An Archaeology of Digital Architecture

Kai Franz[1]

Computer-aided design (CAD) originated as a translation that extended technical drafting into the digital sphere. Alongside the use of computers to aid in the creation and design came new methods of modifications, analyses, and optimizations. The immaterial condition of information as the new basis of digital design and its computational architecture gave birth to parametric design. Today, this digital architecture complex co-describes and ingrains most design practices, processes, and products. It is simply everywhere, and yet remains elusive. This case study explores research, works and phenomena in the area of digital architecture and computational design. This is exemplified in the plopper (dual axis precision deposition system), a low-res 3D printer that drives computation towards its periphery by combining its determinism with elements of chance and chaos. It is a machine that translates vectors, bits, numbers, points, lines, and algorithms into the opaque realm of matter and materiality. Post-digital in nature, the machine-made artifacts fabricated in this process never leave their digital origin entirely behind. Instead, we are asked to read them as traces or relics in an archaeology of digital architecture.

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What is digital architecture? Antoine Picon discusses this question in his book *Digital Culture in Architecture*. He asks if the sheer assistance of computers in the design process allows for this classification, or if the probing of the machine's capacities to be more than a drawing tool is needed. Picon reveals that "in order to distinguish the term [digital architecture] from the rapidly increasing use of computer-aided design […], there has been a tendency to confuse digital and experimental."[2] Furthermore, Picon observed that numerous contemporary practitioners respond to the question of what constitutes digital architecture. But their positions, contributions and models of practice diverge enormously. In the case of Frank Gehry, Picon noticed the heavy use of parametric modeling to achieve complex innovative geometries, despite the top-down authorship model of the practice. In the case of the architecture of Herzog & de Meuron, it is a new emphasis on surface and ornamentation that must be read in relation to digital culture. Finally, Picon observes what he calls "frozen fluidity," capturing the rise of a new formalism rooted in fluidity and gradual variability.[3] All of these concepts and manifestations have their part in digital architecture. They speak to the influence digital culture and computational methods and thinking had on the discipline.

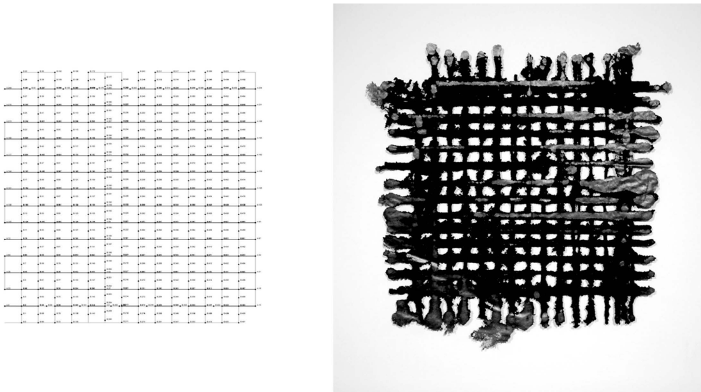
Computational design—another protagonist in the digital architecture complex—is a term that refers to the use of computational methodologies in the design process. Antoni Gaudi's Sagrada Familia in Barcelona, Spain, famously one of the earliest examples with its highly complex and intricate rule-based design, incorporates many computational design techniques. Today, parametric modeling with algorithmic optimization falls into the category of computational design. The Bird's Nest (the Beijing National Stadium in China), a project emblematic of this problem-solving side of the equation, utilized computational design methods for the purpose of advanced digital modeling and simulation to optimize the complex structural design. Computational design also refers to procedural and generative explorations, where practitioners utilize computational approaches more experimentally. An example would be the generative form-finding studies of Gregg Lynn that I will discuss later. These radically experimental practitioners and their search for a new formal language has often overshadowed the algorithmic optimization of parametric modeling and again we get another glimpse at the

2 Antoine Picon, *Digital Culture in Architecture: An Introduction for the Design Professions* (Basel: Birkhäuser GmbH, 2010), 60.

3 Picon, 60.

confusion of "digital" and "experimental" that Picon pointed out. How do we reconcile these differences and their transformational impact on architecture and design? Today, this digital architecture complex co-describes and ingrains most design practices, processes, and products.

Arguably, it is precisely this wide range of meanings—and not mere vagueness—that defines the *digital* in digital architectural theory and practice. Simply, digital architecture also includes the actual tools and software used to create digital models, plans, and environments. And the aesthetics of these emergent forms and processes are hardly neutral. Indeed, this capaciousness, the messy oscillation of digital culture, shifting computational methodologies and tools, and the atomization of the architectural object informs my own engagement with computer-aided design.



CAD Seed for Reset (left) and Reset (right), 2017, CAD drawing, CNC-code, CAM-software, plopper (dual-axis precision deposition system), polyurethane, sand, 36″ × 36″ × 3″[4]

4 © Kai Franz, 2017.

CRTL+A/+C/+V/+Z

The digital turn in architecture began when computers were integrated into the design process. Computer-aided design (CAD) originated as a translation that extended technical drafting into the digital sphere. The use of computers to aid the creation of an architectural drawing was initially intended to increase productivity and efficiency, but—as with most transformations from analog to digital—it had far wider implications for the discipline of architecture than these early promises suggested. The basis for this digital turn is rooted in the conception of *disegno,*[5] the principal method that produced the foundation of architecture and the fine arts during the Renaissance. *Disegno* signified the key intellectual element in the visual arts, validating its elevation from craft. Central to *disegno* was the use of drawings as the basic components to construct a finished composition. The blank ground of the drawing facilitated the space for invention, the capacity for designing the whole. Imaginative and intellectual at its core, this drawing process gave *disegno* its philosophical gravitas and ultimately gave birth to a concept of design as we know it today.

Arguably, much of what separates *disegno* from colorito or the mere skill of drawing from observation also marks the shift from manual drafting to CAD and the application of new technologies in drafting. Let us examine what this shift entailed by closely reading the two techniques, methods, and modes of drafting against each other. Most commonly, CAD software uses vector-based graphics to depict the objects of traditional drafting. Yet, these objects are more than just shapes. Already in the traditions of manual drafting (for example, in technical architectural or engineering drawings), the drawing is always already more than the drawing. It conveys information about processes, materials, dimensions, and tolerances in accordance with discipline-specific conventions. The same is true for the digital CAD drawing—it maintains these conventions of holding additional information, where a line is not just a line. Moreover, the digital line is never an actual line but itself already pure information. As a mathematical vector equation, the line itself becomes information, rendered visible only to the human eye. It starts to float and becomes light, malleable, smart, and fast.

As with other transitions of analog media, however, digitalization produces a profound transformative shift: the immaterial condition of a digital

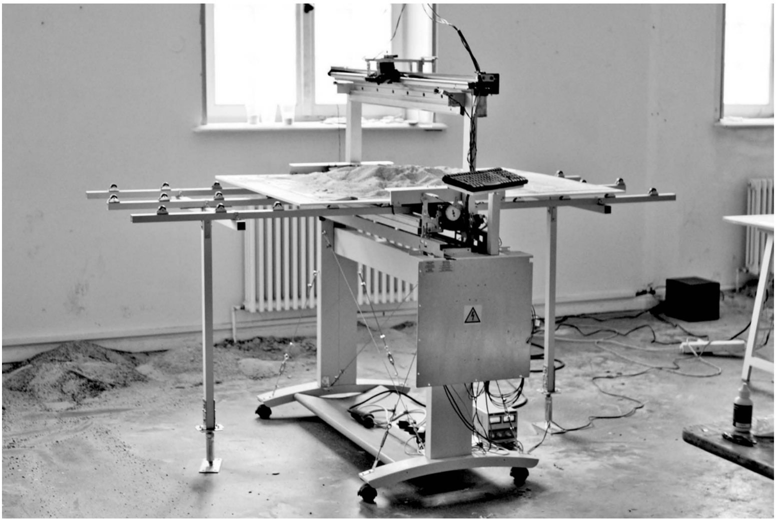
5 Disegno is the Italian word for drawing or design. It describes the total concept that constitutes the design in a work of art.

drawing gives rise to a new kind of editability, and it dissolves the singularity of the original drawing—"same, same, but different."[6] Together, these new conditions have established the foundation for digital architecture and allowed for a new set of design methodologies that would change architecture and its practice. Later, this new state of digital drawing would also be the basis for networked capabilities, creating new forms of collaboration, circulation, and exchange. When editability was established, the line became an informational object in the form of an equation, thus becoming computable. It can now be automated.

As a result, the proliferation of object-oriented programming (OOP), starting in the 2000s, caused new tools to emerge and required different skills, giving rise to parametric projects in architecture and design. Simultaneously, it is indeed the same binary core that set up the basis for the integration of digital fabrication technologies and the possibility of mass customization. Seemingly seamless, digitization in architecture penetrated architecture and the discipline as a whole.

Plans, drawings, and architectural models have played a critical role in shaping the discipline of architecture. These were never just bare artifacts of technical necessity; they acted more like a medium. One has to only think back to the countless examples of designs and buildings in competitions that were never realized but have been influential in effect. The same might be true for digital architecture, including all digital artifacts—be it CAD drawings, renderings, 2D/3D models, building information models (BIMs), or computer numerical control (CNC) technologies. Additionally, when we account for the computational end of things, the list should include information architecture with all its scripts, data structures, for-loops, and algorithms, all of which might be of equal importance, as they might bear the same potential: to reveal and trace their capacity for change.

6 Oliver Laric, *Versions*, online video, 2010, https://vimeo.com/17805188. In this essayistic film, Laric establishes the concept of objects as "versions" that permute through time and history, challenging the modernist dichotomy of copy and original. The work superimposes an audio essay with a visual essay combining animation and found footage from historical references, pop culture, memes and original digital media content to build its theory of version.



Plopper (Dual-Axis Precision Deposition System), CNC machine, hacked plotter, custom software and gcode, 4' × 7' × 5', Stuttgart, Akademie Schloss Solitude.[7]

My research and work have intersected the areas of architecture, computational design, and art through the plopper, a machine built to critically and playfully engage with pressing issues in the field of digital design. The plopper, a hacked architectural plotter, first deposits sand, then drops resin onto the landscape of sand, building up sculptural/architectural artifacts from the digital domain, layer by layer. In doing so, the machine translates the seemingly high-res from the digital condition into the impervious realm of matter and material.

The plopper is something like a low-res 3D printer. The machine and process are designed to critique contemporary fabrication technology for its premature relationship of the physical to the digital, of virtuality to actuality, and of matter to materiality. It drives computation towards its periphery by combining its determinism with chance and chaos. While the plopper's inputs—virtual 3D-models and CAD-drawings—are regulated by control, precision, and perfection, the machine utilizes chance, imperfection, and the will of matter in an effort to overcome determination. Post-digital in nature,

7 © Kai Franz, 2011–ongoing.

the machine-made artifacts fabricated in this process never leave their digital origin entirely behind. Instead, the objects can be read as traces or relics in an archaeology of digital architecture.

The plopper primarily fabricates artifacts that might read as sculptures or architecture, but occasionally, it also produces prints, drawings, and films. The artifacts begin as digital drawings created with computer-aided-design (CAD) software and are then fabricated through a custom computer-aided manufacturing (CAM) process. This additive process starts with the deposition of loose sand onto a wooden board, creating what could be characterized as a serialized landscape—serialized because, unlike natural entropic land formations, the underlying forces at play with this machine are driven by the logic of computation. Factors such as increment, scale, and resolution become substitutes for the weather, and the geology of the terrain is sterile like the monochrome grain of sieved play sand, the kind that we might purchase at a construction store.

In a second run, the machine then drops polyurethane onto this landscape. When the resin hits the sand, it sinks in and freezes the form. When a saturation point is reached, it flows at the contours and along the valleys, leaving the CAD drawing behind, following a new inner logic across the path of least resistance. This moment of adherence defines the point when the CAD drawing is converted into an artifact, when it is translated from a virtual digital drawing into a post-digital medium condition, when it ossifies in matter. Here, the plopps become readable, not just as if the drawing is rendered in a different mode.

In computation, the term serialization refers to the process of translating data structures or object states into a format that can be stored (for example, in a file or memory data buffer) or transmitted (for example, over a network) and reconstructed at a later moment in time. Can we use this concept to decipher the workings behind the plopper? It literally applies because information is translated into machine movement when the digital drawing is interpreted, decrypted by the computer, and transmitted to the machine to be executed. However, serialization might also serve as a conceptual framework to understand the nature of the process and help us unpack the workings and questions behind the machine. Eventually, we might view the constructed artifacts that the machine produces analogous to a file—as information stored in sand. While it might not be possible to reconstruct the original data states from these objects perfectly, this concept introduces a temporal dimension because stored means to be used later and/or otherwise, and equally that there was indeed a past set of operations that have been recorded. The potential for reading these digital artifacts implies that we are at a distant moment of pause. They are readable in an archeological sense.

Untitled Plopp No. 36, CAD drawing, CNC-code, CAM-software, plopper (dual-axis precision deposition system), polyurethane, sand, 6″ × 12″ × 4″.[8]

Was ist das? Was willst du von mir?[9]

Aesthetically, when I started to work with this process, the initial plopps gave me pause. The works seemed as concrete as they were abstract. Their indeterminacy was something that was striking. The objects exhibited an underlying serial nature irrespective of their formlessness. Together, these qualities read almost absurd or surreal. Yet, this surrealism was also immediately nullified by their concreteness, not to mention their superficial origin.

8 © Kai Franz, 2011.

9 English translation: What is that? What do you want from me?

At the time, it was important to me to stay with this technique. I did not want to invent another machine at risk of fetishizing the spectacle of the invention or, even worse, the inventor. I thought it would be more challenging to stay with what was in front of me and figure out what was at stake, conceptually and aesthetically. It was the first step to conceive of these works as artifacts in an archeology of digital architecture, which has become a methodology of my creative practice for over ten years.

There is a discrepancy of the work in its virtual vis-à-vis its physical state. All of the little fingers and arms seen in image 3 are not actually part of the drawing. These only emerge in the fabrication process. I classify the early works that were created by the machine as calibration pieces as they were designed to probe the internal mechanics and manifestations of the process/technique. The guiding questions for creating the CAD input, the seed drawings, were simple: What is the difference in mark between a horizontal, a vertical, and a diagonal line? When does a grid turn into a surface? Later works manufactured total abstractions, where the complexity did not allow reading the machine language as clearly. The impetus then became an inquiry aimed at exposing the differences between the analog and the digital states of the work: What happens when the same drawing is produced twice?

Möbius-Wurst[10]

In the studio classes I teach at the Rhode Island School of Design, I integrate technology into my courses in unorthodox ways so that students immediately question and challenge the meaning and use of a particular software or technology. For instance, when I introduce my students to Rhino, a 3D-modeling software, I usually give a brief fifteen-minute introduction to the

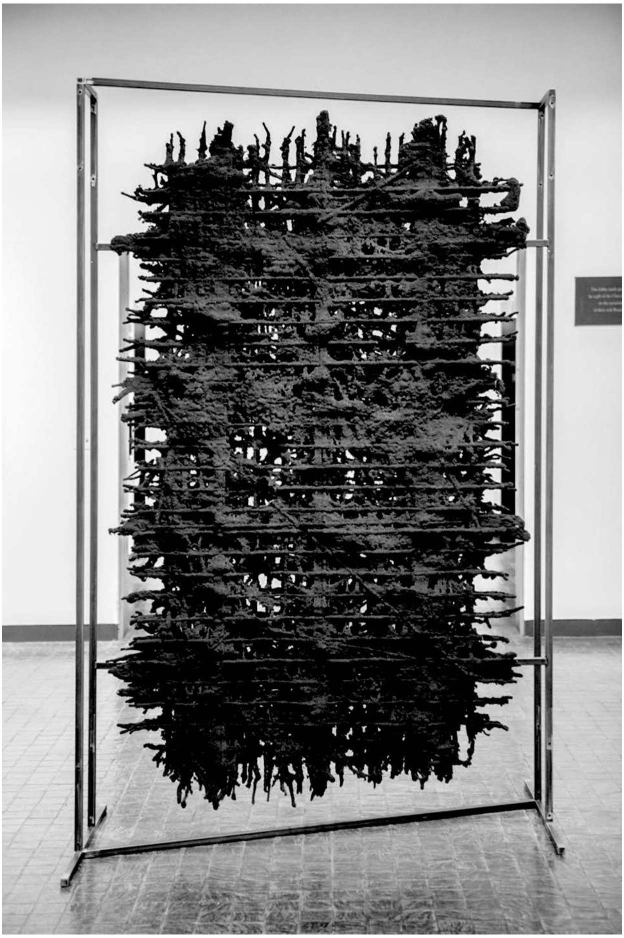
10 "Möbius-Wurst" does not directly refer to the author's artwork of the same title. Said work, a hand-made small-scale sculpture also formed out of sand and polyurethane resin, parallel in material to the plopps yet inversely to their forces, external not internal, was 3D scanned which resulted in a 3D model full of triangles; like a hollow shell the triangulation stood against the original form, a formless sausage-like figure, whose upward facing motion, the tilt and lift of the head, with its spiraling torso, could only be interpreted as though the thing was stretching into a Möbius-strip or maybe becoming a Möbius-strip; but cast with that web of mathematically secure triangles, it oscillated between completely fixed geometric definition and loose formlessness, a Wurst-like thing, a digitally processed Wurst, a triangulated Möbius-Wurst.

user interface and the program's functionality. I then bring in a nude model and continue with "3D-modeling from observation" and give instructions that sit somewhere between a software tutorial and a classical live drawing session. For example, "Create a new layer, and use the polyline tool only to draw the contour of the figure" or "Draw a random shape and use the copy tool to work out the shading by duplicating this curve." This playful—and in certain ways impossible—task that the students are confronted with instantaneously challenges the underlying mathematical bones of the software and its working environment. It also confronts the difference of virtuality, and the diagrammatic nature of space in CAD environments, as opposed to the actuality of physical space in real life, an inquiry that is central to the entire studio, my practice and the work presented here.

Sometimes, I think of the plopps as alien spit—a reference to their serial nature, futuristic characteristics, and loose geometric qualities. Simultaneously, the works also read as remnants of some long-deceased civilization, as archeological relics, or as artifacts retrieved from the bottom of an ocean. The title for my recent solo exhibition at the Bell Gallery at Brown University "While Still Before Us After All" was an attempt to highlight and foreground this contradictory temporal dimension of the work. It was also an effort to render the body of work visible as an acceleration of today–as a dark residue of our current culture and technologically determined existence.

In 2014, it had gotten to a point where I was frustrated with the fact that I would create the initial drawings, the input for the machine. The larger project was conceived to question notions of authorship in an age of computational production. For a human subject to create the "seed" it was operating in opposition to this, as the subject would remain the author throughout. It also seemed old-fashioned, because the work would follow a lineage from idea, over sketch (or drawing), and making, to object (or plopp). Several attempts followed, aimed to question the authority of the drawing.

CAD compositions for one piece were appropriated from test patterns and structural compositions from common 3D printing paths. In another attempt to undermine the deterministic weight of the drawing, the CAD drawing was exposed to virtual gravity in a computer simulation, prior to the fabrication. This intervention was inspired by the process itself. If before the work stayed clean, computed, and perfect in its diagrammatic state (namely the digital drawing), and things only turned messy in the physical realm, then here the attempt was to break these distinctions and hierarchies.



Perlin Grid, 2017, Perlin noise algorithm, CAD drawing, CNC-code, CAM-software, plopper (dual-axis precision deposition system), polyurethane, sand, 65″ × 105″ × 25″, David Winton Bell Gallery Brown University, Providence, USA.[11]

11 © Kai Franz, 2017.

Almost in a kind of for-loop fashion or recursive gesture, it was aimed to replicate what is happening in the physical state of the work in the digital condition using the same logic for its distortion-gravitational force and material behaviors. At other times the drawings were generated mathematically, through probability and randomness, or algorithmically determined, as with the following work.

Sand to Noise

The formation of the sand landscape in *Perlin Grid (2017)* is determined by a Perlin algorithm, a noise algorithm that is commonly used to simulate natural phenomena in computer graphics. In *Perlin Grid,* this digital procedure, which is used to emulate nature in CGI (computer-generated imagery), was returned to the physical realm. Perlin noise, invented by Ken Perlin in the 1980s, produces textural gradient noise that is used to increase the appearance of realism in computer graphics. Synthetic textures using Perlin noise are found in CGI to make computer-generated visual elements appear more natural, by imitating the controlled random appearance of textures in nature[12]–objects of application span from the ephemeral to the complex, they include "representations of clouds, fire, water, stars, marble, wood, rock, soap films and crystal,"[13] but also terrain and vegetation. By now, these images have become ubiquitous, in certain ways they are the very grain of computations' idea of nature.

Emergence

During the second half of the twentieth century, computer science and the natural sciences experienced a revolution, when bottom-up thinking and design challenged its basic methodologies—away from hypothesis, that rests in approval and disapproval—towards the study of the effects of emergence. Cellular automata are an example of this shift and "while studied by some

12 "Perlin Noise," in *Wikipedia*, accessed May 31, 2022, https://en.wikipedia.org/w/index.php?title=Perlin_noise&oldid=1090721154.

13 Ken Perlin, "An Image Synthesizer," *ACM SIGGRAPH Computer Graphics* 19, no. 3 (July 1, 1985), 287, https://doi.org/10.1145/325165.325247.

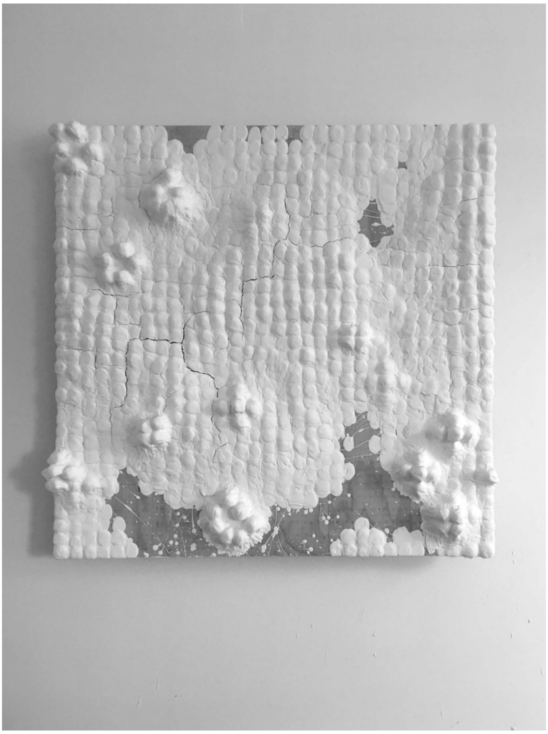
throughout the 1950s and 1960s, it was not until the 1970s and Conway's *Game of Life*, a two-dimensional cellular automaton, that interest in the subject expanded beyond academia"[14]. In the 1980s, Stephen Wolfram developed expansive research of one-dimensional cellular automata, the simplest type of a cellular automaton, a binary, nearest-neighbor, one-dimensional automaton that culminated in the publication of his book *A New Kind of Science* (2002).

Cellular automata are just one example of a generative system that produces emergence. In essence, these systems produce unpredictable phenomena and a high degree of complexity in behavior based on a simple generative logic, such as deterministic rules and parameters. Synonymous to such generative design strategies are agent-based design systems and particle simulations, L-systems, and evolutionary or genetic algorithms, these are computational procedures and models which have been instrumentalized and celebrated by architects over the last two decades as novel methodologies in design.

A common denominator of these generative design processes is that they do not produce a single outcome, but instead output a class of images or results. Greg Lynn, as one of the earliest—and among the most ambitious—practitioners to experiment and theorize digital architecture calls these resulting arrays "families of forms." Lynn's *Embryological House (1997–2001)*, often seen as a pivotal work in the discourse of digital architecture, was a conceptual project, aimed to rethink the house typology beyond the modernist doctrines of simplicity, linearity, modularity, and repetition. His concept was based on an organic prototype that is at once genetic and generic, from this generative prototype or system an infinite number of iterations could be generated[15]. The project was never built, in fact it was conceived as a conceptual work occupying and remaining exclusively in the digital sphere. Moreover, aesthetically and formally, the project embraced the utopian belief in the digital as a paradigm shift and new ground, typical for the 1990s and 2000s.

14 "Cellular Automaton," in *Wikipedia*, accessed June 14, 2022, https://en.wikipedia.org/w/index.php?title=Cellular_automaton&oldid=1093143614.

15 The Canadian Centre for Architecture, "Greg Lynn's Embryological House: Case Study in the Preservation of Digital Architecture," accessed July 2, 2022, https://www.docam.ca/conservation/embryological-house/GL3ArchSig.html.



Keep Smiling, Game of Life cellular automaton, instructional PDF, house paint on wooden board, 48″ × 48″ × 9″ .[16]

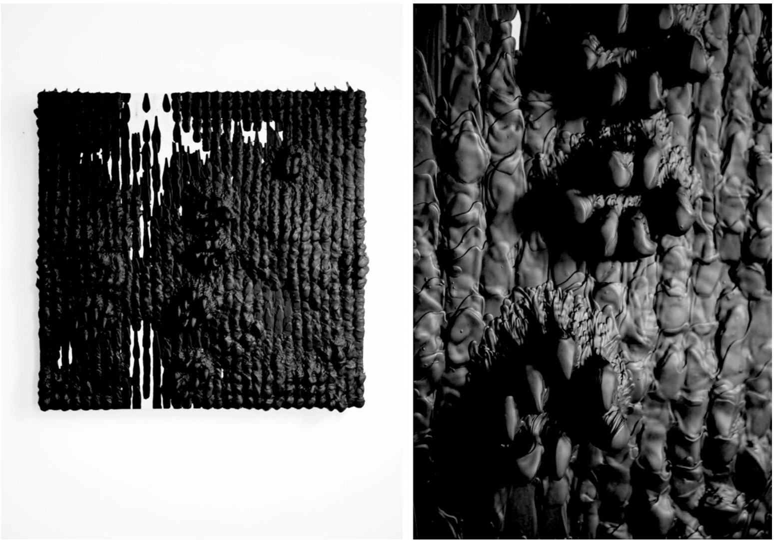
In my own work, I have explored themes of emergence and the relationship of encoded information and rules-based systems intensely. In a series of algorithmic paintings, I literally re-enacted the *Game of Life* following the instructions of the computer simulation of Conway's 1970 *Game of Life*. The act of painting here is dumbed down: Deprived of human agency in the execution of this work, I drop spoonfuls of paint onto a wooden board. The *Game of Life* consists of a two-dimensional grid, where cells can either be on or off, dead or alive. The initial start composition, the states of all cells at the beginning, is called generation zero. It is determined externally, either by the "player" or through randomness—all cells are either dead or alive. What follows is the

16 © Kai Franz, 2015–16.

application of a simple set of three rules relative to the states of the neighboring cells for each cell on the grid: (1) Any live cell with two or three live neighbors will be reborn. (2) Any dead cell with exactly three neighbors that are alive will be newborn. (3) All other live cells die or remain dead. These rules are applied to each cell to compute the following generation(s). In my re-enactment of the *Game of Life*, for every cell that is alive, I drop one spoon of house paint. When the generation is complete, the paint dries. Afterwards, the next generation will be completed. What takes seconds to compute in the simulation, takes many months to execute. To paint via this process means to manage paint. The question is no longer "what", or "how to paint", but maybe how to cope with paint. But paint is only one part of the equation.

Between 2015 and 2016, I created four works as parts of a series of algorithmic paintings in this manner. All four are re-enactments of the *Game of Life* again, all four have the same initial starting condition at the beginning, their diagrams are identical. However, the boards were orientated on different angles in space. This was an effort to acknowledge and simultaneously overcome gravity as a totalizing force or condition. The series took about 18 months to complete. Is it too far to say, duration and the impact on everyday life mirror computational ubiquity and determinism today? The titles of these works indicate the vector of the surface normal of the grid or plane, in other words its orientation in space during the making. One exception, "Keep Smiling", was chosen with a bit of black humor and alludes to the endurance of the work. It was also a silly way to entertain myself, or maintain sanity. I chose this particular pattern or cumulative composition at least in part, because I noticed and liked the grotesque clown-like smiling face in the negative space of the work. It is also somewhat of a friendly smile at many of the modulations that the parametric project in architecture has produced. My critique: While said to reject the homogenization (serial repetition) of modernism and pure difference (agglomeration of unrelated elements) of post-modernism in favor of differentiation and correlation as key compositional values, it seems merely to produce a gradient of form, and it does this across the grid and still within it.

In 2018–19, I created another series of *Game of Life* paintings. This time they were matte black. A decision that seemed at first somewhat counterintuitive. It felt like a digital move, like changing the fill color on a shape in Illustrator. It was a step sideways and not forward. Imagining the black and the white paintings next to each other, it was indeed also a wink at the binary determinism that inspired me to make this work.



Life (-0.14, –0.51, 0.85), 2018–19, Game of Life cellular automaton, instructional PDF, house paint on wooden board, 48″ × 48″ × 10″.[17]

Failure/Infinity

If *disegno* drew its emancipatory power, the facility for intervention and design, from the possibility of the blank ground or the infinity of the whiteboard, then it seems that with digital architecture such affinities for infinity newly appear. Only now they lie within the object itself, namely in the fluid dynamism of architectural form, behind the infinite class of objects.

Earlier, I used the concept of serialization as a metaphorical vehicle to introduce the idea of readability in the plopps. The truth is however, that these artifacts will never be legible to a machine. They are simply incomputable, because the works absorbed actual randomness and chance when they came to life. Any attempt to accurately reconstruct from these artifacts would fail. This point of non-return is indeed a conscious part of the design, aimed to break the all too often linear chain of optimization and computational

17 © Kai Franz, 2018–19.

over-determinism that habitually wants to rest in the pure optimism of digital design. Computational prediction and simulation still fail at the level of individual grains of sand, no matter how banal the parameters of our pseudo-rationality might be. Why do we dare to bring them to life? At best, the dynamism in these digital methodologies presents us with an animated diagram of *disegno*, where all the iterations morph into an endlessly malleable figure. It seems that the captivating allure of this brightly shining figure in the moving image still fascinates us, maybe even blinds us. But this is precisely why judgment should come with urgency. For, if *disegno* is still *design*, the question of quality is still an open one. All too often it seems to be a forgotten one. I am inclined to say it is still a human one.