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Digital Craft

New Mixes of Process, Tools, and Materials

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With the emergence of digital technologies and parametric design, a growing obsession in digital formalism is more evident in the new generation of architects. Digital technology is being harvested as a tool to create new formal complexities but has little ground in the built environment. Renzo Piano adds that "An architect must be a craftsman... someone who does not separate the work of the mind from the work of the hand," which iterates that even with new complex technologies, we are still builders, or fabricators, by nature. (Piano, 1992)

Craft[1] is associated with materials and tools and is traditionally understood as making with physical materials. It then becomes necessary to define and explore the nature of craft as both digital and analog. With several courses taught at the University of Cincinnati, as well as a thesis research in the past two years, the authors experimented a series of research projects that investigated digital and analog craft and its processes. The joint, material, and method of application were examined while utilizing various tools such as digital software, CNC machinery, laser cutting, conventional casting techniques. Precedent research was conducted to compare and understand relations between digital technologies and analog methods to gauge their impact. These findings demonstrated the convergence of digital and analog methodologies influenced by the concept of craft as a driver for architectural form.

Digital Craft and Material

The use of craft as a process can best be described by the terms *techné* and *fabricate.*[2] Its origin suggests a deeply connected relationship to craft (the process) and the maker and maintains that position today. The issue of the tool has been a constant debate with our present context being the computer. How can one distinguish between the work of man and machine? That line has been all but absorbed today with the emergence of parametric and computational design technology. David Pye suggests that classifying between man and machine-work is meaningless. The measure is in the level of risk. He states that the "workmanship of risk" maintains constant risk in the process of making whereas the "workmanship of certainty" is an automated process where the result is predetermined before a single salable thing is made. (Pye, 1995)

This essay recounts a parametric design and fabrication course taught at the University of Cincinnati. Digital production processes that were used during the course allowed for distinct design and fabrication phases. The design phase required the use of parametric modeling techniques with Grasshopper, and Maya for the design of forms and components based on abstract data and scripting. This discourse has developed several different strategies, which investigate the building representation (immaterial process) and fabrication (material) process.

The fabrication process is summarized into two distinct paths:

1. Physical representation: *End product as a scaled model for realizing immaterial form physically*
2. Physical prototyping: *A materially- and tectonically-driven design process*

For instance, in the project titled "Parabiotic Elasticity", material potentiality was used to describe the relationship between matter and form. "Material potentiality" describes the potential for material-informed design procedures. After realizing the disconnect between the generative model and its physical manifestation, which must account for a certain material logic, the design focused on questions such as how is material a factor in the design process? How can its qualities be attributed and quantified in a way to inform both the design and production processes? The fabrication phase explored different techniques in folding, CNC milling, mold-making, and assembly. The final outcomes were physical prototypes of the designed components. (see images below)

The purpose of this project was to explore elastic material properties of castable urethane elastomers and express their structural behavior. The form was derived based on tensile stresses and deflections of this material and behavior of a building skin component. The material performance became the design driver where the tensile stresses in the material were tested and adapted to a rigid frame. CNC-milled high density foam mold served as the casting medium for liquid urethane elastomers. A series of lines were milled into the mold to form surface texture on the components. After all individual urethane elastomer components cured, they were assembled using aluminum connectors. Tools used were Maya, Rhino, and CNC.

Image_*above* "Parabiotic Elasticity" by Trevor Jordan, Brian Ballok; Instructor: Ming Tang
Image_*at left* Closed brain coral was the natural inspiration for our 'Coralight Wall' project

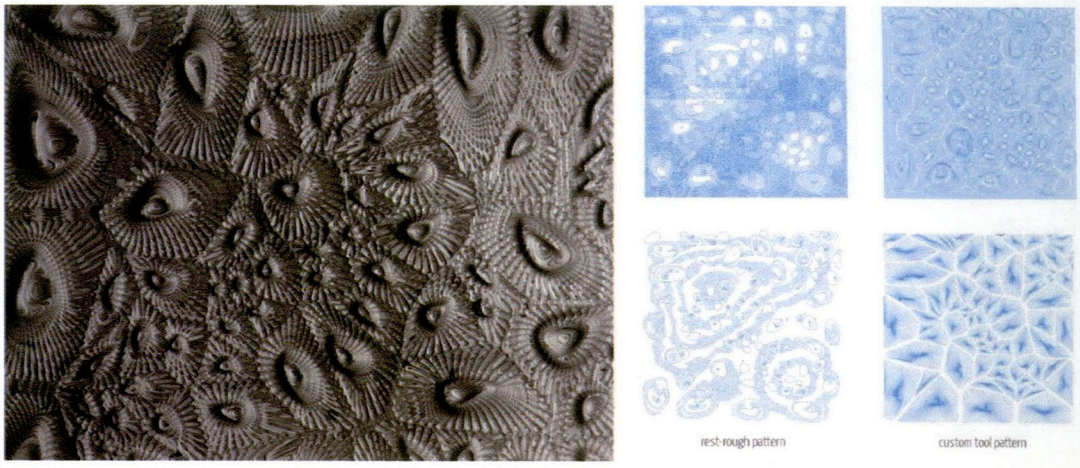
Generative Processes and Tools

With advancements in computation, material knowledge, and emerging technologies, we have been able to realize new types of forms with characteristics and benefits that far exceed most that are commonly used in practice today. The practice of machining artifacts follows the idea of embedding memory of fabrication and design processes into the built artifact. The project titled "Coralight Wall" presents research conducted in relation to digitally-assisted production methods. It is a study in the creation of material qualities, organization, and performative criteria that learns from naturally occurring systems. In this project, brain coral became the focus of study. Brain coral contain a simplicity in their form, but have intricate and complex characteristics in their surface to meet various functional needs (Figure 2). Its grooves and hard shell shelter algae from which it absorbs food and provides resistance against heavy forces such as hurricanes. This project seeks mimic "collection" behaviors across its surface by densifying and scaling formal elements on its surface in collection groups that can potentially store water or house various types of plant life. Machining effects help to induce the matriculation of water, channeling it to desired areas. Larger cells on the surface rotate and orient themselves to collect sunlight (Figure 3).

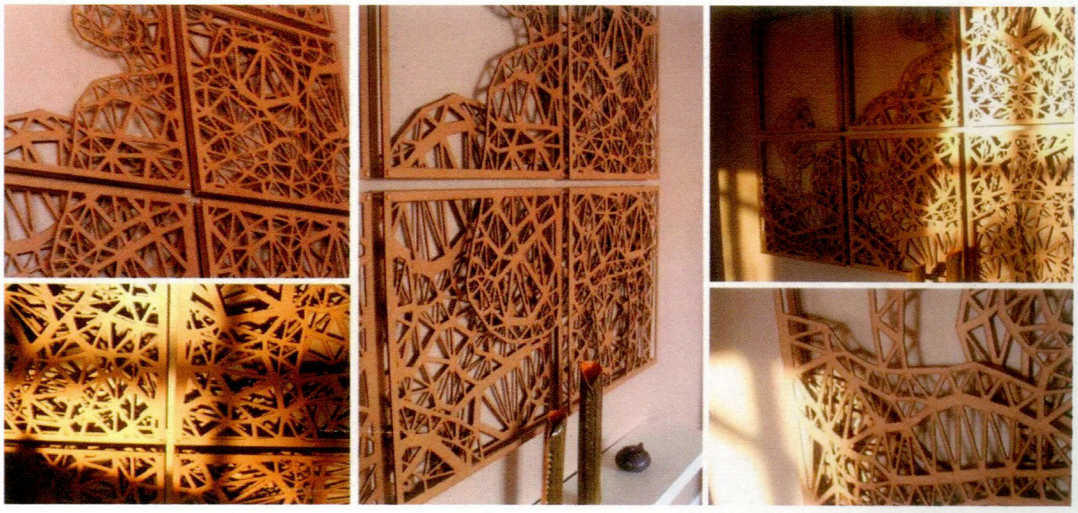
3_Details of machining effects and diversity realized through digital craft protocols. Tools: Rhino, Grasshopper. CNC. *Trevor Jordan, Brian Turcza, Austin Weller, and Yoon Jin Kim*; Instructor: *Brian Ringley*

The construction of the *Coralight Wall* consisted of laminated Baltic birch plywood. Surface depth becomes apparent as each new layer of ply is exposed, developing emergent material behavior from manufacturing processes and material composition. This project explored a generative process resulting in a constructed artifact. Techniques in digital clustering and variation induced by attraction and repulsion forces are primary organizational principles. Lamination and tooling procedures produce material artifacts that range in behavior. Irregularities and diversity are built into the generative design process, anticipating unexpected qualities to emerge while still maintaining a level of control (Figure 4). Digital craft should also operate according to non-quantifiable parameters such as social, historic and cultural values that result from emerging tools and methods.

In the project titled "Lily", shown below in figure 5, digital craft can be understood in this context as the ability of the craftsman to interpret those existing imagery or symbolic patterns and act as they take place in terms of both design generation and design production. The Lily is the result of parametric and non-linear thinking and design applied to an initial goal. This objective began with the hopes of creating modular pieces that would fit together without any extraneous connections while operating in such a way that the individual pieces would create many different shapes when combined together, depending on the orientation and the number used



4_Diagram of generative design process controlled by surface manipulation and point distribution.
Trevor Jordan



5_*Lily Project*. As a presentation of ancient Chinese painting, Digital craft is used to produce patterns of laser-cutting, combining knowledge and experience with technique and imagination. Material: Masonite board; Dimension: 9' by 12'; Tools: Maya; Laser Cutting:
Ming Tang, Dihua Yang

Conclusion

In the traditional process, the design approach can become highly abstracted and remains subjective based on the designers preferences. It usually puts the design in a position where performative analysis takes place after the design process, leaving much of the considerations to the structural engineer and fabricator. Craft, on the other hand, inherently takes into consideration material knowledge and construction techniques in processes of design generation. We believe the "Digital Craft", as a new hybrid approach, is promoting designers to consider evaluation processes and material behavior to inform the design process. "With the ability to visually and numerically quantify the efficacy of fabrication, the results are valued for the process of building, the integration of fabrication, material parameters, and the engagement to the tangible world."

These three projects explored the convergence of digital and analog craft and its impact on the process of form-finding. The experimental design and fabrication exercises elucidated relationships between matter, form, and structure to represent form-finding processes. We must not separate the work of the mind from the work of the hand. There is potential for a reintegration of processes in design generation and design production through digital craft; a reemergence of the architect as maker or craftsman.

ENDNOTES

1 The term techné (Greek for craft) is defined as the rational method involved in the producing of an object. *Fabricate* defines a more holistic sense of craft and process. The etymology of fabricate helps to better explainits significance - "*fabric*" and "*ate*." The term fabric is defined in the following ways; Underlying structure; framework;
2. An act of construction; erection.
3. The arrangement of physical components in relation to each other. The suffix "*-ate*" in this instance describes its use as "the product of a process."

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