Using Solid Freeform Fabrication for the Conceptualization and Corporeal Actualization of Architecture

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This paper forms an update to the paper presented at eCAADe 2003, in Graz. It is a summary of a project which aim is to suggest an alternate methodology for utilizing additive Solid Freeform Fabrication (more commonly known as Rapid Prototyping), for the conceptualization and fabrication of design and architecture. It plans to do so by establishing a methodology that is innate and a direct reflection of the additive SFF production process. The project also aims to address the seemingly divisive discrepancy between the process of digitally conceiving a design and the intrinsically somatic way we perceive it. Whereas the paper in Graz introduced the conceptual foundations and the taxonomy of the project, the aim in this years paper is to present some of the realized designs and discuss, in brief, how what has been learnt could be furthered as the project proceeds.

The three designs described in more detail in the paper, all catalyzed by a specific sensory notion, would have been very difficult, if not impossible, to fabricate by any other means than additive Solid Freeform Fabrication.

Keywords: Architecture, Design, Solid Freeform Fabrication, Senses.

Introduction

The project aims to establish a way for using additive Solid Freeform Fabrication (more commonly known as Rapid Prototyping or Layered Manufacturing) for both the conceptualization and fabrication of design and architecture. It aims to do so by hopefully avoiding falling into the trap of the McLuhanian' notion of 'cultural drag', that seems to affect most 'new' technologies, i.e. it aims to conceive designs in a manner that forms an innate and intrinsic reflection of its production means. Its objective is to make designs that directly benefit (be it in something as subtle as in its texture or material consistency, or something as fundamental as its overall form) from the process of making them through additive Solid Freeform Fabrication (SFF for short), and that would be difficult, if not impossible, to make by any other means.

The project’s polemic was also partially catalyzed
by the fact that much of, particularly CAD based
design and architecture, seems often to be very vi-
sually biased in its conception. It seems to be made
to predominantly please the eye. This it does in spite
of the fact that architecture, unlike the other (par-
ticularly, visual) arts, such as painting photography,
graphics and even sculpture (usually in a gallery one
can look, but seldom touch, the displays...) inevita-
bly entails an intrinsically multi-sensory experience.
The three designs included are all from the 'Sensory
Design' series. The initial one, 'Oral Architecture',
and the two latter ones, both formulated under the
heading of 'Olfactory Architecture' (the 'Fragrant
Tower', and 'Fragrant Slug' projects), are sensory
(sensual?) follies, of sorts. None of the designs nec-
essarily fulfill a directly functional purpose, however,
on a, call it, more 'cerebral' (and gustatory & olfac-
tory) level, they do perform the role of something
that is somewhat of an erudite indulgence, which
perhaps has some value in itself. All included
designs attempt to consider, and perhaps recon-
figure, the way one thinks about what the generic
term 'architecture' entails, something that itself in
not particularly original of a theme, examined here
through the notions of taste, smell and SFF, which
one could claim is...

**Sensory designs**

The Sensory Designs are a self-imposed theme or
a set of parameters in which all the designs are de-
erved from a predominantly non-ocular perspective.
The included designs come from two of the initial
three headings derived from the five occidental
senses Aristotle defined for us already two and a
half millennia ago. The original three headings were
spawned from the three senses (taste, smell and
and touch) that, from a more customary architectural
context, could be most difficult to interpret, and
from a digital viewpoint, lent themselves least natu-
rally to the digital medium (in this paper the heading
dealing with touch has been excluded as this design
was described in detail already at last year's event).
These designs question a common notion that
something can be fully comprehended and judged
based on vision alone. They assume the premise
that the tacit qualities of a design inevitably have
to be included as essential elements in any, even
digitally conceived, designs.

**Oral Architecture (the architectural
tidbit)**

„Our sensory experience of the world originates in
the interior of the mouth, and the world tends to re-
turn back to its oral origins. The most archaic origin
of architectural space is the cavity of the mouth.“
(Pallasmaa, 1996)
In this design the oral cavity, and everything that
might entail and include, is accepted as an archi-
tectural condition, i.e. the mouth - its lips, teeth,
tongue, inner cheeks, thorax and saliva, along

*Figure 1*
Left - Early illustration of
the architectural tidbit. Right
- The Rhino model of the fabri-
cated piece.
with actions such as chewing, swallowing, sniffing, savoring, inhaling, etc. are conceived as elements, nodes, to be assembled into an affective architectural condition or brief. This, still hypothetical (as of yet it hasn’t been made through the final intended means), project was catalyzed by an assumption. What if one switched the color cartridges of the Z Corps Z406 system to distribute flavors instead of colors? This three dimensional printer (3DP) uses either a plaster or starch based (edible) material to fabricate objects. Wouldn’t it be interesting? Wouldn’t it be appropriate, to use this aspect of the fabrication method for an alternate and somewhat deviant and perhaps unexpected purpose? Taking the standard CMYK colors - Cyan, Magenta, Yellow and black, and replacing them with the generic flavors of Salty, Sweet, Bitter and Sour, and with the doughy nuances of Umami (sometimes considered the fifth flavor) added as a gustatory catalyst, one could add a new idiom into the annals of conceiving things through additive SFF.

These flavors would be applied into a multi layered, textured, and consistent ‘architectural tidbit’, a chewable and digestible entity, one puts into ones mouth, the site onto/ into which the architectural brief is applied. Here the gustatory logistics are analyzed from a more spatial, procedural, mechanical, tactile, olfactory, and culturally semiotic (architectural) tack. This entails exploring how the various layers of the tidbit will dissolve and collapse, and how they consequently blend and interact with each other. The project also attempts to consider how saliva, the pace of chewing and breathing, the motility of the tongue, and how the disparate flavors, sensations and senses would commingle and interact.

“I am also tempted to believe that smell and taste are in fact but a single sense, whose laboratory is the mouth and whose chimney is the nose. […] We eat nothing without being conscious of its smell, either at once or upon reflection; and towards unknown foodstuffs the nose always acts as the advance sentry, crying: ‘Who goes there?’” (Brillat-Savarin, 1825)

**Olfactory design**

„Just as society is criss-crossed with symbolic and actual olfactory boundaries, so is the urban environment. The different olfactory spaces of the modern western city are largely a product of zoning laws. These laws regulate the kinds of construction and sorts of activity that may go on in different areas, and by so doing also regulate the distribution and circulation of smells. (Classen, Howes, Synnott, 1994)

The aim here was to make designs as subtle and discrete, yet as expressive and catalytic as a fragrance. A design that could be experienced without being seen. A design that is senses before it is comprehended.

The designs form discrete interventions that interact with their surroundings through evocation, rather than provocation. Like benign parasites they aim to conjoin with existing conditions, buildings and beings, stealthily adapting themselves to what’s there. The designs are nuances, filling abandoned cracks in walls and pavements, old air-outlets, the space between the wall and a drainpipe, unused.
keyholes. Powered, triggered and spread by the wind, a sneeze, benignly infusing their locales with their fine-spun, misty whispers. The designs are 'mechanical' in the sense a termites' nest, a spiders-web or a beavers-dam is mechanical - fulfilling their aims in a comparably congenial manner.

As we inhale, we smell. As we exhale, we don’t. There’s an inherent pace and rhythm to experiencing something olfactory. Our hearts beat, our feet walk, noses breathe, chests respire, fingers tap...

Here the design is not the protagonist, but the ethereal experience of the scent actually takes place 'in' its audience, as the fragrance enters their bodies through their noses, mouths and pores. The experience of the design becomes an internalized event, where the usually optically derived formulations of semblance are forgotten.

Figure 3
Analysis of the tidbits breakdown and gustatory process and experience.
It can be used to repulse or attract. A person exiting from a foul smelling public toilet will inevitably be afflicted with a reflective degree of spite that is directly proportional to the level of olfactory repugnance emitted from the recently exited cubicle. And anyone who’s ever managed to catch even a glimpse of the seemingly multiplying ‘how to sell your house’ shows on British television will tell you

Figure 4
The gradual interactive ingestion of the architectural tidbit.

Figure 5
The completed stereolithography model of the tidbit.
that the best way to make your house attractive to prospective buyers is to put fresh flowers in the living room, scented candles in the bedroom, and have newly baked bread in the kitchen to benignly entice them, with every sensuous inhalation, to re-mortgage their old, bland and a bit stagnant, habitat so as to be able to occupy this new aromatic and comely abode asap.

**The implementation of olfactory design**

Usually there are three levels to a fragrance - a bottom, middle (heart), and top (head) note (Aftel, 2001). Top notes are the most volatile, these form the initial layer of an aroma one usually smells first. The middle notes diffuse more slowly, and are usually floral essences, they provide the fragrance with a body. The base notes are the most fixed of all the fragrances. They provide the foundations for the initial two levels (Watson 1999). In the included Fragrant Designs the bottom and middle notes are the same (base note - a home-made Vanilla fragrance, with some Benzoin Tincture as a catalyst. Middle note - Rose Absolute). Only the top notes varied between the designs, with one having Orange-Sweet (Citrus Sinesis), and the other Grapefruit (Citrus Paradisi). This was done to provide some variation in the olfactory-sc ape during the initial display of the designs in the same space. "You should smell the stones," Goldsworthy said in a jovial tone. Their scent was surprisingly evocative, a whiff of briny sea". (Solomon, 2004)

**Fragrant tower**

"The idea was that the shape of the building itself would ensue satisfactory ventilation, thus rendering traditional methods redundant. Cupola and dome were transformed into machines to draw up miasmas; experts climbed onto rooftops to breathe the invisible, evil-smelling spiral they created. The degree of stench was a measure of the architects efficiency". (Corbin, 1986)

Of all the designs fabricated thus far the Fragrant Tower must have been the most cumbersome to realize. It required a total of five generation and fabrication attempts to achieve a satisfactory level of semblance and detail to its initial intended aims. A few specific interests catalyzed the design. Firstly I wanted to try to build something that was larger than the available SLA (stereolithography) machine's building chamber allowed for. Something that would transcend a bit beyond the usual scale and type of designs affiliated with SFF. This meant that I needed to design something that could be fabricated in sections and that could subsequently be easily assembled. Also, I wanted to try to appropriate one of the particularities of the SLA process in an actual design, which entailed in this instance that part of the designs 'body' was constructed by the default, mesh-like, support-structures that the process automatically applies to support fine or fragile build features.

On a more conceptual level the design is taking its analogous cues from things like termites nest and

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*Figure 6*

Some of the initial attempt to fabricate the tower.
the 'badgirs' (wind-towers) and 'malqalfs' (wind-scoops) still occasionally found in the Middle-East. All suggestive means for how to potentially encourage the air, and subsequent fragrances, to move about and disperse their vaporous clout away from the design.

There are similarities in all the aforementioned systems. Obviously the tower is not as refined in its detailing to claim the same level of emergent sophistication to that of a termite hill, however, there are some formal insinuative semblances between the porousness of the towers varyingly thick epidermis, and the more hollow areas in its center chambers, which are more open towards each tower segments base, that should lend themselves quite well to act in a similar fashion to that of a wind-tower or scoop, or even in a comparable manner to a termites nest...

To better understand how the various fragrant viscous liquids would move and occupy the tower, tests were made with variously colored inks, mixed into a similar consistency to the liquids containing the fragrances, which were poured into and through the towers ascending segments. Beyond this action having a certain aesthetic appeal, as the layers of colors reveal the intricate patterns and varying porosity and depth of the tower (something unfortunately not visible in the included black & white images), the exercise was also informative in that it provided suggestions for how the various fragrant liquids would interact and thus provided suggestions for how and where one should dispense the different liquids in the tower.

**The fragrant slug**

“Smell has therefore been described as the intimate sense […] This is intimate in two senses: structurally - it generates an immediate or local geography - and emotionally it establishes a strong bond between person and environment”. (Rodaway, 1994)

Having a likeness to either a parrot or, as the name suggests, a slug, the Fragrant Slug is perhaps the most analogously suggestive of the Fragrant Designs. This quality is further emphasized as the design is usually displayed perched on a stick, ledge or even a finger.

Designed as a fragrant mobile, that would slowly sway on its perch, the design also tests how the manual application of (additional) support-structures of the SLA fabrication process could be used for both more utilitarian as well as more adorning purposes.

As can be observed in the images above (figure 9.), the built design has a number of sticks or pins (termed Balancing Fillers) sticking out from its back. These are needed to both inject the design with the fragrant liquids (the Balancing Fillers are hollow inside and have a small container at the top), as well as to, perhaps more importantly, perform as counterweights to allow one to actually balance the design on its narrow-tipped feet.

**Conclusion**

Can the aforementioned designs be deemed or categorized as architectural? Perhaps that is the wrong question to ask before one defines what the term 'architectural' entails? Without lingering excessively on this point a suggestion for how this potentially could be achieved is provided by the Finnish ar-
chitect Juhani Pallasmaa who shifts away from the usual emphasis in (median) architecture from the architectural 'object' or 'space', into a paradigm of 'architectural experience'. He states:

"Authentic architectural experiences derive from real or ideated bodily confrontations rather than visually observed entities [...] The visual image of a door is not an architectural image, for instance, whereas

Figure 8
Left - Three views of the completed Fragrant Tower.
entering and exiting through a door are architectural experiences. Similarly, the window frame is not an architectural unit, whereas looking out through the window or daylight coming through it, are authentic architectural encounters”. (Pallasmaa, 2000)

This principal can be appropriated to all the designs included here, particularly to the latter olfactory ones. The object might not be architectural, but the ensuing experience provided by it is. This presence of the architectural experience would here be

Figure 9
An initial sketch, the slug just post-fabrication, and a completed rendition of the slug.

Figure 10
Left - The Fragrant Slug build, placed on the virtual build platform in ‘Lightyear’. Right - A sample of the manual application of the additional supports. Here the thin line indicates how and where these additional supports will be placed in relations to a specific chosen slice of the build.
more of a retrospective mnemonic occurrence, i.e. at the initial exposure of a locale in which a, even very subtle, fragrance is present, ones conscious awareness of the aroma would perhaps not even be acknowledged by oneself. However, if one came across the same distinct fragrance at a later date, even at a place far away, both in context as well as in distance, from the initial exposure, one would probably both recognize and recall where and when one came across the fragrance originally. In a similar manner one can formulate an understanding of the architectural tidbit according to a more experientially based model. The aim with all the designs here is to reintroduce, not only an illusionary and illustrative representation of the body into the equation, but to actually involve our, call it, corporeal or physical self in the processes and means by which we conceive designs, regardless if these are digital or analog in origin and method.  
In some sense the projects aim is to act as a suggestive catalyst for how SFF could be formulated as the conceptually integrative tissue connecting the digital and analog mode of design. This is pursued through a process that allows a reciprocal and symbiotic affinity to evolve between the digital and analog aspect of the design process that, in conjunction with the designer, aims to produce something that can be claimed to be more than the sum of its (initially virtual) components. The idea is to provide one with an insinuative framework within which one can easier formulate and realize ones aspirations when using additive SFF technologies and materials. By incorporating particular sensory notions as constraints (here involving taste and smell) this process, when realized through the CAD-CAM means, will inevitably result in something simultaneously reflective of both of these realms that usually occupy opposite sides of the fence. Here the aim is not to exclude the other senses from the equation, but to create a more comprehensive and attuned understanding of how, what we usually define as the subservient senses, could raised in their pecking order to be included more naturally into the, now predominantly digitally based, grammar and vocabulary by which we read, define, design and build our architecture by. By utilizing something as intuitive and immediate as taste and smell as catalysts for this specific brief the hope was to form the foundations of a more personalized and distinctive approach by which to understand and define our built environment. An approach that transcends beyond the purely pictorial (conceptual) and ocular drive that seems to saturate so much of what we today consider to be architecture, and bring forth a realm more in tune with how we actually sense things, both within and outside ourselves.

References