Rapid Gestalt

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A clear distinction generally exists between processes of design generation and processes of design production. The profusion of digital fabrication tools and technologies make evident such distinctions in the context of design production but at the same time carry potential for material and fabrication-based processes promoting generative design methods. Such strategic application and customization of digital fabrication tools, inherent in and inclusive to the process of design generation, require the knowledge and skill-set of production associating material to its fabrication and assembly methods. The paper addresses the area of *fabrication based design* and the term *Rapid Gestalt* is proposed to suggest that certain skills acquired through fabrication-customization processes, achieved through material formation, may contribute to *fabrication-guided design protocols*. Through the demonstration of some design experiments for multi functional and responsive structural skin systems, the paper classifies several forms of fabrication-informed production processes in which the notion of *Rapid Gestalt* is manifested through material selection, fabrication-method and assembly logic. The conception, development and application of such classification express a shift in contemporary design discourse promoting the notion of *mass customization* in the context of generative processes of design fabrication.

Introduction

Design by virtue of its very nature is largely dominated by formal exploration. Its *physical* manifestation however, is fundamentally perceived by way of implementation and deemed reductive and/or limited as far as generative design methods are considered [1]. The rapid development of digital-design fabrication methods challenge such processes of production promoting design that is *informed* by fabrication, as opposed to simply being (free-) formed by it.

The question still remains: what is the relation between the ways in which things are made and how they work (beyond their formal uniqueness)? Can fabrication methods affect material formation within the early design stages? Furthermore, what are the ways in which such relations may be classified and understood in order to promote efficiency of use and effect of application between the design artefact and the tool which assisted its fabrication? Such questions carry relevance for process (methodology) and function (application) of digital design in that they may potentially promote a significant fit or connection

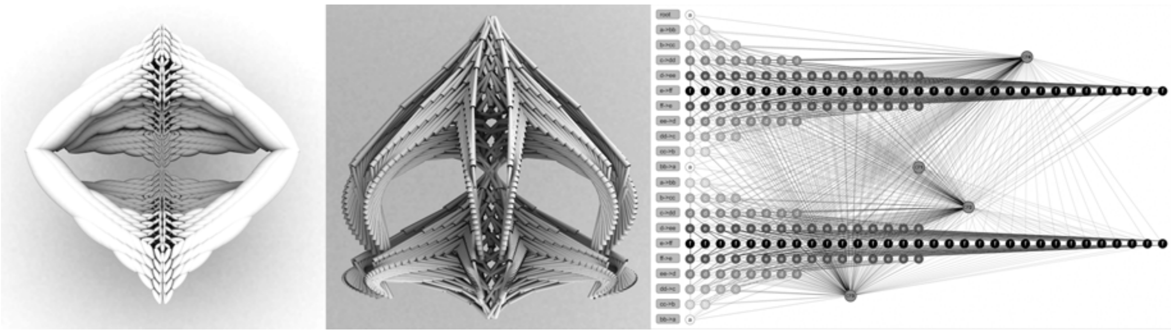

Figure 1 Tropisms: Light-responsive structural systems and logic dependency graph illustrating parametric association between physical features and environmental conditions.

between the artefact and its context (whether user and/or environment). *Fabrication-based design* prioritizes the tools and fabrication methods being assigned to generate material form and behaviour over manifestations which are purely formal in nature [2].

Theoretical Foundations

Factory to File

In the words of David Pye, technology is "the study and extension of technique" [3]. Technique denotes a specific approach for accomplishing a given task or function by way of perceiving and putting into use material integrity and processing methods. A hierarchical approach tends to prevail where fabrication methods and material considerations are only brought into the design process as final design solutions in preference to promoting explorations which are generative in nature.

However, the material and technique in which a natural artefact has been formed is directly linked to its behaviour [4]. So ways of making things are inextricably linked to what and how they serve as final artefacts. The work of the craftsman involves the knowledge and skill-set of particular practical arts. A craft of any kind which embodies the skill set and techniques of selecting and processing material is inherent to and apparent in the final artefact [3]. Thus, process of material formation, or Gestalt, are directly linked to the methods by which they have been produced.

Today, rapid prototyping technologies offer this knowledge to the people. But there's obviously more to the notion of rapid craft than simply hitting the power switch.

Machining is by convention a form of execution, a final phase. "File to Factory" protocols have indeed pushed ahead our vision as designers with regards to efficient CAD/CAM/CAE processes [5] and yet the other way around, "factory to file", has never been considered. In other words, machine execution should not be regarded simply as a service tool for materializing design but rather an opportunity to inform the design process as one which integrates machine-logic across all scales of production. This notion extends from Simondon's view of the craftsman engaging both his knowledge and creativity in the process of making, beyond acting as machine servant or assembler [6]. Material choice and fabrication methods are not innocent decisions but rather pre-determined factors which could potentially guide the design with respect to both artefact and process.

Machine Immanence and Naïve Materialisation

An intelligent wall or a responsive skin is, at its simplest, an environmental manifestation of technology that is already being appropriated [7]. However, in much of the work generated recently which falls under the umbrella of "responsive skins" there still exists a separation, both in process and authorship, between "what" a building senses and "how" it does so. Electronics is mostly embedded in the artefact post its production rather than considering the association between the sensors and the sensing elements of the building. In most of the work shown here, the digital presence (or any proof of CAD) is in most cases absent: complex geometrical form is fabricated in physical matter, and sensors are embedded within it as potentially seamless and ubiquitous elements enhancing material response to local stimuli. One of the crucial ideas that this work seeks to portray is that of integrated sensing. Simply put, this means that instead of "adding-on" sensors to the artefact, material choice and processing is targeted towards, and guided by, an understanding of the mechanical and structural properties which initiate dynamic behaviour.

Rapid Gestalt

In his essay, "The gadget lover, Narcissus as Narcosis", Marshall McLuhan defined the relation between media and self as an amalgam of tools and bodily extensions seamlessly at work [8]. The "servomechanism" is an adaptation of the self to its technological extensions such that a closed system is created whereby the detection of such extensions as individual entities is unattainable. In this light, the designed artefact may be perceived as an entity weighted with commensurate "extensions". The tool, technique or technology applied for production has as much value and meaning as the artefact itself, inherently promoting explicit effects which are the result of an intentional affinity between machine and material. Gestalt, in general, proposes such an affinity between the maker and its immediate context, the environment, which is to contain the object of desire. As such, beyond its traditional description or meaning, Gestalt may be reinterpreted as a set of instructions combining knowledge and application, matter and tools relating form to processes of formation; an operational framework for processing and re-organizing material constructs. Thus Gestalt may potentially serve as a guiding instruction-set, a formalism, which merges knowledge of application with a naive instrumentality of material organization.

Aims

Material and fabrication based design denotes design processes that are informed by material and/or fabrication constraints as part of the generative phases of design. The aim is to develop a preliminary taxonomy which attempts to redefine the use and application of digital fabrication tools and technologies through the notion of craft. In this context the term *Rapid Gestalt* (in German, Rapide Gestalt) delineates the ability or potential to control material formation and behaviour through a particular fabrication method inherent in the nature of the exploration.

Methodology

This paper considers several design projects for responsive structural skin systems, from the perspective of Rapid Gestalt, its significance and implications for a design paradigm engaged with, and brought about by material production. Three classes or types of "gestalt" are demonstrated by each of the three projects presented. Each class defines a relationship between the type of structure or morphology developed and the tools applied and/or customized to support materialization. In addition, each class assumes its initial point of departure with regards to a given phase of production. Such phases include for example material selection, material fabrication and material assembly and are directly assigned to a given class of formation.

Demonstrating Rapid Gestalt

The projects below demonstrate the notion of condition-based programming and informed fabrication (or "Rapid Gestalt") through the integration of structural and environmental performance data into form-generating processes. Each project explores unique relationships between material organization and behaviour, inherent in their form and attributed to the ways and methods in which these objects have been fabricated. It is precisely this interaction between material organization and environmental pressures that is a novel approach to the genesis of form. Combined with this aspiration, the projects postulate our ability as designers to exploit digital fabrication technologies as a generative domain for material production Making is not secondary to from-generation and directly ties to it, beyond its being an agency for production.

5.1. Monocoque

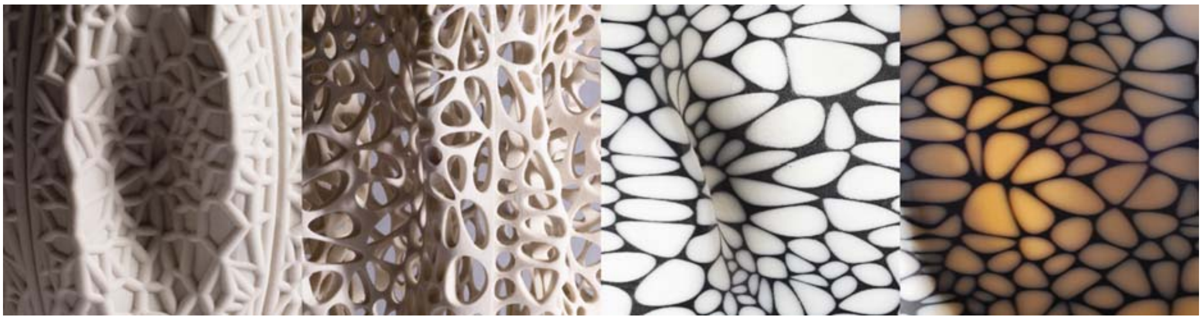

Figure 2. Monocoque: illustrated are three fabrication approaches

Monocoque (*French* for "single shell") stands for a construction technique that supports structural load using an object's external skin. This stands in contrast with using an internal framework (posts and beams) that is then covered with a non-load-bearing skin. The project demonstrates the notion of a structural skin using a voronoi pattern, the density of which corresponds to multi-scalar loading conditions. The distribution of shear-stress lines and surface pressure is embodied in the allocation and relative thickness of the vein-like elements built into the skin. The composite prototype models represent three strategies for the design and fabrication of single shell structures.

5.2. Raycounting

Raycounting is a method for originating form by registering the intensity and orientation of light rays. 3-D surfaces of double curvature are the result of assigning light parameters to flat planes. The algorithm calculates the intensity, position and direction of one or multiple light sources placed in a given environment and assigns local curvature values to each point in space corresponding to the reference plane and the light dimension.

The models explore the relation between geometry and light performance from a computational-geometry perspective. Light performance analysis tools are reconstructed programmatically to allow for morphological synthesis based on intensity, frequency and polarization of light parameters as defined by the user. The project is inspired by one of the first rapid prototyping technologies from the 1860's known as photo sculpting. The method was developed with the aim of regenerating accurate 3-D replicas of a given object by projecting multiple prints of different angles and carving them relative to the reference artifact. Photo sculpting employs 2-D projections to regenerate 3-D objects; Raycounting employs 2-D planes as they are informed by light to generate form.

5.3. Subterrain

The physical features of a terrain represent the distribution and magnitude of the forces that have brought it about. These elements embody the complex relations between

Figure 3. Raycounting: SLS nylon models (top) and printed resin composites including structural pockets (bottom).

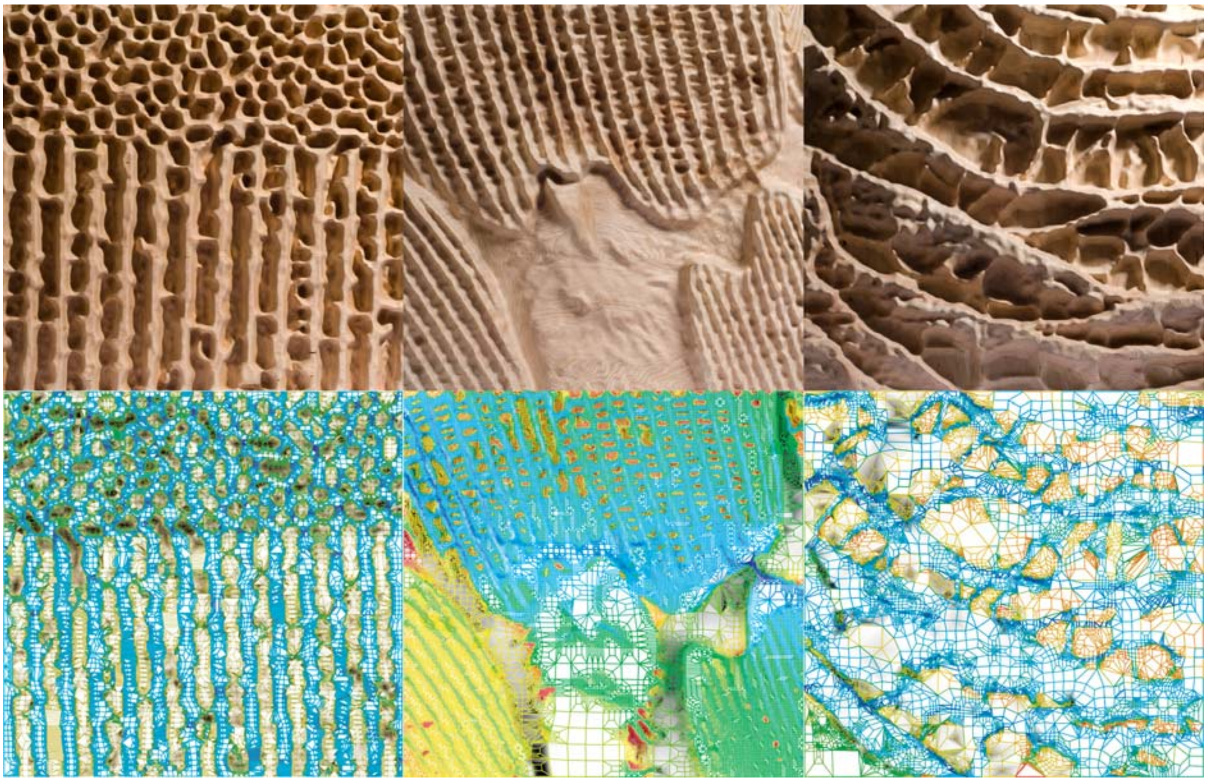
Figure 4: Subterrain: Micro structural biological tissues structural compost (top) and perofrmance analysis (bottom).

physical matter in its given environment and denote its subterranean force field. The work explores the notion of material organization as it is informed by structural load and environmental conditions. 2-D micro structural tissues are visualized, analyzed and reconstructed in 3-D macro scale prototypes. Computational analysis is used to determine material behaviour according to assigned properties and performance such as force, stress, strain, deformation, heat flux and energy such that the tensor properties in atomic scale are kept isomorphic to the morphological pattern. The tissue is then reconstructed using a CNC mill and multiple types of wood composites. Anisotropic in nature, grain directionality and layering are informed by the analysis resulting in a laminated structure which corresponds to a range of loading conditions. Three micro scale biological tissues (a leaf section, a butterfly wing and a scorpion paw) are reconstructed using this generative digital protocol.

5.4. Cartesian Wax

The project explores the notion of material organization as it is informed by structural and environmental performance: a continuous tiling system is differentiated across its entire surface area to accommodate for a range of conditions accommodating for light transmission, heat flux, and structural support. The surface is thickened locally where it is structurally required to support itself, and modulates its transparency according to the light conditions of its hosting environment. 20 tiles are assembled as a continuum comprised of multiple resin types - rigid and/or flexible. Each tile is designed as a structural composite representing the local performance criteria as manifested in the mixtures of resin.

The work is inspired by the Cartesian Wax thesis, as elucidated by Descartes in the 1640’s. The thesis relates to the construction of self knowledge and the way in which it is informed by and reports about an individual’s experience of the physical world. According to Descartes, the knowledge of the wax is whatever survives


Figure 5. Cartesian Wax: full scale and details composite image of final installation

the various changes in the wax's physical form. That is, the form of the wax embodies the processes that have generated its final features. Replace the notion of knowledge with that of performance and the wax's physical form represents the force fields that grant its birth.

6.0 Conclusions

In his seminal work "The Work of Art in the Age of Mechanical Reproduction" Walter Benjamin poses the assumption that the very nature of art is defined by (among other things) the way in which it has been produced and materialized [9]. Such supposition may indeed release us into the comfort of revisiting the notion of "art" and "production" in the context of design and digital technologies respectively.

Rapid Gestalt is a designation for the incorporation of craft materialization knowledge within the framework of CNC and RP processes of fabrication. Technologies for incorporation of naïve materialization within fabrication and assembly processes may be said to be cases of fabrication-driven form generation according to the various craft principles as defined in this paper. The ability to recreate and apply tools and techniques of and for materialization, not only as motorized versions of their ancient ancestor-tools but rather as customized versions of a generic universal technology, points towards a conceptual shift for custom-fabrication from a design perspective.

The depiction of design through fabrication may sustain such material sensibility in design. This work attempts to establish rapid craft protocols for responsive structural skin systems. Each exploratory phase aims at establishing a conceptual framework which may promote such novel interpretations of digital design tools, techniques and technologies. Finally, the notion of a rapid craft is manifested in this work as a design method which promotes the creation of novel structural systems through processes of digital fabrication and assembly.

7.0 Acknowledgements

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Oxman, N., (2008): Rapid Craft: Machine Immanence and Naïve Materialization, in Proceedings for IASS 2007, Shell and Spatial Structures: Structural Architecture: Towards the Future Looking to the Past, Venice, Italy, 3-6 December 2007, 99. 269 – 276

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