Abstract:

This paper is an analysis of the insufficient nature of binary terms to define and discuss digital information flow and fabrication, and seeks to purport ways in which these binary definitions can be dispelled in favor of a push towards wholeness in both our understanding of the contemporary design climate as well as our own interaction with objects and material.
1 The Nature of Information Flow

One fundamental principle of information is that it flows in the direction of inertia; it simply does not function if it is not passed from one point to another. It operates as both deliverer and shipment, sweeping up everything in its path in a fluid malleable fashion, while at the same time being vulnerable to the processes by which it is disseminated. The methods through which we absorb and generate information profoundly affect the nature of the information, and thus, the way we interact with and utilize it. It is because of this affectation that computing systems and digital fabrication warrant close analysis, as Sherry Turkle, Abby Rockefeller Mauzé Professor of the Social Studies of Science and Technology in the Program in Science, Technology, and Society at MIT mentions, “the tools we use to think change the ways in which we think,” (Turkle, 2004). At the base of all information exchange is an interaction between a human being and an (often technological) information source.

The nature of how we learn has changed. We need to drive towards the idea of wholeness, of understanding broad concepts in their entirety. Designers and theorists such as Christopher Alexander reflect an effort to understand and define process: “In each case, we are aware that the future growth of the thing is created from the present by an impulse towards wholeness, somehow, this impulse towards wholeness is allowed to govern the next steps in the creation, the expansion, the formation of details, the formation the largest and the smallest wholes,” (Alexander, 1987). The perceived duality between the current digital fabrication model (esoteric sequences of software platforms, file types, and interfaces) and what we can make through an intuitive approach (handcraft, for instance) is nonexistent. These two fabrication approaches do not exist in opposition to one another; instead, each utilizes and organizes different types of essential information in a way that informs our designs in terms of wholeness. We can understand digital process on an intuitive level through the same methods that one learns a second language or a survival skill: one is immersed in a new process and thus absorbs on a primal level the inherent outcome and function of a process. This language of intuition can be linked to digital fabrication if we can connect our physical actions with our conceptual and theoretical designs. Intuition must not be sacrificed in design and production; too often, digital design tools render ungrounded theoretical forms while a scant understanding of the nature of manufacturing tools furthers the distance between the designer and the act of making with real materials.

As technology continues to develop at a blistering pace, intuition acquires a close competitor in the world of contemporary production in the form of software. In basic terms, software exists as a static set of commands and conditions that communicate information to hardware which processes the data. To draw a parallel between software and a physical/material process, one would have to imagine a woodcarver who fastidiously records every movement while carving a block of wood. Once the final object emerges, the carver could revisit every movement and make changes and variation to every single motion and decision. Advanced software seems able to anticipate every possible variable, making its relationship to the hardware or tool it communicates with (and thus the final artifact, by proximity) increasingly intimate. It is because of this blossoming relationship that our ability to access and manipulate multiple parts of this process is essential. While the relationship between software and hardware opens possibilities, there is a limit to the exploration; after all, even though the two grow ever closer, software is finite, and hardware cannot function alone, so our physical intervention can discard the limits of a binary relationship in favor of limitless and often unpredictable potential.

2 Iterative/Collaborative

The schism between conceptual conventions and their existence in physical material indicates a separation between our design concepts and the physical reality that communicates and embodies those design intentions. Digital making lends itself to iterative investigation, which in itself is a critical part of architectural design. Susannah Hagan explores this idea of iterative investigation in architecture in terms of digital making: “there have always been those within architecture impatient with its incremental nature... CAD/CAM is another instance of a technology borrowed from elsewhere, in this case, tool and die making, which can be used to manufacture architectural models and structural elements” (Hagan 2008).

This technology makes borrowing “process” from other disciplines natural and innovative, an experience in which we gratefully participate at the University of Oregon. Expelling binary language from interdisciplinary discussions has produced encouraging results, and as many departments in the university are coming from similar environmental and ecological positions, so the environmental ethos surrounding the fabrication
research creates an information exchange. It is important to realize that while much of the research cycles around technology, the technological components are not central as much as they are being used to emphasize environmental means. Our ability to operate in broader, more network-based systems will exponentially increase the viability of any innovation that comes about. As Kevin Kelly, writer and founding executive editor of Wired magazine mentions, “Every time a closed system opens, it begins to interact more directly with other existing systems, and therefore acquires all the value of those systems” (Kelly, 1998). Similar to a prism beaming light through its angles, interdisciplinary information at the University of Oregon is absorbed and produced fluidly: energy is directed towards the digital equipment, coming from the same perspective, yet the results are widely varied and incredibly interesting.

Looking at production in a more connected and fluid fashion allows us to explore the inevitable cyclical catalyst motion that begins with technology: “technology does not determine change but it encourages us to take certain directions” (Turkle, 2004). Working outside of a binary system means we make a new object and system with which we make the object simultaneously, because we are not making any assumptions about the object before it actually exists. “We have never had a greater need to work our way out of binary assumptions...we need to rebuild the culture around information technology. For never has our world been more complex, hybridized, and global. Never have we had so many contradictory thoughts and feelings at the same time. Our tools must help us accomplish that, not fight that” (Turkle, 2004).

3 Sending Interference: Hacking the Laser Cutter Process

We can play with digital precision through the knowledge and serendipity of handcraft by fostering experiments with quick feedback loops between machine and material results. We strive to develop digital fabrication interface strategies that are approachable and fuse the interactive process of material engagement with digital fabrication tools. The ultimate desire of this fusion is real-time interaction and feedback loops in which a physical motion is directly translated to a physical material via digital technology. Contemporary precedent for this kind of making can be found in research by Jason K. Johnson of Future Cities Lab/CAA Architecture and Andrew Payne of LIFT Architects/Harvard GSD, who introduced Firefly at the AA/CAA Biodynamic Structures Summer 2010 Workshop. In their words, “Firefly is a new set of software tools dedicated to bridging the gap between digital and physical worlds. It allows near real-time data flow between Grassopper (a parametric modeling plug-in for Rhino) and the Arduino microcontroller” (Firefly primer, 2010). Thus, Firefly allows a formerly liminal architectural model to interact with the physical world through the Arduino and sensors and make software adjustments in Grasshopper that change the model to accommodate this real-time information input. This type of research becomes increasingly relevant as the relationships between designers and machines continue to evolve.

In order to exploit this evolution, we performed different experiments that immediately associated our physical input with a machine's actions. At the University of Oregon, the laser cutter is our most utilized and basic digital fabrication machine, and is bound by the limitations of its functions. For example, once the physical material is in place for a fabrication operation, the process becomes fully automated and makes interaction with the material impossible as the laser ceases to function when the door is opened. We wanted a more direct hand to machine control and we also wanted to be able to record and playback motion through physical programming. To do this, we collaborated with UO Digital Arts department faculty member John Park, who worked with us to program an Arduino circuit board. Our set up allowed us to physically control a servo-motor to which we attached material, and also to record and play back the details of our physical motion so we could visualize our experiments through a range of data displayed in graphic form (Figure 1).

We set up a lathe attachment that we could physically control through a servo-motor hooked up to the Arduino and a WiiChuck independent from the laser cutter machine (Figure 2). We created a program that operates for 20 seconds at time and is designed to use the WiiChuck to control the servomotor. In real time, the movement of the lathe attachment is based on how the WiiChuck is being rotated via hand motion. The servomotor is capable of 180 degrees of rotation, and as the hand motion moves the piece through the degrees, that information is fed back to the computer serial monitor. This information is being processed at a rate of 1 sample every 10 milliseconds and the degree information being streamed back to the computer serial monitor gets recorded and saved. Since the range of values between the WiiChuck and the servomotor are different, we
have "mapped" the values of the WiiChuck to a range of values corresponding to the servo-motor (Figure 2). After we have conducted an experiment, we copy the hand motion data into an Excel spreadsheet where we then graph the numbers of the hand movement over a 20 second timeline. The data set can be played back with different geometry, or the data set can be remapped using a different time scale, resolution, or amplitude.

The interest here lies in the fact that physical movements are being recorded and the capacity to play back is possible. The physical hand movement isn’t just a series of discrete motions dictated by CAM, rather it could be a series of gestures indicating a technique with a particular craft, or the development of new hybrid tools in which physical recording and playback are vital to the production of objects. Interaction with predetermined machine processes is only the first step. It will be possible, with the further development of these hybrid techniques to set variables to physical parameters of the making process. In other words, if one is trying to limit the intensity of a hammer blow to a nail, a resistance could be applied to the hammer internally that would dampen the blow to a desired force. Since we physically controlled the material in the laser cutter through a set up that was essentially hand controlled, we could actually move the piece during the laser cutting operation, which opened the door to emergent, iterative explorations that were of a more immediate and direct nature than the process by which we had formerly used the machine.

Figure 1: Experiment analysis

Figure 2: Arduino, WiiChuck, and lathe attachment set-up in the laser cutter.

Figure 3: Breakdown of the code that communicates information going into and coming from the laser cutting operation/servo motor motion.

4 The Hand Signal

Our relationship to the machine is still separate from the way we self-identify as designers. Design ideas and material manifestations can be immediate and exciting, and we must push to constantly evolve our understanding of and relationship to digital design technology and physical output processes. We absorb information on many levels, and while it is tempting to analyze information in binary terms—an object/idea functions or does not, communicates or confuses, supports or dispels—contemporary production makes clear that we cannot analyze in terms of binary definitions anymore. Information and thus processes always change, and our perception shifts along with the changes: for instance, Italo Calvino described modern production in terms of the way the information is exchanged between machine and digital file: “the iron machines still exist,
but they obey the orders of weightless bits (of data)” (Calvino, 1988). When we combine a physical process of emergence and the iterative qualities of digital design tools, we can take many paths at once.

Thus, our research prioritizes intuition. In essence, we want to reproduce the physical act of making by recording human movement through parameters and variables. To have the freedom to use anything perceived or learned without conscious attention, reasoning, or concentration allows all design elements to become alterable, and this information allows us to create a system in which production will be possible; we are able to generate through a system that has the capabilities of varying alterable and mutable values.

The exploration and application of a formally driven design process that embraces change and risk is well documented through contemporary works of commercial firms like Gramazio & Kohler, who not only employ a system of logic that relies on rules to “define relationships and intentions” (Gramazio, Kohler, 2008), but who also continue to push the limits of what architecture can do and in what format. This sentiment echoes the ideas of contemporary thinkers such as Rem Koolhaas, who speak to the evolutionary potential of architectural design: “Once you are interested in how things evolve, you have a kind of never-ending perspective, because it means you are interested in articulating the evolution, and therefore the potential change, the potential redefinition” (Koolhass, 2004). This redefinition is absolutely important, as our relationship to the act of building and the systems we use to build them is constantly in flux. Ambiguity as to what informs an emerging object/material reality is an exciting place to be, and there is much opportunity in “a dynamic relationship between things and thinking. Objects are able to catalyze self-creation” (Turkle, 2007).

Another particularly interesting precedent for information sets (a combination of parameters and variables) in conjunction with hand making is the recent work of science writers Margaret and Christine Wertheim, who founded the Institute for Figuring to “advance the aesthetic appreciation of scientific concepts.” Their recent research, dubbed “coral reefs,” utilizes crocheted forms as a way to communicate the spatial and dimensional qualities of hyperbolic functions. The forms emulate the growth patterns and formal qualities of their namesake; they examine the nature of hyperbolic functions and allow those systems to generate vast and emergent objects that are...
unexpected, diverse, and impossible to design or predict. When paired with the intuitive and tactile act of manual production, the resulting objects provide a reflective and reproducible imaging of a complex three-dimensional concept. The possibility of these systems exchanging information can help us understand that “the highest levels of abstraction, things like mathematics, logic, and computing cannot just be engaged with cerebral, algebraic, symbolic methods, but by literally, physically playing with ideas” (Wertheim, 2009).

With this in mind, we worked with fiber artist Rob Mertens, a teaching fellow at the University of Oregon, to explore more about craft as a process and its relationship to the structural logic of hyperbolic forms in an effort to understand the nature of both the material and the mathematics generating the pattern that forms the material. From a traditional perspective, the shapes formed by imposing a hyperbolic function onto the crochet process are often considered mistakes in traditional stitching, as they represent a doubling or tripling of a stitch that is usually singular. While math is intrinsically linked to crochet, thinking of crochet through mathematical theorems (such as hyperbolic equations) is a contemporary development, and the combination of the two systems of logic yields beautiful and surprising outcomes, even though the creation of the final object was accidental in many ways (Figure 4). The fortunate accidence is actually a variation on a traditional “code” or stitch, which in many ways parallels our laser cutter investigation in terms of information: the software is a series of patterns that dictate form, and Rob’s intuitive disruption of the pattern informs his hands and tools, resulting in the final artifact. For Rob, the hyperbolic nature of the doubled or tripled stitch exposes “the importance of improvisation as opposed to simply playing from a score.”

4 Conclusion

Being able to collect, analyze, and assemble information in ways that inform our thinking in a generative direction is valuable: the most innovative thinkers of today often simply magnify what already exists. We want to able to frame and contextualize the information that buries us every second of our fast paced lives and use it to provide forward momentum. Inertia will always keep us moving, and it is absolutely essential that we take action to direct it. Hagan speaks of the contemporary absorber of digital information as a modern flaneur: “a lone and idle drifter...the internet surfer has cut himself off from any direct relationship between cyberspace and material world” (Hagan, 2008). Directing our trajectory through developing methodologies is not a chore, nor does it have to be drudgery. If we connect our processes to our solutions in a more direct way, especially in the realm of architectural design and digital fabrication, we will truly love what we do: analyze the information in front of us. Architects, artists, and all designers are looking for the same types of solutions right now: how to make connections that build up and out. We thrive on change and innovation, and these things already exist in the information ephemera; it is just a matter of organization and chance.

References