Almost Natural Shelter: Non-Linear Material Misbehavior

ABSTRACT
This paper critiques computational design and digital fabrication’s obsession with both precision and images of natural patterns by describing a messy attitude towards digital and material computation that integrates and blurs between linear and non-linear fabrication, resulting in material formations and spatial affects that are beyond pattern and image and are almost natural. The motivation behind the body of work presented in the paper is to question the production of space and aesthetics in a post-human frontier as we embark on a new geological era that is emerging out of the unprecedented influence of the human race on the planet’s ecological systems. The paper and the body of work posit that the blurring between the natural and the synthetic in the post-human frontier can materialize a conception of space that exhibits qualities that are both natural and synthetic.

The paper is organized in three parts. It begins by describing the theoretical framework that drives the body of work. Next, it describes early digital and material casting explorations that began to blur between linear and non-linear fabrication to produce almost natural objects. Finally, it describes the process of designing and making Almost Natural Shelter, a spatial installation that emerges from the integration of messy computational design methodologies and chemically volatile non-linear fabrication. In specific, High Density Foam is persuaded to chemically self-compute in an attempt at uncovering a shelter that has almost natural spatial qualities, such as non-linear textural differentiation and sudden migration between different texture types.
A NATURALLY IMPRECISE INTRODUCTION

“Your parents were wrong—messiness is a virtue” — Eric Schmidt and Jonathan Rosenberg (Schmidt 2014)

“Disciplined making has become a security blanket against the realities, disruption and disorder of everyday life.” — Jeremy Till and Sarah Wigglesworth (Till 2001).

Almost Natural Shelter is a spatial installation that attempts to respond to two prevailing tendencies that continue to proliferate within contemporary architectural work which falls under the umbrellas of computation and digital fabrication. The first tendency is the continuing false pursuit of ultimate precision in architecture, which continues to make the production of the built environment an unbearably slow endeavor. The second tendency that Almost Natural Shelter interrogates is the fascination with images of natural patterns which has been made easy and abundant by off-the-shelf computational design tools that continue to adorn the computer screens of many. As such, Almost Natural Shelter, a mostly synthetic object, presents a messy attitude towards digital and material computation that integrates and blurs between linear and non-linear operations, resulting in material formations and spatial affects that are almost natural.

In her timely book, The Architecture of Error: Matter, Measure, and the Misadventures of Precision, Francesca Hughes reveals the fallacy of precision. She argues that the degrees of precision that we hear about today are neither required for habitation and construction, nor even possible to execute given the messy reality of construction (Hughes 2014). Where the blame for slowness falls is unclear. On the one hand, architects, who do not wield as much control over construction as they desire, persist in producing hopelessly precise solutions and drawings, and on the other hand contractors who actually know the real impossibility of absolute precision continue to demand it upfront.

Unsurprisingly, the pursuit of precision does not lurk in the fringes of architectural history, it has always been part and parcel of it, achieving legendary status with the spread of Modernism. Having lost some of its conceptual stomping ground in early and highly reactionary Post-Modernist projects, the contemporary proliferation of computational design methodologies and digital fabrication tools has given the pursuit of precision an undeniable resurgence. This has allowed it a significant growth in momentum within architectural practice, and with surprisingly more thrust, in academia. Amongst the many symptoms of this is that architects are increasingly attempting to eradicate margins of error towards the perfectly snap-fit, no matter the scale of the endeavor. Excel sheets and performance analysis software reign supreme. It sometimes seems that imprecision has become ethically
objectionable, in much the same way that ornament was for Adolf Loos. All this, and I continue to see parts from fully digitally fabricated projects getting banged into place by rubber mallets or some other less benign tool. How, after watching Jacques Tati’s _Mon Oncle_ are architects not completely skeptical of the banality of space that is brought about by precision?

The same technological advances that are driving the pursuit of precision have helped accelerate the speed at which the built environment is produced. However, this acceleration is not nearly at an acceptable rate vis-à-vis other technological advances in other fields. There exists no Moore’s Law for the built environment. One reason behind this is that architects operate spatially just as they did during Modernism, which results in excruciatingly similar space-types. Within all of this fetishization of precision, there exists a number of lost opportunities. More specifically, we might miss the window for experimentation with new space conceptions\(^2\) that truly engage the zeitgeist (Giedion 1941).

These issues are not without response within the contemporary discipline. David Ruy decries the recent shift away from architectural objects and champions an architectural embrace of strangeness towards the production of new objects (Ruy 2013). The development of precise and complex networks and systemic relations within architecture that continues to amplify the pursuit of material precision lies in opposition to the pursuit of strangeness that Ruy champions. A more applied response to this critique is found in the material and intellectual work of the Possible Mediums Project, where its founders continue to explore unconventional 2D and 3D materialities.

The motivation behind the work in this paper is to question the production of space and aesthetics in a post-human frontier as we embark on a new geological era that is emerging out of the enormous influence of the human race on the planet’s ecology. More specifically, it attempts to present the contribution that a conscious and designed blurring between the natural and the synthetic in the post-human frontier can materialize a space conception that exhibits qualities that are both natural and synthetic. _Almost Natural Shelter_ describes a faster and messier architectural world-view that embraces material misbehavior through integrating linear and nonlinear fabrication techniques, resulting in a highly naturalized space conception and aesthetic.

**LETTING GO AND MASTERING THE MESSY**

Letting go of control when working with materials implies a disciplined and collaborative relationship between all agents in a design process. In the case of the examples presented in this paper, there exists a three-part collaboration between the author as designer and human agent, digital information and
material behavior (and misbehavior). This collaborative relationship is amplified when using materials and material processes that are less prone to submission. Figure 2 + Figure 3 show an early exploration into this attitude towards messy making. These explorations are essentially a resin casting workflow that explores the relationship between the moldable casting material (epoxy resin) and a formwork (Expanded Polystyrene – EPS) that reacts in a volatile manner when exposed to the exothermic process of curing resin. This process results in an object that deviates to varying controllable degrees from its intended form and is characterized by a high resolution differentiated texture. These early explorations succeeded in responding to the two overarching critiques set out at the beginning of the paper, namely the creation of objects through an imprecise fabrication method that results in an almost natural aesthetic that shies away from linear patterns in favor of differentiated textures.

There remains a resistance towards this attitude in the production of architecture in general. Jeremy Till and Sarah Wigglesworth lay the blame squarely at Mies’ feet. (Perhaps the blame should go to Miesian disciples, and not to Mies himself.) Through his cult of personality, the Miesian mythical attention and expression of detail continues to give credence to the pursuit of precision. Teachers of architecture continue to speak of that corner detail with extreme reverence. David Spaeth has gone as far as referring to him as “the architectural conscience of this age.” (Spaeth 1988) (Till and Wigglesworth 2001). Today, it is not the spatial discipline of Mies that is at work, it is the fetishization of the detail, and ultimately of precision. Thus, the potential of developing new space conceptions, as Mies had masterfully contributed to through his oeuvre, goes untouched. Miesian ideas such as openness, lightness, transparency and movement are still driving much of architecture. These had their moment, but this must pass.

Ultimately, Till and Wigglesworth put it aptly when they write that “the project to provide society’s salvation through recourse to architectural honesty, truth, economy of means and precise tectonics appears deeply flawed and delusional” (Till and Wigglesworth 2001). Precision is a delusion; it is high time architects just let go of it. Thus, mastering a messy collaboration with volatile materiality is needed. There is an unusual video floating around the internet where Richard Long, acclaimed English land artist and winner of the 1989 Turner Prize, paints a relatively large and rather intense wall mural with a specific mixture of mud in less than 18 minutes. Long’s oeuvre is abundant with mud paintings at different scales and in different configurations, giving him a unique experience with his medium of choice. On top of portraying his technical mastery and control over the material, the video shows a quick production of a work of art if there ever was one. However, while the mural is painterly on the surface, it straddles a very particular material and conceptual space between the messy and the precise, the orderly and the misbehaved. This is evident by watching the artist produce the mural; one can easily note that his strokes do not lack intentionality. Long embraces the volatility and precariousness of his medium, allowing it a very long leash to express its misgivings.
Photograph showing the 5-axis routing process of the different blocks prior to gluing.

Photograph showing full object under gluing. Epoxy resin and fiberglass were applied on the outer surface to increase object bonding and lateral stability.

Photograph showing some of the analog tools used to create the textures including a hand-held wire cutter and a hot gun.

Photograph showing full object while the outer timber skin was being installed.
Long’s attitude towards the production of art is antithetical to the production of most of contemporary architecture in general, and work that falls under the umbrellas of computational design and digital fabrication in specific. He posits a relationship between material, artist and product that is volatile and collaborative as opposed to submissive. Ultimately, the artist exerts control, but it is a radically different kind of control than the one that have proliferated with the advent of digital fabrication techniques. His kind of control results in an aesthetic of exuberant naturalism characterized by material misbehavior and messiness. Revisiting his work and others of a similar kind through the lens of computational design methodologies and digital fabrication techniques has the potential to illuminate alternative modes of contemporary architectural production that result in a new space conception and aesthetic discourse at a time when most architecture relying on contemporary tools ironically looks homogeneous in its pursuit of surface differentiation. A faster, messier and highly energetic form of spatial practice can emerge through an oblique and deviant adoption of technological advancements.

MISBEHAVED DIGITAL THINGS
What follows is a description of a series of experiments that are influenced by the ideas and critique described above and whose overarching aesthetic is strongly driven by digital and material misbehavior. The relatively small scale results have paved the way for the design and construction of a 3 m x 3 m x 3 m (approx. 10 ft x 10 ft x 10 ft) installation that will be described below.

Initial digital studies (Figure 4) relied on a custom-built computational system that produces results that amplify textural readings within compression-only structures. Historically, compression only structures, masonry construction such as columns and domes, exhibited high degrees of part-to-whole relationships. Sometimes, as with examples of rustication, mass begins to breakdown in favor of textural readings. Thus, this made an appropriate starting point and test condition. Here, the process attempts to transform discrete readings of column grids (discrete lines) and domes (discrete surfaces) towards non-discrete textural object readings that blur part-to-whole relationships. In the initial stages of the exploration, these studies were continuously fabricated utilizing additive manufacturing techniques. This was doubly preferred given that these techniques prefer compression only structures and perform much weaker in tension.

Digital misbehavior in these models comes in two forms, the first structural and the second organizational. The structural misbehavior occurs through allowing a high margin of error for the above set goal of compression-only solutions. For example, the approach allows portions of the system to refuse to optimize towards compression and remain under tension. Some of these conditions translate into failed 3D prints, as seen in Figure 5, which becomes a form of evaluation criteria (i.e. how much structural misbehavior is allowed).

Organizationally, the explorations are deployed to structure themselves in one of two rigid organizational patterns, a radial (dome) and a bi-axial (column) grid. The misbehavior occurs through allowing a high degree of flexibility for the elements within the form to exist simultaneously and in different degrees between the two patterns. The central image in Figure 4 and Figure 5 shows an organizationally misbehaved condition.
MISBEHAVED MATERIAL THINGS

The studies were scaled up through developing a resin casting workflow that explores the relationship between the moldable casting material (epoxy resin) and a formwork (Expanded Polystyrene – EPS) that reacts in a volatile manner when exposed to the exothermic process of curing resin. As a scale test, these models aimed to produce highly textural things that exhibit the ability to perform as chairs, as seen in Figure 7 + Figure 8.

The choice of exploring misbehavior through casting comes from a desire to re-question the operation’s contemporary history. Casting is typically a very precise type of construction and easily reproducible. Since the advent of reinforced concrete in the early 20th Century, procedures have been developed to ensure quality control. Thus, in trying to relinquish some control at the beginning of the process, the question arises: How can one make casting a little less precise?

The solution lies in rethinking the relationship between the casting material and the formwork (Figure 6). In typical casting processes, the formwork is primary in that it directs the flow and form of the casting material and allows it to cure with a little temperature control. Within this body of work, resin was chosen as a casting material and was paired with a specific form of polystyrene. Here, the relationship between the two flattens since the exothermic reaction between the cast material and the formwork produces deep textures (Figure 3). Basically, the heat from the curing resin burns some of the closest layers in the formwork. Making the formwork deep enough allows the process.
to cool over time and permits some form of misbehaved formation to emerge. The resultant textures penetrate the surface into the core of the chairs to truly allow for a reading of a textural formation and blurs any reading of pattern or unit-to-whole relationship.

**PRECISE FABRICATION**

In March 2016, an opportunity presented itself to conduct the above research on a spatial scale with a given space of 3 m x 5 m. This was funded by 1971 Design Space in Sharjah, U.A.E, to be exhibited at Design Days Dubai 2016. Conceived as a hollow object, the interior of Almost Natural Shelter rejected traditional part-to-whole relationships through the design of deep and spatial textural formations. This shelter emerges from the integration of messy computational design methodologies and chemically volatile non-linear fabrication. In specific, high density EPS is persuaded to chemically self-compute in an attempt at uncovering a shelter that has almost natural spatial qualities such as non-linear textural differentiation and interplay between line, surface and mass. The blurring between the synthetic and the natural is also evident in the manufacturing processes at play within this shelter. A juxtaposition of slow and precise manufacturing techniques, such as cutting and gluing, with messy and fast operations such as melting. This results in a determinate and synthetic exterior and an interior that exhibits an amplification of texture that is almost natural.

The first response was to linearly scale up the chair casting process to create a spatial object at 3 m x 3 m x 3 m. While the space available was larger, the 3 meter cube was a function of the largest single object that can be transported on a flat-bed truck without police escort. The casting process proved materially unscalable because the amount of heat generated from the exothermic reaction at that size exceeded the amount generated from casting the chairs exponentially, while the EPS’s ability to withstand that heat does not scale up equally. This resulted in the epoxy resin completely melting the EPS prior to curing.

The above failure lead to rethinking and scaling down the chemical reaction that acts on EPS. The phasing and manufacturing of Almost Natural Shelter mimics the two-step process that takes place when manufacturing the chairs. The first, linear and highly controlled, is the 3-axis milling of the negative form in 60 cm x 60 cm x 10 cm blocks of EPS that were eventually stacked and glued. The second, non-linear and slightly volatile, is the exothermic resin casting into the negative spaces of the EPS. At the larger scale, a 5-axis mill was utilized to cut out a predetermined form. The overall form was produced in 3 large sections and eventually glued into its final composition as seen in the milling process in Figure 9 + Figure 10. Epoxy resin and fiberglass were applied on the outer surface to increase EPS bonding and lateral stability (Figure 11 + Figure 12), resulting in a single transportable volume that weighs less than 500 Kilograms; a temporary base was constructed to allow a small forklift to position it in its exact location.

**IMPRECISE FABRICATION**

The second phase in the process utilizes the volume produced via the 5-axis mill as a canvas on which major guidelines for a differentiated pattern are drawn using chalk by the 5-axis arm. This is then transformed into a heterogeneous textural formation in a 2-step process. The first step in the process is the cutting out of the pattern using a hand-held hot wire cutter (Figure 13). The tool used allows for a quick adjustment of profile and size, and while manual, far exceeds the speed it would have taken to create the cavities in using the 5-axis mill, which has a double effect if one factors in the cost of machine time. It was also conceptually desirable given the lack of interest in deploying a precise pattern onto the surface, especially as it will completely transform into something other and far more differentiated in character.

After the cavities are fully made (Figure 15), the second step in the process includes using an off-the-shelf white enamel spray paint. Using a solvent-based spray will react to the porous surface of the EPS and induce a chemical reaction whereby the integrity of the cavities will be dissolved. To achieve a highly differentiated condition, the spray was applied in different speeds and at different distances from the EPS surface as these variables change the strength at which the EPS dissolves.

The final layer is the assembly of a series of timber panels on the outside face of the object. 3 m x 8 cm timber panels were glued using silicone onto the fiberglass surface with a 2 mm gap. The introduction of this skin was meant as a hint at the blurring between the artificial and the natural that takes place on the interior surface. Thus, the exterior is the only surface where precision gets introduced to identify to observers that they are entering a fully artificial condition, even though the resulting textural formation might indicate otherwise. This was further put to test during the exhibition, where visitors invariably showed various expressions of surprise at being told that this was neither coral nor any other purely natural material, but simply EPS.

**CONCLUSION**

Further explorations within this umbrella of research fall under two main strands. The first is the development of a more...
streamlined process where the messiness is machine automated in a loop from bits to materials. The second strand might require moving away from the discrete object reading where the material formation can be deployed in conjunction with other material systems on a fully functional architectural space. For example, this includes designing installation techniques as well as ensuring that the material passes code such as being fire resistant. This will also push these explorations to become truly space-making tools and generators of space conception in the post-human frontier.

ACKNOWLEDGEMENTS
Almost Natural Shelter was funded by 1971 Design Space in Sharjah, United Arab Emirates and was first displayed in Design Days Dubai 2016, in the United Arab Emirates.
This work was done with Khawla Al Hashimi and Nada Taryam.

NOTES
1. Graduate programs at leading institutions continue to develop degree courses that aim to explore the space of ultimate precision.
2. The use of the idea of space conception is based on its appearance in Sigfried Giedion’s Space, Time and Architecture. Giedion describes the emergence of a new space conception in Modernism in relation to older space conceptions. The first space conception is defined by volumes and objects in space, and the second by questions of interiority brought about by the vaulting problem. According to Giedion, the space conception developed in Modernism is concerned with the simultaneity of volume and interiority as space generating and defining.

REFERENCES

IMAGE CREDITS
Figures 1–2: Pachica, 2016
Figures 3–4: Tabbarah, 2015
Figures 5–6: Tabbarah, 2014
Figures 7–8: Abu Shakra, 2015
Figures 9–15: Tabbarah, 2016
Figure 16: Roldan, 2016
Figures 17–18: Kalo, 2016

Faysal Tabbarah is an architect and educator, currently Assistant Professor of Architecture at the American University of Sharjah, U.A.E. He is also co-founder of Architecture + Other Things, a collaborative and interdisciplinary platform exploring alternative models of architectural practice and design to produce work at multiple scales and within multiple disciplines. He received his Master’s in Architecture and Urbanism at the Architectural Association School of Architecture’s Design Research Lab (AADRL) in London and his B.Arch from AUS. He has held professional positions in architecture and design in London and the U.A.E.