

Gehry and the Glitch: Serendipity in Digital Design Processes

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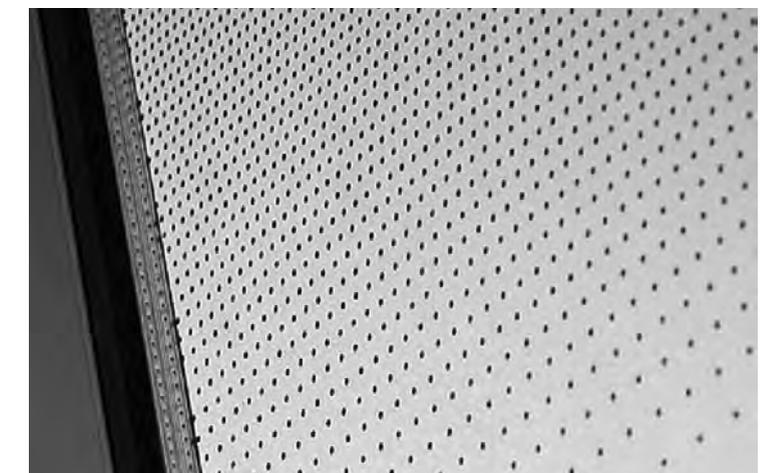
INTRODUCTION

In 2006, Frank Gehry completed his first building constructed entirely of glass. The Interactive Corporation Building in New York, or IAC as it is known, broke new ground in terms of the degree to which mass-customization of building components drove the design and construction process. In a time when visual programming was limited, 1,349 of the 1,437 exterior glass panels are unique in their shape and degree of twist. Additionally, baked-on ceramic white dots—so-called frit (fig. 1)—cover each of the glass panels and were coordinated and composed with regard to each individual piece of glass.

Tolerances were introduced by the glass panels' cold-warped assembly, or bending elements, in situ to fit the curtain wall's design. In contrast, the process of screen-printing ceramic frit onto the glass involved fusing it to the surface during the heat strengthening process. The resulting durable patterns in glass (fabricated by Saint Gobain in the Netherlands) required precise assembly of each distinctive piece. Post-fabrication required an on-site laser scanner to correlate and analyze the construction process as discussed by Brandt's essay on computational determinism.¹ Since these frit-

ted glass products are tempered, or heat-strengthened, they cannot be further altered on site. Reflecting on the exactitude of the design, fabrication, and coordination prompted this investigation into methodologies experienced in the process, like digital serendipity or 'glitches,' turning them into "formal" aspects for future use.

Figure 1: Close-up interior view of the IAC fritted glass panel



FRITTED GLASS IN ARCHITECTURE

Ceramic fritted glass has recently become more salient to architecture as digital fabrication techniques expand the possibilities of combining graphics with architecture. Beneficial features of ceramic silk screening—such as indestructible enamel bonding, excellent scratch resistance, ease of cleaning, variation and customization of colors and patterns, sun shielding capacity, and spandrel blocking—make this process appealing. Projects such as Gensler Los Angeles, the Aqua Tower in Chicago by Studio Gang Architects, and One Midtown Plaza by Mack Scogin Merrill Elam Architects are just a few examples that demonstrate these benefits of frit as a building design element. Improved energy codes have also increased the interest in fritted glass. Even non-building related organizations, like the Audubon Society, endorse fritted glass as a sustainable design feature because these graphic marks make it easier for birds to see glass buildings, preventing them from flying into windows.

THE HALF-TONE SCREEN ON IAC

Not unlike Gehry's well-documented design process whereby rigorous model-making occurs at multiple scales², the same held true for the execution of the frit pattern. The pattern had to conform to several constraints: the height of the office desks, the necessity to see out without graphic obstruction, and the visual suppression of the spandrel panel or horizontal banding by a use of a gradient pattern (fig. 2). As a priority, the white silkscreen pattern had to achieve an overall 50% opacity across the building for the basic reason of reducing the HVAC tonnage. Beyond the inevitable aesthetic intent, the frit pattern element was primarily employed to reduce glare and enhance the building's environmental efficiency by acting as an integrated sunscreen. The pattern's requisite coverage adapts to the height applied in each panel to control solar heat gain and glare while providing privacy and views.

In keeping with Gehry's process, versions of lines and dots were first generated as hand-drawn, line sketches

Figure 2: (left) Wall section showing constraints of frit pattern; (right) Intended gradation for typical glass piece and spandrel panel during design development.

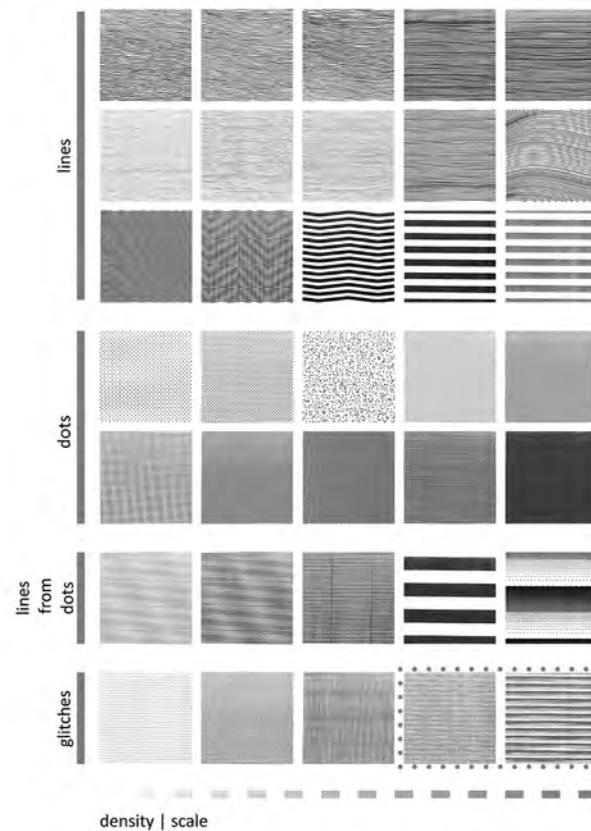
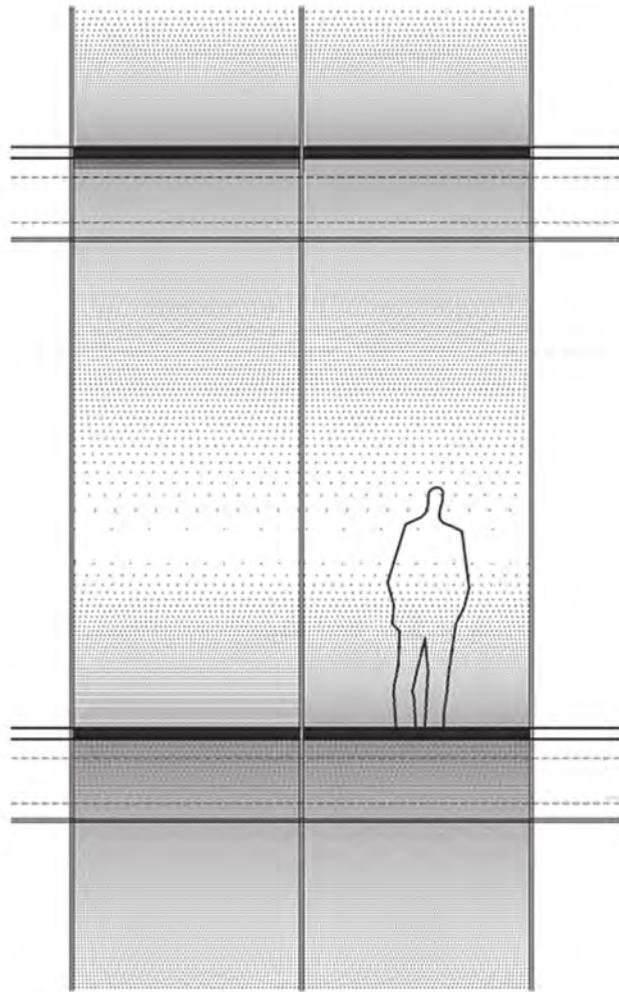
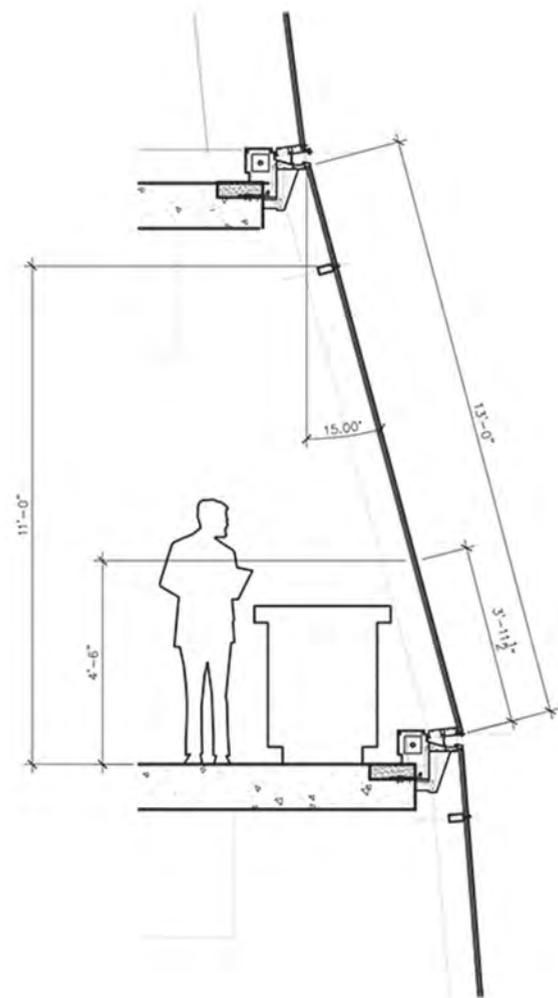


Figure 3: Various pattern-making methodologies and versions were explored to give a sense of depth to the bending panes of glass. With each operation a coverage count was calculated.

OPPORTUNE GLITCH

Maintaining the data in vector form for design production pushed the computers at Gehry Partners to their limits, and often exceeded them. This workflow was extremely processor-intensive and resulted in very long pattern generation times and very slow resultant files. So much so that, unexpectedly, alternative patterns (glitches) started appearing (fig. 5). In retrospect, these (re)configurations constitute a more complex and nuanced outcome worth readdressing for its irregularity, greater 3-dimensionality, and mapping of uncontrolled data. In hindsight, greater opacity coverage with a less clear graphic "dot" and banded condition to the exterior could have resulted from these glitches. For instance, this pattern provides a 95% coverage at its maximum, while the one used at the IAC provides a coverage of 75%. The serendipitous conversion of the original data into these patterns was assumed to be happening in the raster image processor (RIP) internal to the plotter; hence, in this case, the patterns were not under the control of the authors.

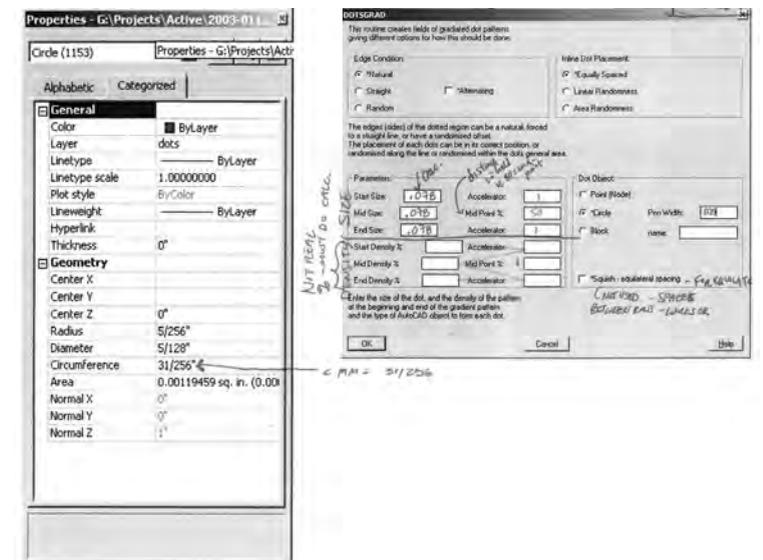
resembling sailcloth for a fabric-like effect (fig. 3). These were then digitized, but they quickly necessitated control of the graphic object's density, which could be achieved by implementing precisely controlled half-toning software. The half-tone screening software created in-house accomplished (pre-fabrication) the necessary gradation to create a smooth blend from the fully opaque spandrel to the fully transparent glass at eye height.

The use of raster data was ruled out because of the limitations for customization of the pattern given available software technology, and because the size of the panels at the resolution required would have far exceeded available computer power for processing, transmitting, and printing the data in raster form. AutoCAD was the platform of choice as it was the easiest to write a custom pattern generator for at the time. The custom pattern generator was written in AutoLISP, which uniquely calculated the location for each dot and laid the dots down as individual objects in the AutoCAD drawing file (fig. 4). A serendipitous "Bleed Test" aligned the circumference of each dot to the bleed of the silkscreen fabrication, making the dot size smaller in its production than in its final output. Several parameters were also established in this process to allow variation in the percentage of dot density and unique levels of gradation for each panel.

FOUND FILTERS VS. CONSTRUCTED FILTERS

The IAC case study above is an example of what constitutes a "found distortion filter" in architectural design. In this case, a bug in the internal RIP of the Océ plotter "incorrectly" processed the incoming vector data into a

Figure 4: (left) Bleed test settings to coincide with silkscreen fabrication; (right) DOTSGRAD script created to generate non-linear gradient pattern and dot size variation patterns.



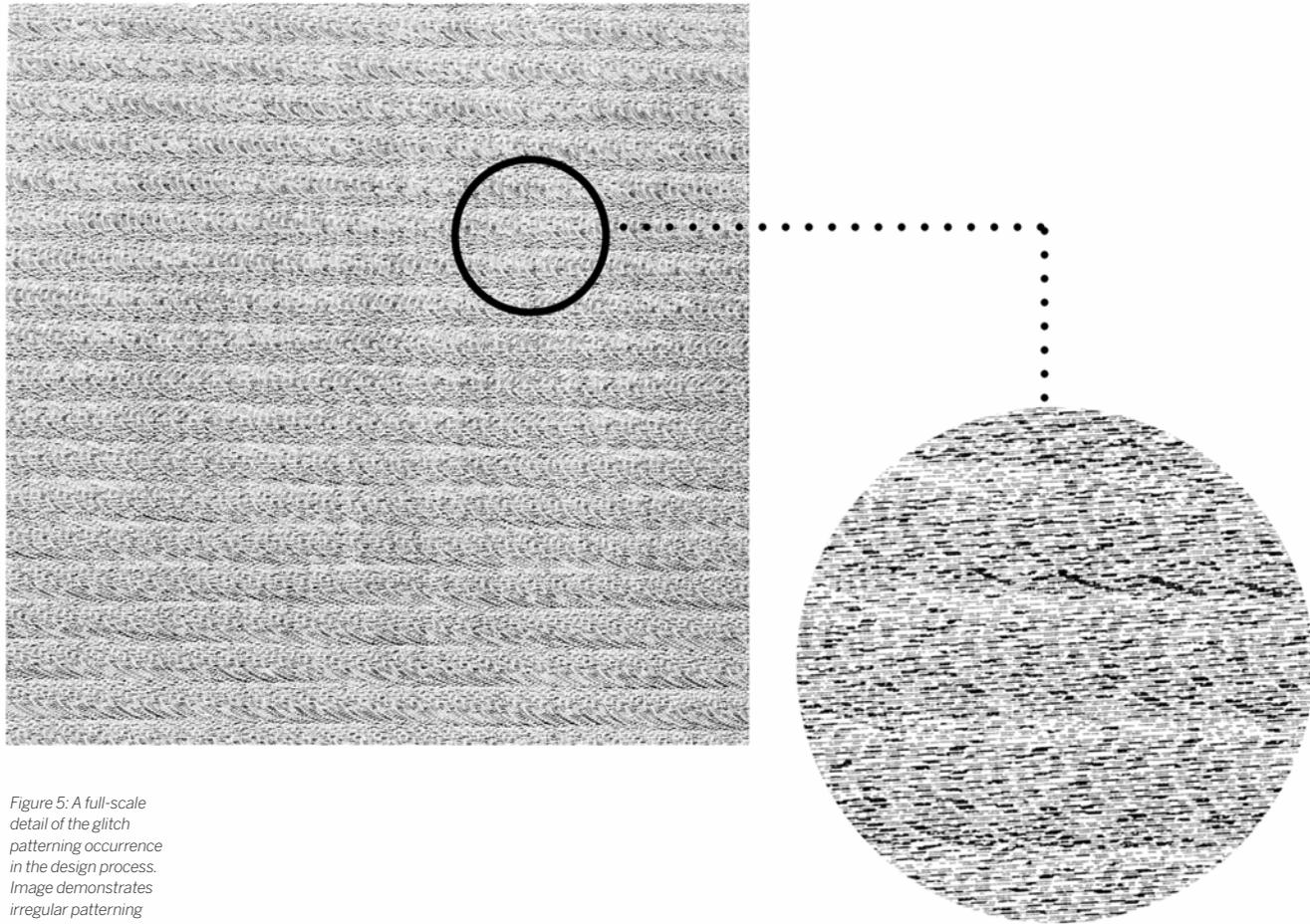


Figure 5: A full-scale detail of the glitch patterning occurrence in the design process. Image demonstrates irregular patterning particulate.

result that bears no resemblance to the original, but is remarkably beautiful for its depth and complexity and could not have been generated by the authors using conventional means. Being a found distortion filter, it was not directly controllable, but could have been indirectly controllable to some degree by varying the size, density, and arrangement of the dots in the input vector file.

The primary issue that a designer faces utilizing a found distortion filter is the capture of output data in a usable form. If the distortion happened to occur, for example, in the generation of the HPGL print file by AutoCAD, it may be possible to redirect the HPGL output to file and then re-ingest that data into AutoCAD for further processing and fabrication. If the distortion occurred in a RIP external to the plotter, even if that RIP did not allow for the redirection of the output to file, it may be possible to scrape the data transfer to the plotter off the wire using sniffing tools: "A packet analyzer (also known as a network analyzer, protocol analyzer or packet sniffer, or for particular types of networks, an Ethernet sniffer or wireless sniffer) is a computer

program or a piece of computer hardware that can intercept and log traffic passing over a digital network or part of a network. ... The captured information is decoded from raw digital form into a human-readable format that permits users of the protocol analyzer to easily review the exchanged information."³ If the distortion occurred in a RIP internal to the plotter (as was the case in the IAC example), it is almost certainly impossible to retrieve the output in digital form due to the internal complexity of the plotter hardware.

This can be contrasted with the idea of a "constructed distortion filter," which would be a process step (hardware or software) designed to introduce visual distortion. Designed controls would be provided to tune the distortion, allowing for a more formal distortion design. This distortion design could then allow for parametric control of necessary constraints like controlling solar heat gain and glare while providing privacy and views out, as was the case with IAC. The tool would then output the desired distorted data in a format suitable for further editing and, ultimately, fabrication.

INCORPORATING SERENDIPITY INTO DIGITAL DESIGN PROCESSES

Serendipity is, of course, ever present in design, and as a valid generative tool, it has long been debated in traditional design circles. Digital artists, however, often embrace serendipity and treat it as an artistic process (for example, complex layering of looped digital samples in music, like the work of Reggie Watts, who creates unpredictable performances on the spot using his voice and looping pedals⁴). The use of distortion can also be seen as a form of serendipity—while the choice of when to use distortion is controlled, and the general style and quantity of distortion is somewhat controlled, the distorted output is not controlled.

Upon discovery of a found distortion filter, the following generalized method can be employed to make the filter a productive part of the digital design process:

1. Research where in the chain of digital workflow the glitch occurred.
2. Isolate that process and establish its controls.
3. Capture the output from the distortion filter in a format that can be passed on to further design and fabrication steps.

In the IAC example discussed in this paper, the dot field in the AutoCAD file constituted the input data, and the plotted paper constituted the serendipitous distorted outcome. Workflow testing could have been

performed to determine which step constituted the distortion filter, such as: viewing the HPGL file as generated by AutoCAD in a software viewer, printing through the same print server to a plotter configured differently, or printing to the same plotter through a print server configured differently. Once isolated, the input data could have been varied in a series of experiments to establish the range of controls available.

In order to be usable to the design and fabrication team, the output data from the found distortion filter would need to be captured in digital form. If the captured output was in vector form, it could be fed back into the vector workflow (that is, opened in AutoCAD and used as design data). If the captured output was in raster form, it would need to be opened in an image editor capable of handling very large raster files. Whether raster or vector is preferable would depend on the fabricator's process, but for most architectural applications, vector output would be required. This illustrates how the glitch pattern could be instrumental in defining a final frit configuration.

SUPPLEMENTARY PATTERNING TECHNIQUES

Further investigation is underway into methodologies for generating frit, capturing digital "glitches" and turning these patterns into "formal" aspects of the digital design process. Continuing research intends to determine potential viability of patterning techniques of distortion filters, such as using: a photograph as the driver of the pattern, attractor points, and agent-based

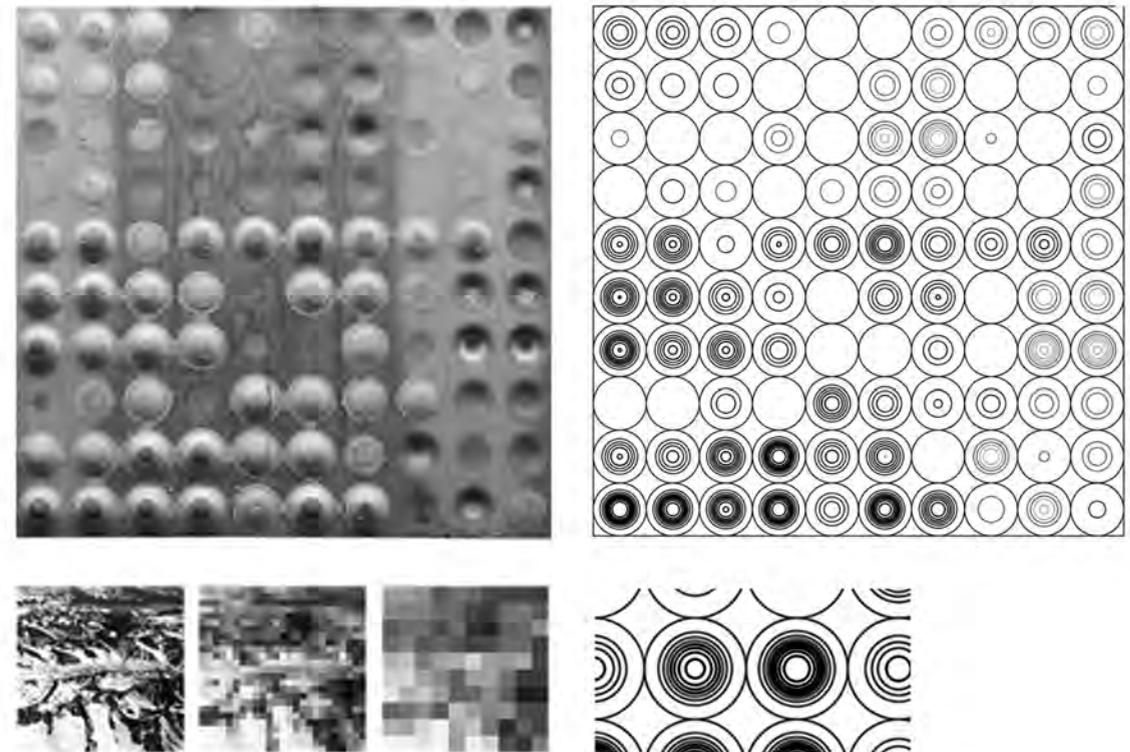
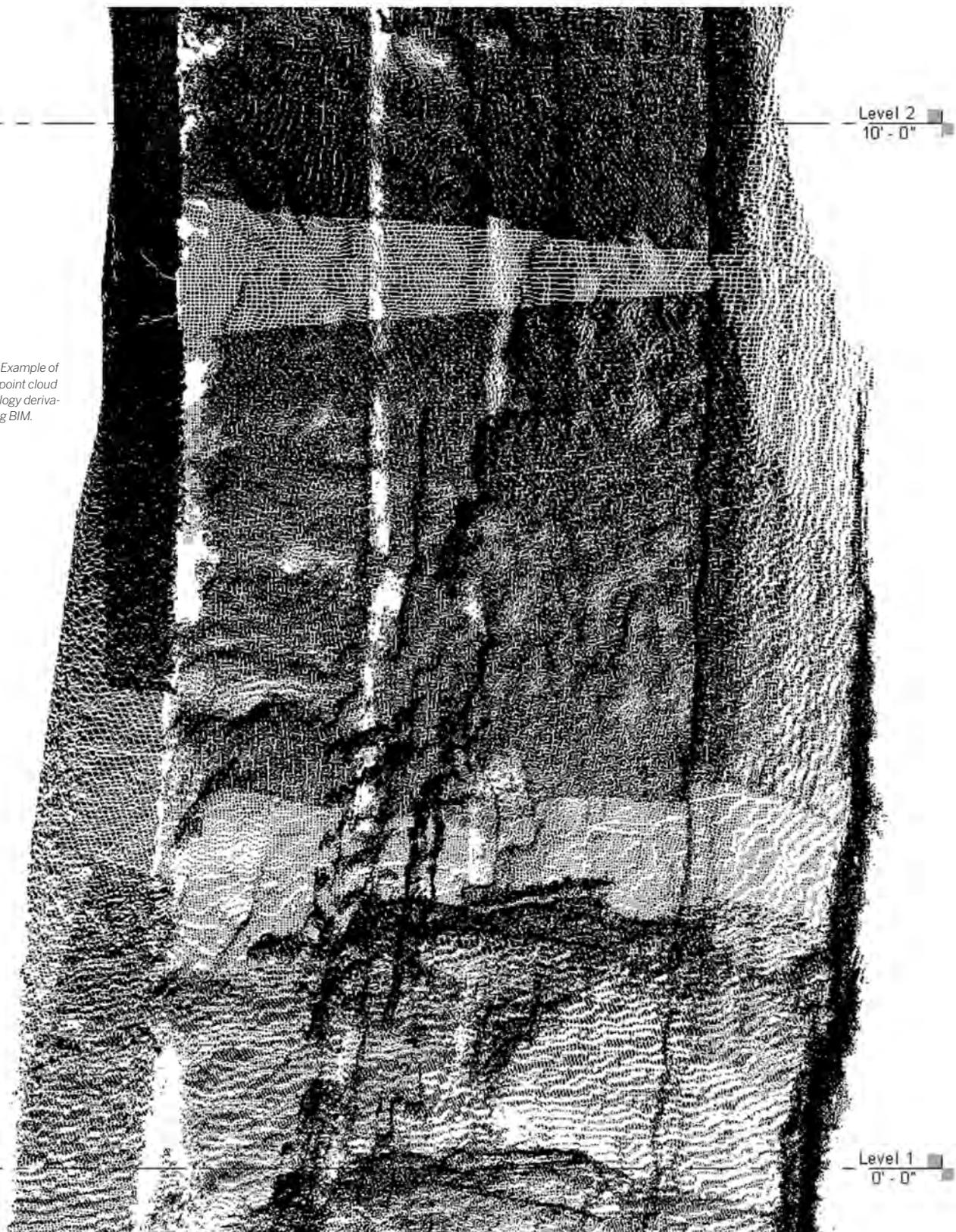


Figure 6: Example of bitmap pattern derivatives using BIM.

Figure 7: Example of adaptive point cloud methodology derivatives using BIM.



patterns within a pragmatic BIM platform. Alternatively, software like IGEO allows for open-source, agent-based distortion and generation.

BIM, generative exploration, and CNC fabrication demonstrate evidence of photography-driven pattern as a means of producing aesthetic effects through visual coding. Through the translation of an image-based parameter algorithm, a design process creates unique frit patterns with distortion embedded in the image resolution. This method has the added benefits of construction coordination as well as potential for a greater 3-dimensionality of the graphic controls. Glitch or serendipity in this sense comes from the adaptation of serendipitous imagery from pattern into low-tech material.

Point cloud data harvesting provides another means to investigate the applicability of serendipity in the generation and/or hosting of frit patterns and distortion filters with CAD and BIM platforms. This “block” reference allows frit to be more efficiently adaptive to given programmatic space, it acts parametrically for variability with ease of point cloud capture, and it adapts more readily to different space functionalities. Such a point cloud allocation of frit in IAC would have eliminated the overall coverage of the same applied frit pattern and, thus, the horizontal banding at each floor.

Continuing research intends to run tests to determine potential viability of these ideas:

- Recreate and test the limits of the original IAC Auto-CAD script using modern computer capacity.
- Refine the limits encountered in embedding a frit pattern using distortion filters into contemporary software such as Rhino/Grasshopper and Revit.
- Refine supplementary patterning techniques with distortion filters.
- Explore constructed distortion filters (hardware and software) for application in architectural processes.

CONCLUSION

The research demonstrates a classic example of benign “hacking” or “repurposing of something physical or digital in a way not foreseen (benign hacking) or explicitly against (cracking) the original intentions of its designer.”⁵ If we agree that the parametric is a technique for the all-inclusive control and manipulation of design objects at all scales from part to whole, we must employ the algorithmic method of generation to produce complexity within an element as small as a particle or, in this case, a dot. To address the claim that parametricism today falls short of its potential to correlate multivalent processes or typological transformations, parallel meanings, complex functional requirements, site-specific problems, or collaborative networks,⁶ this research intends to develop parametricism to control environmental data inputs at the truly granular scale.

ENDNOTES

1. Jordan Brandt, “The Death of Determinism,” in *Persistent Modelling*, ed. Phil Ayres (New York: Routledge, 2012), 111-14.
2. Mildred Friedman, *Gehry Talks: Architecture + Process* (New York: Universe Publishing, 2002).
3. http://en.wikipedia.org/wiki/Packet_analyzer
4. http://www.ted.com/speakers/reggie_watts.html
5. <http://www.adaptivebuildings.com/adaptive-fritting.html>
6. Michael Meredith, “Never Enough (transform, repeat ad nauseam),” in *From Control to Design* (New York: Actar, 2008), 98.

IMAGE CREDITS

Figure 1: Danelle Briscoe photo

Figure 2: Briscoe, Danelle (2002) IAC Project. Gehry Partners.

Figure 3: Danelle Briscoe research diagram

Figure 4: Prentice, Reg (2002) IAC Project. DOTSGRAD script notes

Figure 5: Briscoe, Danelle (2002) IAC Project. Gehry Partners.

Figure 6: Example of bitmap pattern derivatives using BIM. Submission by Chris Renke, BArch Candidate '12, University of Texas at Austin

Figure 7: Danelle Briscoe drawing and experimentation with Revit and point cloud