hands into *the fold*, a formal tectonic, thought to be capable of changing not only traditional viewing conventions, but also inherited conceptions of space. *The fold* seems—at least to Eisenman—a perfect device with which to play his games of confusing the imaginary with the real, and the real with the imaginary. *The fold* presents an alternative to the grid of Cartesian descent as it 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.

Eisenman writes that the moment in which "space does not allow itself to be accessed through gridded planes"[40] is the moment in which the architect realizes that the process of imaging was always already present in the process of design and its realization—and thus inscribed itself into the material substance of architecture.

## CATIA: Escaping gridded space or realizing a hyper-industrial modernism

Frank O. Gehry's architecture, on the other hand, stands for the close interrelation between architecture's notational systems and architecture's material substances and the thereby resulting potential to challenge existing conventions. In this respect Kurt Forster has described Gehry's architecture as a work that "does not bear the dubious imprint of the modern form-giver but seems instead to have been released from its imprisonment in convention."[41] And Gehry himself confessed: "I used to be a symmetrical freak and a grid freak. I used to follow grids and then I started to think and I realized that those were chains."[42]

Gehry's outbreak from the imprisonment of conventions began with a fish, a form that according to him "escapes the architect's imaginary powers."[43] In 1989 the design for the 180 feet long (54 m) and 115 feet (35 m) tall fish for Barcelona began: The fish was at first modeled in wood and metal but the complexity of its surface quickly reached the limits of what two-dimensional drawings could represent.[44] It was this complexity, which suggested to James Glymph, the offices' new managing architect, to use computer technology. At this point the office operated still with only two computers in accounting. Soon also the design of the Disney Concert Hall in Los Angeles needed to be represented: While the office previously rationalized and documented the shapes of Gehry's physical models in two-dimensional drawings with conventional geometry, the newly developed double curved surfaces clearly represented the limits of this technique (fig. 9, 10).

In order to cope with these difficulties, Glymph hired Rick Smith, an IBM consultant, who had, although trained as an architect, specialized in CATIA—software developed in the 1980s by the French aerospace manufacturer Dassault Systems for the then already highly automated car- and aerospace industry. In contrast to most architectural software, built on so-called Cartesian or analytic geometry (algebra), which defines forms through x, y, and z coordinates, CATIA, built on differential analysis (differential and integral calculus), defines forms through mathematical equations. Working with differential calculus allows designs with much greater flexibility:[45] rectilinearity, so favored over the past centuries—partially due to Gaspard Monge's projection techniques[46] which were also introduced to architecture through Jean-Nicolas-Louis Durand[47] and which have since ever then literally coordinated the discipline—was replaced through curvilinearity.

Suspending this century-old coordination Gehry's architecture destabilized the already embodied conventions of spatial experience. The soft-

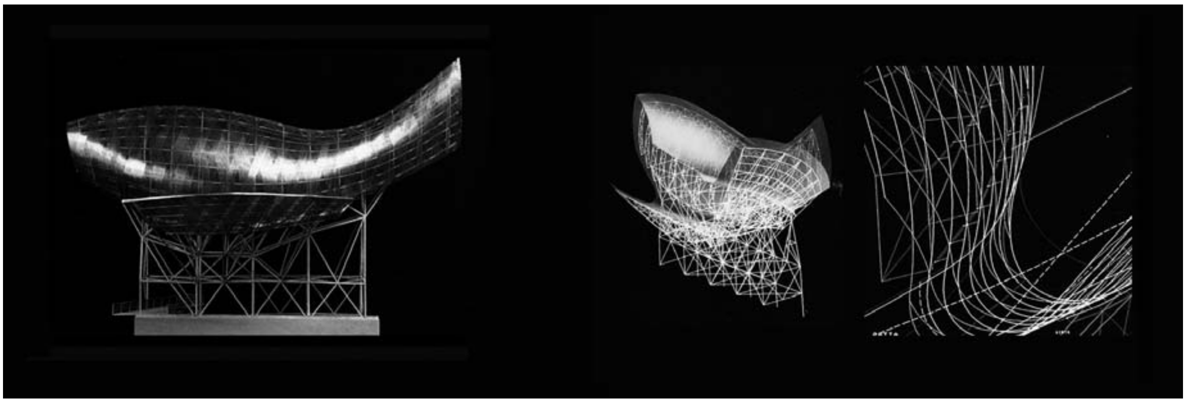


*Fig. 9 and 10: left: Frank O. Gehry & Partners: Physical model of the fish, Olympic Village, Barcelona, Spain, 1989–1992; right: Frank O. Gehry & Partners: CATIA model of the fish, Olympic Village, Barcelona, Spain, 1989–1992; the fish was at first modeled in wood and metal, which became rationalized with the software CATIA*

ware CATIA played hereby a significant role, as it allowed the representation of Gehry's designs, which defied architecture's traditional two-dimensional projection techniques: plan, section and elevations. Gehry's fish became the first large-scale architectural realization of a digital computer model, which did not rely on two-dimensional drawings.[48] For the first time in Gehry's office the imaginary realm of the digital model was successfully linked with the real realm of the actual design.

Despite the introduction of the computer into his office, Gehry's own working methods did not change: he still developed his designs in the tension between the imaginary of sketches and the physicality of models. The computer is thus merely used as a notational device, translating these models from the physical into the digital realm as Michael Sorkin has pointed out: "For Gehry the computer is a tool, not a partner—an instrument for catching the curve, not for inventing it."[49]

Nevertheless, much of Gehry's design could only be invented and developed after the computer had significantly changed the designer's imagination: The computer captures that which could otherwise not have been drawn, and thus assists the imaginary of the sketch to become embodied within the limits of that which is calculable: "The only sufficient (geometrical) description of the form is the form itself—now as a three-dimensional digital model."[50] (fig. 11, 12)

To be reviewed by Gehry or simply to be built, the digital model must eventually be transposed into the physical realm. The digital model and visualization techniques finally lead to innovations of material construction. The success of the digital model's realization in the physical realm depends—as Gehry's Disney Hall may here exemplify—increasingly on a close collaboration between designers and the construction industry. Bruce Lindsey remembers that: "A key reason for Gehry's adaptation of digital tools was the increasingly difficult task of describing innovative new designs to the contractor. His complex three-dimensional forms, when represented in traditional two-dimensional plans, sections, and details appeared to be even more complex."[51]

Deeply involved in the planning for the Disney Hall, CATIA was used to model the design in the digital realm, then to develop models and finally a 1:1 mock-up of the initially planned curved stone façade showcased at the 1991 Biennale in Venice: the software generated a model of the façade, dividing it in single segments while limiting the element's curvature and variation. It became quickly evident that the rationale underlying the CATIA software actively inscribed itself in the model as much as into the final design of the façade and even more so into the actual process of manufacturing the façade out of stone, which allowed tgo treat material in entirely new ways. The artist and architectural critic J. Gilbert-Rolfe pointed this out in his interpretation of Gehry's work in 2001: "Gehry used stone in the early versions of the Disney Concert Hall but made it behave as an image of its opposite: mobile, anti-gravitational, supporting nothing and the foundation of nothing."[52] *(*fig. 13, 14*)*

What then does it mean when Gehry in the words of Gilbert-Rolfe cites that: "'the truth to material' is silly in an age when one can build anything one can draw, and it may therefore be more fruitful to think instead about the truth to ideas"?[53]

Well, first we would disagree that everything that one draws can also be built, in the sense that this would deny the necessary translations that must occur between the digital and the physical realm, so there is no 1:1 relationship as Gehry suggests. It rather seems that with the aid of digital media, materials and their appropriation are pushed to new limits, which Gilbert-Rolfe puts this way: "If we recognize that the age of things is past and that of the image well advanced [... if with other words the] truth to materials becomes focus when one

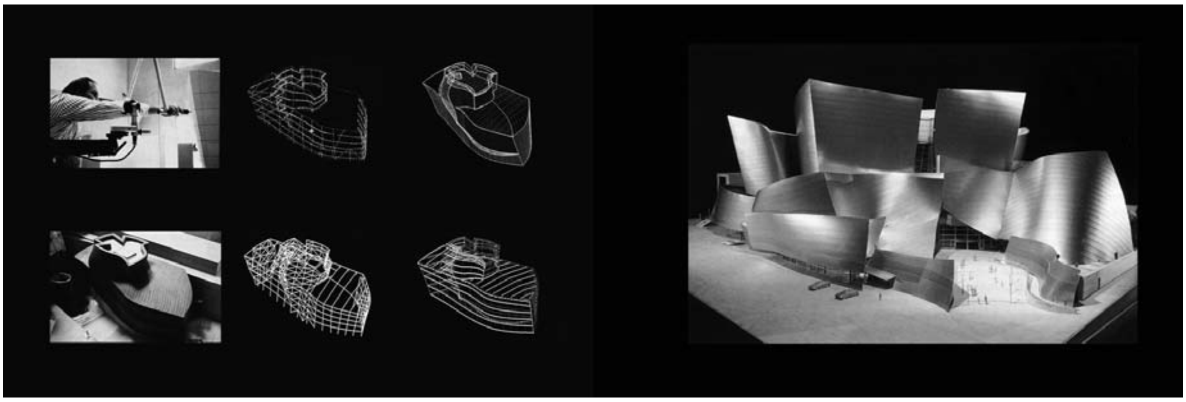


*Fig. 11 and 12: left: Frank O. Gehry & Partners: Discretization of the Disney Concert hall model in Gehry's office 1992; right: Frank O. Gehry & Partners: Final Model*

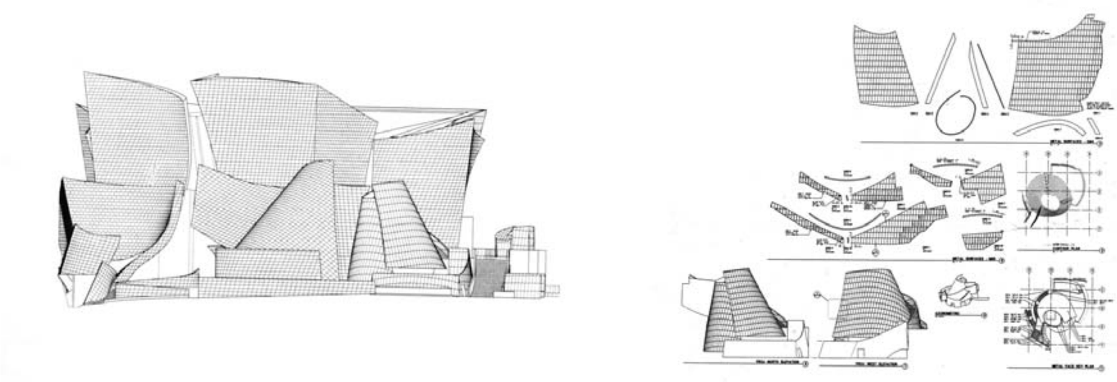


*Fig. 13 and 14: left: Frank O. Gehry & Partners: final elevation; right: Frank O. Gehry & Partners: Discretization of the Disney Concert Hall. A CATIA model has layed out the stone patternof an early version of the Disney Hall Facade (1991). Here the pattern for the final Titanium facade is unfolded.*

can make materials do anything one wants, then meaning must lie in the disposition rather than the disposed, in the image rather than the thing."[54]

And yet, we are not witnessing in Gehry's architecture the triumph of the image-sign, the disposition, over the material, the disposed. Rather familiar materials are used to such an extent that we are de-familiarized as the very notion of presentation/re-presentation is challenged: Gehry uses actual materials and at the same time presents the materials as their own representation.

In the same moment materials maintain their identity they are also turned into visual effects as Gilbert-Rolfe also emphasizes: "This can begin with a simple reversal through which Gehry can exploit a material's latent potential for self-contradiction. [… A] simultaneous canceling and evoking of the familiar."[55]

Self-contradiction is played out through the choice and application of materials: conventional expectations in the tectonic characteristic of architecture are generally frustrated, when that which is expected to be a solid load bearing wall is turned into a 'true and legitimate' representation of a wall. It is in a similar sense that the very thin titanium cladding presents the image of massiveness, even though it is nothing other than a paper-thin surface that has been turned into a perceived solid; or that the massive stone cladding is turned into a perceived surface. Gehry is invested in the material's potentiality—and, it seems, in a so far unexpected one. The application of the materials does not rely on what a material might be considered to be, nor on the conventional use of the material, but rather on what it may be applied as. It is in this sense that Gehry's work re-imagines the possibilities of the physical realm: "[…] The idea of ornament has been displaced into skin itself, into which the ectoplastic emphasis of the building also displaced from the inside to the outside, the idea of structure."[56]

Through the introduction of the digital medium in architecture the physical realm receives a new momentum. Gehry's designs go beyond that which was once considered possible in architecture: he has built the previously unimaginable, unrepresentable—in short, the previously unbuildable. And perhaps paradoxically that which seems uncalculable, geometrically ungraspable becomes realized through mere calculation. And while for Gehry "in the past there were many layers between [… his] rough sketch and the final building and the feeling of the design could get lost before it reached the craftsman,"[57] it is in the present the software CATIA —developed by a herd of anonymous programmers —which allows Gehry to get closer to his craft, the craft of building.

The introduction of the computer also introduced new means of reworking and re-presenting architecture, namely through a three-dimensional data-set rather than through two-dimensional drawings. These data sets have in the meantime become so perfected that they are 1:1 constructions of the final building in the digital realm—perhaps it is not far fetched to say that they are the hyperreal representations of the building, since the building can be reviewed in its entirety—a condition even impossible in the physical realm.

The digital version of the building is also hyperreal as its parameters and their effects upon one another can be deliberately adjusted as the continuously updated representations of the three-dimensional dataset showcase. Also Antonio Saggio emphasizes in his foreword to *Digital Gehry* the difference between the physical and the digital model: "An electronic model is by its nature something extremely different with respect to a traditional model since it is a living, interacting […] whole. While in one case the information is static, in the other all the bits of information are dynamically interconnected. An architectural element can be modified and the effect simultaneously verified not only on the desired design but also building codes, costs, static calculations or thermal distribution. […] The electronic model in this sense becomes a tool for studying, testing simulating and constructing. It is no guarantee for success but for the task of designing it is the most important step forward since the discovery of the perspective."[58]

Have we been so far accustomed to develop architecture through two dimensional planometric drawings, and to use the model and perspective drawings to represent the already designed architecture, certainly, those previous models and finally also the architecture had inscribed the techniques of their generation—had inscribed the preference for planar thinking linked to the notational techniques necessary for two-dimensional paper.[59] It is in this sense that "a real object resembles the methods that its contemporaries had of representing it."[60] Knowledge itself becomes 'represented' in the architectural object and enables the notation of spatial conceptions previously unimaginable in the double sense of the word. With the three-dimensional computer model a new mode of producing and reproducing architecture has arrived as Bruce Lindsey from Gehry's office realized:

"Drawing and modeling is a way of thinking out loud – we represent things in ways that are related to how we think. [… Thus] it is also likely that as we have invented new ways to represent things, so to have prompted new ways of conceiving things."[61]

CATIA has not only influenced the way Gehry builds but also how he thinks and sketches. Retrospectively Gehry's work has significantly changed, as much as it has changed the way the software company Dassault Systems develops its product CATIA.[62] In 2002 Gehry's office created an offspring, Gehry Technologies, which ventured in 2004 with "Digital Project"[63] into new territory: the development of architectural software. A recent press release suggests that: "Virtual Building harnesses powerful simulation technologies to underpin and support the entire construction project lifecycle within a single digital environment. Design, engineering, analysis, fabrication, project management and on site construction activities are all simulated and contained within the solution."[64]

The role of the architect can be expected to change significantly: Gehry himself thinks that he and his team are "on the verge of revolutionizing the way architecture is practiced. And […that he] may become the new Bill Gates of architecture."[65]

The here described changes in the design and construction of buildings suggest not only a change in the tools architects use—but also in the conception and construction of design. It is in this sense that our writing and drawing tools work on our thoughts and finally become constitutive what we call the physical realm. It is in this vein of thinking that Malcom McCullough suggested: "that computers allow us to work on abstractions as if they are things, and inhabit representations as if they were spaces."[66]

## Digital turn

Recently, in order to escape the limitations of traditional software, architects have started to utilize the full potential of the universal machine computer, and begun to code their architecture, a thought Yessios already had after his design experience with Eisenman in the late 1980s: "[…] It was becoming apparent that what we were talking about could only be done on the computer. Thus we almost had no choice. The design process had to include the development of new computer tools."[67]

"[…] It is probable that the whole design process might have been even more productive and imaginative if the designers were also the developers of the tools they considered desirable."[68]

In this respect, it is less digital imaging techniques than the calculability of design processes which comes to the fore. The digital image of a design is now seen as only one of infinitely many possible versions of the entry point to a multidimensional architecture dataset.

Is a conceptualization of the digital design process based on a theory of images sufficient?

No. A reconceptualization of the process of architecture based solely on a theory of the image is—as the examples of Eisenman's and Gehry's work have shown—too limited. The "digital turn" seems only to gain its full momentum when the potential of the universal machine "computer" is no longer confused with the potentials of the image-creating programs, which are merely effects of its operations.

Notes:

* Thanks to Miranda R. Callahan for discussing the paper with me.

1 Antoine de Saint-Exupéry, *The little prince*, written and drawn by Antoine de Saint Exupéry, translated from the French by Katherine Woods, New York: Reynal & Hitchcock, 1943, Chapter 2.

2 Opening note in Georg Flachbart, Peter Weibel (ed.), *Disappearing Architecture: From Real to Virtual to Quantum*, Basel, Boston, Berlin: Birkhäuser, 2006, p. 5.

3 See for a discussion on the real and the virtual my article: Ingeborg M, Rocker, *The Virtual: The Unform in Architecture*, in: *The Virtual House, Any Magazine* 19/20, New York: 1997.

4 W. J. T. Mitchell, *Picture Theory: Essays on verbal and visual representation*, Chicago: University of Chicago Press, 1994, pp. 11–35.

5 Richard Rorty, *The linguistic turn: Recent Essays in Philosophical Method*, Chicago: University of Chicago Press, 1967.

6 W. J. T. Mitchell, see note 4, p. 16.

7 Friedrich Kittler, *Grammophone, Film, Typewriter*, translated by Geoffrey Winthrop-Young and Michael Wutz, Stanford: Stanford University Press, 1999, p. 200.

8 Claude E. Shannon, *A universal Turing machine with two internal states*, in: *Automata. Studies, Annals of Mathematics Studies*, 34, pp. 157–165, 1956.

9 Friedrich A. Kittler, *What is new about the new media?* Internet source no longer available.

10 Lambert Wiesing, *Die Sichtbarkeit des Bildes: Geschichte und Perspektiven der formalen Ästhetik,* Hamburg: Rowohlt, 1997.

11 Wolfgang Hagen, *Computer Politik*, in: *Computer als Medium*, Norbert Bolz, Friedrich Kittler, Christoph Tholen (ed.), München: Whilhelm Fink Verlag, 1994, p. 158.

12 Peter Eisenman, *Visions unfolding: Architektur im Zeitalter der elektronischen Medien*, in: Peter Eisenman, *Aura und Exzess, Zur Überwindung der Metaphysik der Architektur*, Wien: Passagen Verlag, 1995, pp. 203–225, here p. 204.

13 The Carnegie Mellon Research Center, Pittsburg Pennsylvania, 1988, was a development from the Guardiola House 1987, which Eisenman praises besides Cannaregio, and Romeo and Juliet as one of his major theoretical and architectural breakthroughs.
See Peter Eisenman in an interview with David Cohn, *El Croquis*, 41, 1989, p. 9.

14 Peter Eisenman, *Carnegie Mellon Research Institute*, in: *El Croquis*, 41, 1989, p. 82–89.
In another text a year later—this time imbedded in the deconstruction debate—it is no longer Eisenman but his client who states that "the knowledge revolution, artificial intelligence, the system of knowledge have gotten out of hand, and have started to control man rather than the reverse. Science today is trying to find a way to control knowledge, and the knowledge revolution […] I want you to do a building, which symbolizes man's capacity to overcome knowledge. […] I do not want you to merely illustrate the problem. I do not want you to decorate a façade, with a computer chip, cut into the chip, there – we have symbolized the overcoming of knowledge. […] I want something far more significant. Something that challenges men's very occupation of space, not just the surface of space."
Quoted from Peter Eisenman, *En Terror Firma: In Trials of Grotextes*, in: *Deconstruction II, Architectural Design*, London: Academy, 1989, p. 40.
Eisenman's architectural response is what he calls a weak object, that is, an object which continuously escapes its comprehension as either that or that, but which remains instead always unknown. It is in this sense that the weak object does not symbolizes a destabilization rather it destabilizes as it withdraws its proper recognition.

15 Peter Eisenman, see note 13, p. 95.

16 Peter Eisenman, see note 11.

17 Manfredo Tafuri emphasized the axonometric condition of House X: "It is a rather unusual choice of axonometric model: unlike an axonometric drawing, which aims at providing the most possible objective information regardless of the position of the eye, this model presents itself as paradox, demanding only one point of observation and frustrating anyone who might want to take advantage of the possibilities presented by the three-dimensional reality of the model." The model appears as a representation, confusing reality and its representation.
See: Manfredo Tafuri, *Peter Eisenman: The Mediations of Icarus, translated by Stephen Sartarelli*, in: *Houses of Cards*, by Peter Eisenman, New York and Oxford: Oxford University Press, 1987, pp. 167–187, here p. 179.

18 Form*Z was first released in 1991 by auto·desksys, Inc. (automated design systems). Chris Yessios and partners started in January 1989 informally the work on the software with the aim to develop an advanced 3D modeling technology for personal computers.

19 Robin Evans, *The projective Cast, Architecture and its three Geometries*/Robin Evans, Cambridge, Mass.: MIT Press 1995.

20 Chris Yessios received his Ph.D. in Computer Aided Design from Carnegie-Mellon University in 1973. Afterwards he taught at the Ohio State University for more than ten years, where he met Peter Eisenman in the late 1980s.

21 Noam Chomsky introduced with his book Syntactic Structures (1957) the theory of generative transformational grammar (today sometimes referred to as computational theory of human language) suggesting that humans have the inherent ability to construct comprehensive sentences based on generative grammars. Chomsky distinguished two levels of structure: surface structures and deep structures. The creation and interpretation of sentences occurs by generating the surface structures (words) from deep structures according to a limited set of abstract transformational rules, which allow for unlimited variation. (See Noam Chomsky, *Deep and Surface Structure*, in:

*Cartesian Linguistics: A Chapter in the History of Rationalist Thought*, 2nd ed., Christchurch, New Zealand: Cyberedition, 2002, pp. 72–87.
Eisenman referred in his earlier house projects to Noam Chomsky—and in particular to the notion of deep (conceptual) structures and surface (perceptual) structures when he varied the basic architectural components: column, surface and volume using abstract rules of composition. In this way it was not so much the elements themselves as their conceptual relationships, which gained importance. Thus Eisenman referred to House VI, for example, as the virtual house. Regarding the surface structure Eisenman focused on the "objective material" of architecture "form" deprived of all its possible representational qualities. Form was no longer perceived as the means to an end, but became rather an end within itself. Architecture's functional and semantic meanings were hereby denied.
See Peter Eisenman, *Houses of cards/Peter Eisenman*; critical essays by Peter Eisenman, Rosalind Krauss and Manfredo Tafuri, New York: Oxford University Press, 1987.
See: Mario Gandelzonas: *From Structure to Subject: The Formation of an Architectural Language*, in: *House X*, New York: Rizzoli, 1983, 7–30.

22 Pierluigi Serraino, *Form*Z: Its History and Impact on Design Practice*, in: *History of Form*Z*/Pierluigi Serraino, Basel, Boston, Berlin: Birkhäuser, 2002, pp. 5–69.
23 Ibid., here p. 6.
24 Peter Eisenman, see note 13, p. 69.
25 Chris I. Yessios, *A Fractal Studio*, in: *ACADIA 87*, Proceedings of the Annual Conference of the Association for Computer Aided Design in Architecture, University of North Carolina, Nov. 1987, p. 3.
26 Ibid., p. 1.
27 Chris I. Yessios, *The computability of Void Architectural Modeling*, The Computability of Design, Proceedings of Symposium on Computer-Aided Design at SUNY, Buffalo, 1986, pp. 141–172.
Since 1986 Yessios has concentrated on void modeling, which considers the designing of architecture as a design of spaces, voids, enclosed by walls. The type of geometric modeling is in particular suitable for set theoretical operations, the so-called Boolean operations: Union, Intersection, and Difference. Eisenman's work which had already earlier conceptualized the void and its index in e.g. the F'ind-out house, became now 'empowered' through the software and Boolean operations gaining another level of complexity.
28 Peter Eisenman, *M Emory Games*, in: *M Emory Games: Emory Center for the Arts*, New York: Rizzoli International Publications, 1995, pp. 58–59.
29 Most recently Eisenman speaks about codex rather than index in regard to computer generated architectures: while the index is linked to a physical entity leaving a physical trace behind, the codex leaves traces yet without ever having had a physical presence of its own.
30 Gilles Deleuze, *The fold: Leibniz and the baroque*/Gilles Deleuze; foreword and translation by Tom Conley, Minneapolis: University of Minnesota Press, 1993. Originally published in French: Gilles Deleuze, *Le Pli: Leibniz et le baroque*, Paris: Les Editions de Minuit, 1988.
31 Greg Lynn, *Folding*, in: *Folding in Architecture: guest edited by Greg Lynn, Architectural Design*, vol. 63, no. 3–4, 1993.
32 Ibid., p. 8.
33 Gottfried, Wilhelm Leibniz, *A New Method for Maxima and Minima, as Well as Tangents, Which Is Impeded Neither by Fractional nor by Irrational Quantities, and a Remarkable Type of Calculus for This*, 1684.
34 The other great discovery of Newton and Leibniz—closely related to the finding of the differential calculus—was the finding of areas under curves—the integral calculus. Leibniz approached this problem by thinking about the area under a curve as a summation (ò) of the areas of infinitely many infinitesimally thin rectangles (dx) between the x-axis and the curve.
35 Greg Lynn, see note 30, p. 11.
36 Ingeborg M. Rocker, *Calculus-based form: an interview with Greg Lynn*, in: *Architectural Design*, vol. 76, no. 4, 2006, pp. 88–95.
37 Peter Eisenman, *Folding in Time: The Singularity of Rebstock*, in: see note 30, p. 24.
38 Ingeborg M. Rocker, *Versioning: Evolving Architectures—Dissolving Identities; Nothing is as Persistent as Change*, in: *Architectural Design*, vol. 72, no. 5, 2002, pp. 10–17.
See in this context also my discussion with Greg Lynn about his embryological house series and his Tea Pot series for Alessi in: Ingeborg M. Rocker, *Calculus-based form: an interview with Greg Lynn*," in: see note 35, pp. 88–95.
39 Peter Eisenman, see note 36, p. 25.
40 Peter Eisenman, see note 11, here p. 214.
"Der Raum läßt sich nicht weiter durch gerasterte Ebenen erschließen."
41 Kurt W. Forster, *Architectural Choreography*, in: *Frank O. Gehry, The complete works*/Francesco Dal Co, Kurt W. Forster; building descriptions by Hadley Arnold, New York: Monacelli Press, 1998, 9.
42 Frank O. Gehry, *Gehry talks: architecture + process*/Gehry Partners; Mildred Friedman, editor; with an essay by Michael Sorkin and commentaries by Frank O. Gehry, New York: Universe Publishing, 2002, p. 176.
43 Kurt W. Forster, *Architectural Choreography*, in: see note 40, p. 21.
44 B. J. Novitski, *Gehry Forges New Computer Links: Aerospace-developed software translates curved forms into crafted construction*, in: *Architecture*, August 1992, p. 105.
Bruce Lindsey, *Digital Gehry: material resistance, digital construction*/Bruce Lindsey, preface by Antonino Saggio, Basel, Boston, Berlin: Birkhäuser, 2001, p. 32.
45 Stephen Pacey, *Pure Disney*, in: *RIBA Journal*, vol. 110, no. 11, pp. 78–79.
46 The French mathematician and physicist Gaspard Monge published *Traité élémentaire de statique,* Paris (1848), *Géométrie descriptive,* Paris (1847) and *Application de l'analyse à la géométrie,* Paris (1850), with which he introduced projective techniques (plan, section, elevation), influencing ever since then our profession significantly.
47 The French architect Jean-Nicolas-Louis Durand introduced in the spirit if the French Revolution, a rational systematic architecture with *Précis des Lecons d'architecture données a l'Ecole Royale Polytechnique*, Paris 1819.
48 Laurie Manfra, *Rick Smith joins Frank Gehry*, in: *Metropolis*, April 2006, 179, p. 241.

49 Michael Sorkin, *frozen light*, in: *gehry talks*, Frank O. Gehry associates, Rizzoli: New York, 1999, p. 34.
50 Bruce Lindsey, see note 43, p. 39.
51 Ibid., p. 38.
52 Jeremy Gilbert-Rolfe with Frank Gehry, *Frank Gehry: The City and Music*, Amsterdam: G+B Arts International, 2001, p. 27.
53 Ibid., p. 1.
54 Ibid., p. 9.
55 Ibid., p. 4.
56 Ibid., p. 83.
57 B. J. Novitski, see note 43, pp. 105–110.
58 Antonino Saggio, *Preface: Flying Carpets*, in: Bruce Lindsey, see note 43, pp. 6–7.
59 Dan Willis pointed this out in: *The Contradictions Underlying the Profession of Architecture*, in: *The emerald city and other essays on the architectural imagination/*Daniel Willis, New York: Princeton Architectural Press, 1999. "The logic of the drawing has superseded the logic of building, resulting in buildings that aspire to be like drawings."
60 Antonino Saggio, see note 57, p. 8.
61 Bruce Lindsey, see note 43, p. 20.
62 Frank O. Gehry, *Commentaries by Frank O. Gehry*, in: see note 48, p. 52.
63 Digital Project by Gehry Technologies is a software package based on CATIA. It includes programs such as: Designer, a 3d modeling software, Knowledge Template, Viewer, Structural Steel, to incorporate steel structures into the design.
64 Gehry Technologies, Press Release, *Arup, Gehry, CenitDesktop Offer Digital Project*, Los Angeles March 23, 2006. www.gehrytechnologies.com
Gehry's partner Bruce Lindsey "describes the design process to be continuous through the digital model, computer aided manufacturing allows the continuity to extend from design through construction. The continuity crosses traditional professional boundaries and practices, reconstituting the architect as a central role in the process of construction. For architecture it promises to be as important an influence as the adaptation of industrial practices over the last fifty years. Mass production, standardization, prefabrication, and the industrial production of building components have changed the design of buildings into a process of building component selection and arrangement. These practices have changed the role of the contractor into one of management and assembly. With the opportunities offered through 'mass-customization', the traditional rules of economy, where regular organization and straight repetitive elements cost less, are no longer operative." Bruce Lindsey, see note 43, pp. 79–80. A good example for this approach is Gehry's Zollhof in Düsseldorf, Germany, for which concrete panels were poured in Styrofoam models that had previously been cut with numerically controlled routers. See Frank O. Gehry, *Der Neue Zollhof Düsseldorf/*Herausgeber Thomas Rempen, Fotograf, Thomas Mayer, Bottrop, Essen: Pomp, 1999.
65 Frank O. Gehry, *Commentaries by Frank O. Gehry*, in: *gehry talks*, see note 48, p. 52.
66 Malcom McCullough, *Abstracting craft: the practiced digital hand/*Malcolm McCullough, Cambridge: MIT Press, 1996. Quoted after: Bruce Lindsey, see note 43, p. 90.
67 Chris I. Yessios, *A Fractal Studio*, in: *ACADIA 87*, Proceedings of the Annual Conference of the Association for Computer Aided Design in Architecture, University of North Carolina, Nov. 1987, p. 3.
68 Chris I. Yessios, see note 24, p. 12.

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