# Algorithmic Design: Pasts and Futures

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## Algorithmic Design

Few would argue that there are profound ramifications for the discipline of architecture as the field continues to digitize. Finding an ethic within the digital process is both timely and necessary if there is to be a meaningful dialogue regarding the new natures of these emergent methodologies. In order to examine the relationship between implement and implementer, we must seek the roots of the underlying infrastructure in order to articulate the possible futures of digital design processes.

A quarter century into the information age we are compelled as a discipline to enter this dialogue with the question of technologia as program; information as both a process and program for spatial, architectural solutions may be proposed as a viable source for meaningful work and form generation.

## Techne and Episteme

Aristotelian thought suggests there is a difference between technique and technology: Technique, *techne,* is the momentary mastery of a precise action, the craft. Technology implies the understanding of craft, its underlying science, the *episteme.* The relationship is more complex; one needs to know to make, and one can have knowledge of a subject without the ability to make within the discipline. Further, to consider the changes in design methodology as simply a matter of changes in technique is to deny the historical links between the techne and the episteme. A third Aristotelian approach applies, the *phronesis*; the valued deliberation upon praxis. In this sense, the question of the ethic of technology is not a matter of technique; it is a matter of the implementation of its understanding.[1]

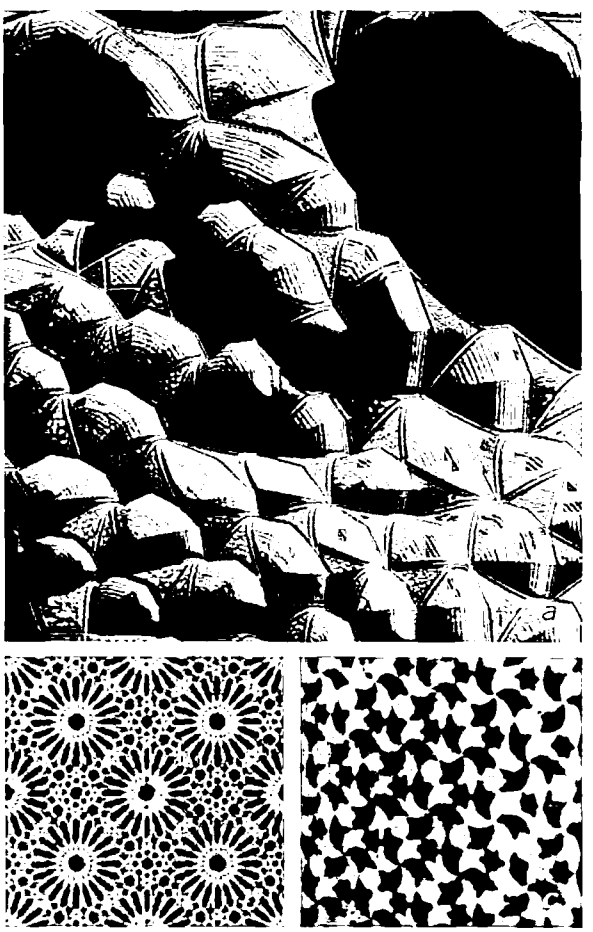


*Figure 1. a, Bifurcating modular ceiling vault detail from the Palazio de Nazarres. b, c, Patterned tiles located on lower wall.*

Several precedents begin to frame the questions regarding the nature of our current technology and the ethic that may produce a new mode of form making. The following

historical sections attempt to reveal connections between ways of thinking and ways of making.

**Andalucia and the Moorish Vaults**

Moses Maimonides, born under Moorish rule in Cordoba, a medical doctor known for his Kabbalistic writings argues for a subtle but substantial difference between image and form, or rather form that is *image* and form that is *substance*. Form as substance is that which is extendible both physically and psychologically, simply by the possibility that extension is required for its existence (this is a criterion for contemporary dialogue as well). If image is the emulation of dissimilarities, then substantial form is the relationship of similar qualities; it is the similar qualities rather than physical resemblance that construct a relationship between techne and episteme, providing in some sense a form to technologia. The existence of a formal relationship between the described qualities in the philosophical texts and the crafted qualities of the constructed palace is not coincidental.[2]

At the time Maimonides was writing, the ruling class in Andalucia was the Moors who forbade figural representation in both art and architecture. The walls of the Palacio de Nazares in the Alhambra detail the transformation from image/form to substance/form through surface pattern repetition and variation from the floor to the ceiling vaults. At the base, an organic ornament, an emulation of natural forms, stalks, leaves and inflorescences is flattened into the surface. Overlaid at border conditions is a formally similar but distinct written language. It is possible to image, if just for a moment, that the form of the language evolved from patterns observed from local nature conditions. Geometric patterns serve as the vehicle, when confronted with gravity, to differentiate into a structural proposal (fig. 1), a substantial proposition. A transformation has taken place, from repetitive 2 dimensional floral patterns to differential spatial vaulting, which bifurcates in complex 9-fold symmetry and when considered as a form, would also be considered quite figural.

**Ernst Haekle, Gruntvig's Church, and Antonio Gaudi**

As Maimonides and the Alhambra exhibit a relationship of complex form as an extension of both language and natural ornament, the taxonometric relationship of Gruntvig's church,

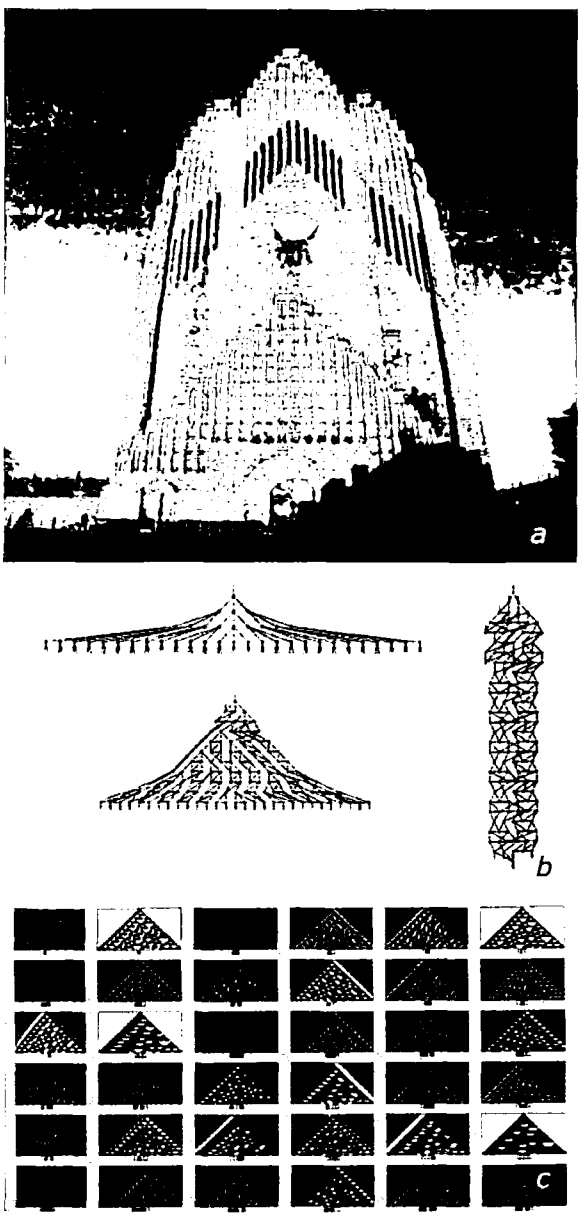


*Figure 2. a, Gruntvig's Church. b, Tabulated branching automata. c, Rule variations showing different 'corbelling' patterns.*

Gaudi's Casa Vicens, the roofscape of La Pedrera, and the illustrations from

evolutionary biologist Ernst Haeckle demonstrate this relationship through multiple and variable iterations of simple units.

Ernst Haeckle, 1834-1919, was a physician who abandoned his practice after reading Darwin's 'Origin of the Species,' this work now considered to frame the fundamental epistemic discovery of the 1800's. Haeckle subsequently became a vocal evolutionary biologist, coining the words ontology, ecology, and phylogeny. His work after 1850 could be partially described as attempting to draw the formal geometrical connections between all living things. His drawings and plates number in the thousands and believably capture the ontological relationships between evolutionary neighbors. These illustrations draw out the intrinsic geometrical formulas that frame systemic mathematical linkages between situations, objects and qualities that are seemingly disparate.[3]

Gruntvig's Church (fig. 2), located outside Copenhagen, was designed by Danish architect and painter Peder Vilhelm Jensen-Klint. The complex took 27 years to complete and although Jensen-Klint died during construction in 1930, his son Kaare Klint, the architect often noted for initiating Denmark's' modern furniture movement, took 10 additional years to complete the project. Gruntvig was an author 50 years prior who started an educational movement leading to the creation of a series of folk art schools. These schools were considered both a social and educational movement and the project included substantial social housing. The church is singularly powerful, and the humility and dignity given to the workers housing, each entrance is unique, and each structure is assembled from the same small yellow brick, is both hopeful and inspiring. The brick assembles into door arches, exterior corbelling, the pulpit, walls, piers, groin vaults, windowsills; its multiple variations appear limitless.

Barcelonan architect Antonio Gaudi y Cornet, 1852 - 1926, is well known for his innovation in concerning funicular derived modeling for structural resolution. It is his earlier work, notably Casa Vicens (fig. 3) and the roof work of La Pedrera (fig. 4) that share a patterning recognition with Haeckle and Jensen-Klint. The relationships of Gaudi and Jensen-Klint with Haeckle is revealing; the forms are

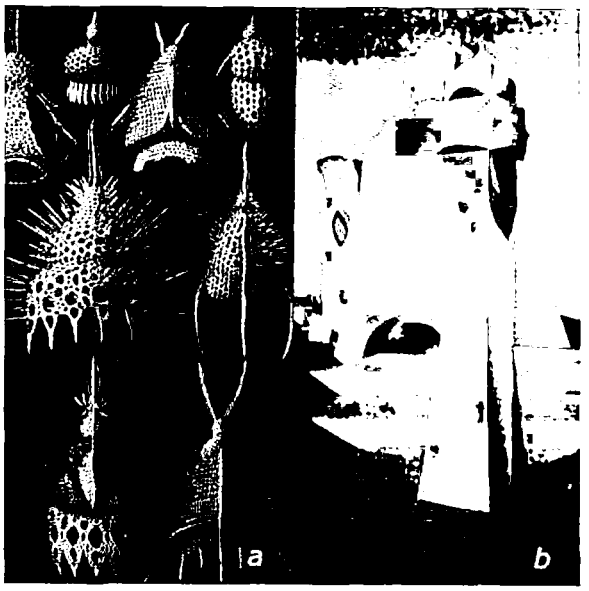


*Figure 3. a, Haeckle illustration of spirochete variations. b, Roof scape of La Pedrera.*

systemically derived, Gaudis' from gravity, corbelling systems and a sort of pre-biomimetic expression and Jensen-Klint from an almost pure reduction to iterative unit modulations. That which is Generally considered ornament ceased to be ornamental: the architecture was viscerally connected to the contemporary scientific and mathematical thought of that period. What might seemingly be a peculiar coincidence is rather a unique analysis of the way in which we perceive and process figures and patterns. The similarities are too close to be considered circumstantially. This does not suggest emulation; rather the inference is a key to the knowledge intrinsic in the perceptive process.

**Cellular Automata**

Developed in the 1940's as method of inquiry concerning the behaviors of complex extendable systems, cellular automata are localized algorithmic functions capable of adaptive behavior approaching evolutionary states. They are largely self-replicating and self -governing, and because of these feature can both emulate and solve problems of complexity. The universality of these simple systems has allowed adaptation to uses that include information theory, complex organization strategies, communications networks, particle physics models, economic theory, and construction; any discipline for

which computation is required.[4] It is on this inherent characteristic of universality and computational ability of cellular automata that emerging software environments utilized in design, engineering, fabrication and construction management are based.

Mathematician and software designer Stephen Wolfram popularized this condition of technological episteme with the publication 'A New Kind of Science.' Significant portions of this work are devoted to how cellular automata may seek to prescribe ontological connections through the multiple iterations and variations of simply rules expressed as algorithms. Developed into spatial, ornamental and structural propositions they seek to emulate the phenomenological processes of the world in real time. This is the radical postulation; to begin with an algorithm and find a whole, the *figure*, from the part, generatively, whereas previously the algorithm was developed to approximate the figure descriptively.[5]

In this sense the figure is defined as that which approaches the lifelikeness, and in the emerging methodologies of the architecture discipline it is the new figure, initiated by these infrastructural systems that may be sought.

**Branching Theory and the Latent Figure**

Once used primarily in computational evolutionary modeling, numerical branching systems have been co-opted by software engineers providing the basic strategies for organization of online databases and search engines. Confronted with only one node, considered as a digital 'place' containing sought information, at any moment, it is easy to imagine the experience over time constructs a complex map as a portion of information is linked to other portions. Based on algorithms arranged as cellular automata this map is a branched structure assembled with discreet sets of rules: node A links to node B, node B to C and D, D links to A, and C links to a new set and so forth. This experience is becoming if not increasingly more prevalent in our daily lives, it certainly emerging as powerful active and passive tools within our discipline. If the precedents show

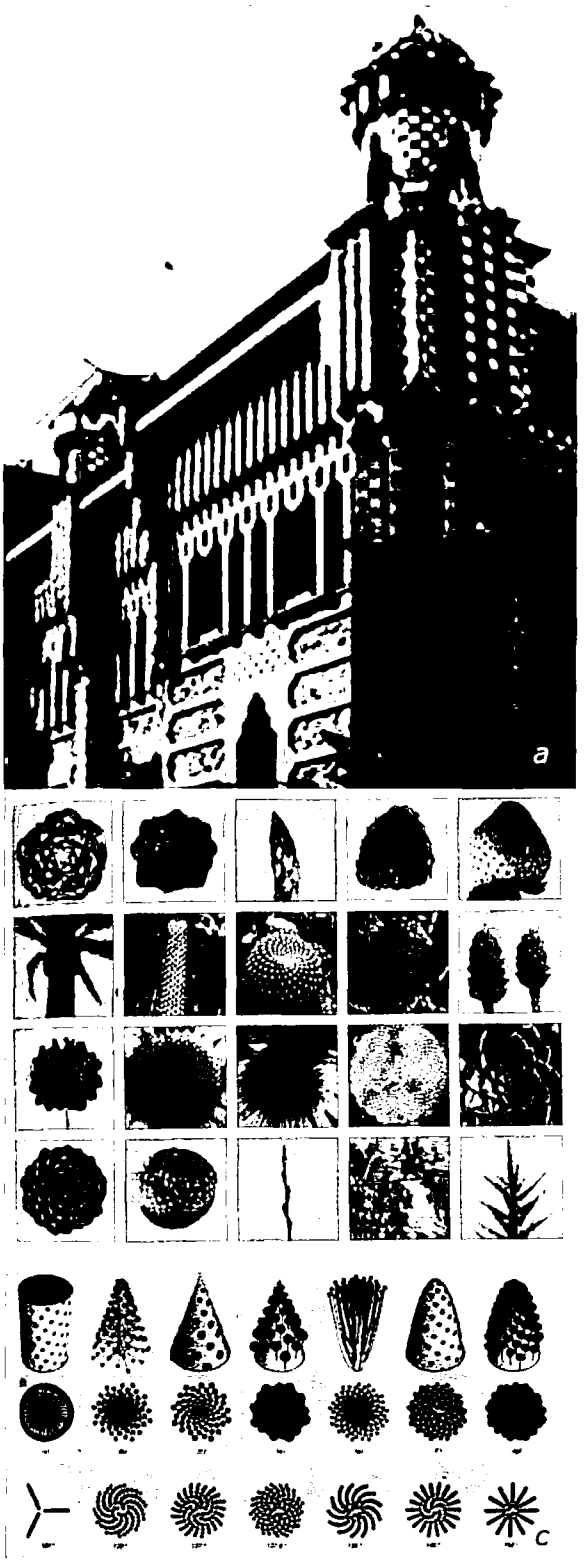


*Figure 4. a, Corbelling of Casa Vicens. Note the similarities with b, natural 'corbelling' patterns and c, the algorithmic patterning.*

multiple units *ad extensia* develop into figures, then these figures should be considered latent in the cellular unit. The causality of which may be that figure is inherent in pattern, or more probable, that *figure* is inherent in *us* through pattern, so in the most extreme case of systemic patterning, as the algorithm extends, a figure will always arise from self-reflection. This may be Maimonides' 'substance in form' and the Moors complex patterning evolving into figural space.

Organelles assembled from groupings of molecules form cells whose multiple self-organized extensions beget organs, which beget systems, which beget the body. The cell has no formal relationship with the body as a whole, instead considered the relationship is intrinsic to the nature of extensions of simple parts forming, by example of our own physiology, complex assemblies and forms.[6]

It is possible that Wolfram has opened up new possibilities for finding a substantial linkage from ornament both as structure and surface to our time through the possibilities of algorithmic patterns and digital corbelling.

Immersed in branching strategies, the current state of technological knowledge is literally at our fingertips. With the application of cellular automata the contemporary world is modeled, providing ever more accurate numerical descriptions in with the purpose of finding a deeper understanding. Following historical examples, the question is tendered: how should we build in our time?

The modeled branching system shown in fig. 5 articulates one structural and formal possibility for a system of units in multiple and variable extensions. Truncating cones stack with a variable of 13 degrees vertical rotation and full horizontal rotation. At the fifth iteration the variable y unit bifurcates the system, at the middle iteration of the next set the x variable reinforces the structure binding it to other stacked threads and so forth until and entire body is woven, reminiscent not of the individual cone but instead creating a new spatial figure. The ceramic cones are proposed as a discretely assembled sacrificial formwork. The degree of intrinsic variability assures that while any two structures would be similar, no two would be exactly the same. The cellular system begins repetitively and becomes more complex with each bifurcation until the system approaches randomness. Although the model is ceramic and not digital, it is digital in nature being cellular and autonomous, essentially the final figure is programmed from the geometry of the single cone.

**Tools for Complexity**

The techne and episteme of our discipline have become more intertwined with the implementation of self-replicating 'smart'

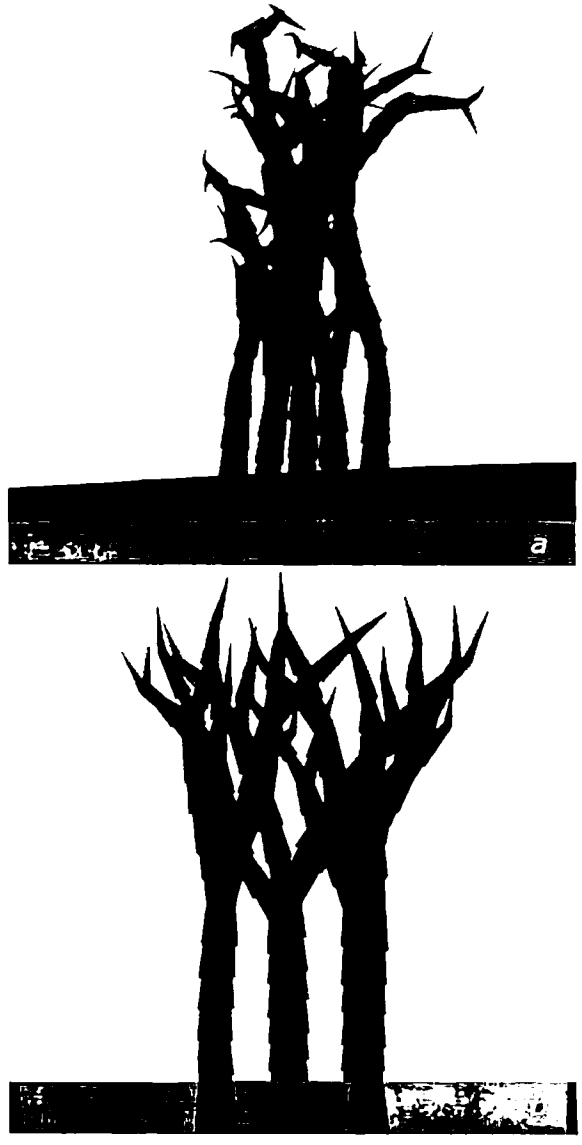


*Figure 5. a, b, Ceramic branching structures based on cellular iterations transforming repetition to complexity.*

systems. These systems simulate self-knowledge and software based on this technology is becoming commonplace. Current scientific and engineering inquiries into Complex fluid dynamics, finite element analysis, and dynamics modeling utilize some form of parametric cellular programming. Adapted by the architecture industry as a way to link costs with assembly, the value of parametric design as an investigatory implement for architecture lies with the ease of manipulation of carefully considered parameters. *Parametric* is defined as a point linked to the surface of a plane or the position along a curve in relationship to multiple parameters.

Mathematically, parametric equations express a set of quantities as explicit functions of a number of independent variables.[7] The digital design environment and can easily manipulate these functions both graphically and numerically allowing the creation of multiple versions with real time representation. A powerful pedagogical tool, the parametric design environment directly relates complex variables to a formal geometry where structural viability can be empirically tested through both digital and analogue modeling and directly outsourced to digital fabrication machinery.[8]

**Ethics of Technology**

With emerging digital processes and increased dexterity over our new implements, the discipline is well poised to address the question of content and clarity of form derived from emerging technologies. It would be good for us to remember, as we move towards these design futures, the historical *pathos* that located both meaning and understanding in preceding related methodologies.

The floral languages solidified into the walls and differentiating bifurcated vaults of Andalucia, the veracity of the single brick and all its variations delineating social housing and community in Gruntvig's Church in Copenhagen, and the structural and expressive clarity of Gaudi's work, provide explicit guides for the ethic that has yet to emerge from the digital process. Each of these examples examines both the language and knowledge of the time as fundamental to the nature of the architecture methodology. Cellular automata and algorithmic form generation is the contemporary descriptive language of episteme, and by virtue of its iterative qualities, desires to become a figure that is reflective of the current limits of knowledge. The value culturally is far greater than as an organizational tool, it is an expression of our everyday experience. Patterns exist in nature regardless of algorithmic expression, yet this code is still implicit within nature's structure, continually verified as attempts are made for accurate numerical models. It is our need for understanding that releases the patterns from obscurity. In this sense the distilled algorithmic pattern is not a reflection on of the generating object or its intrinsic numerical description; it is a reflection of us.[9]

These precedents suggest a lineage detailing an evolution from flat ornamentation, structural bifurcation, and unit corbelling construction. Considering corbelling as a bifurcation from multiple variations of a simple unit, cellular automata are digital bricks, these algorithms contain systemic information for extensive self-assembly. Popularized architectural shape making glorifies hermetically sealed organelles. The same degree of freedom, with increased efficiency and formally based on the intrinsic qualities found in proliferating branching systems, can be achieved through collective simple assembles. In this sense, the emerging field of state of the art 'smart' architecture methods, parametric in nature, can be defined a complex assembly of simple parts.

**Notes**

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