Serendipity and Discovery in a Machine Age: Craft and a CNC Router

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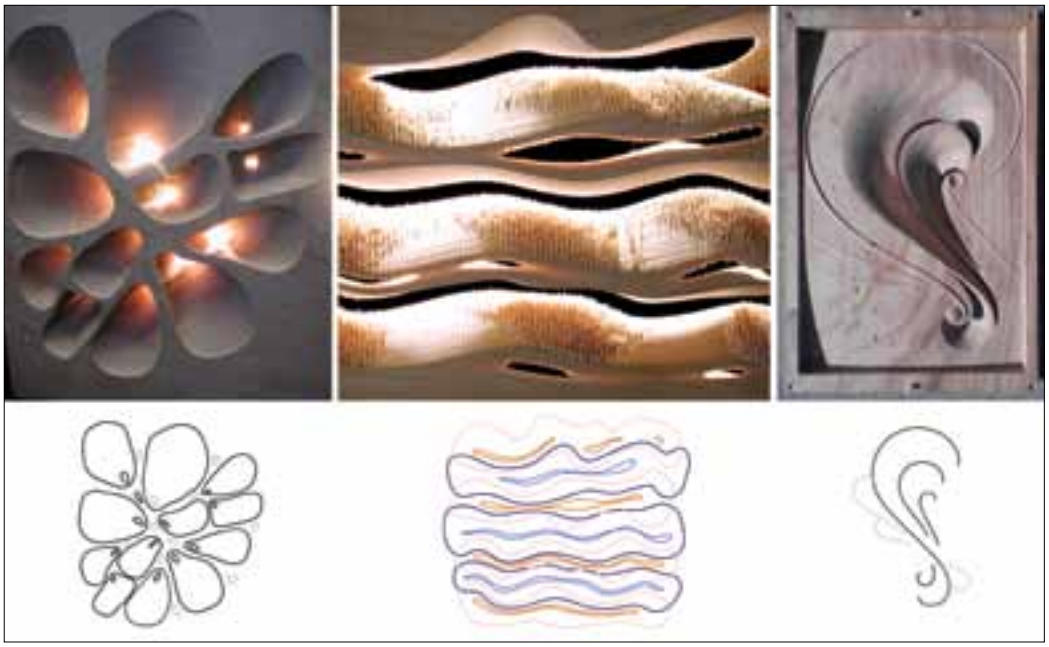

Figure 1 Carving from hand sketches (l, c) show more vitality than purely digital form (r). (all by Cheng)

ABSTRACT

Our digital carving experiments reveal ways to invite discovery into the design process. Working with sketched lines, handcrafted finishing, geometric overlay, and tool path coding can lead a designer to unexpected results. Concentrating on forming processes moving through material over time encourages open-ended play. Iteratively examining how computer operations generate carved results provides a craftsman's understanding of tools and materials.

1 INTRODUCTION

Our carving experiments fall into the realm of craft, a humble activity that involves the use of tools in shaping materials for aesthetic and functional purposes. This paper uses lessons learned from CNC carving to illuminate how a craft orientation can enrich digital fabrication. It builds on architect Luis Eduardo Boza's (2006) idea that the automated "Workmanship of Certainty," as defined by furniture designer David Pye in 1968, can be invigorated with the "Workmanship of Risk." It discusses ways to introduce this risk so that it brings the delight of serendipity.

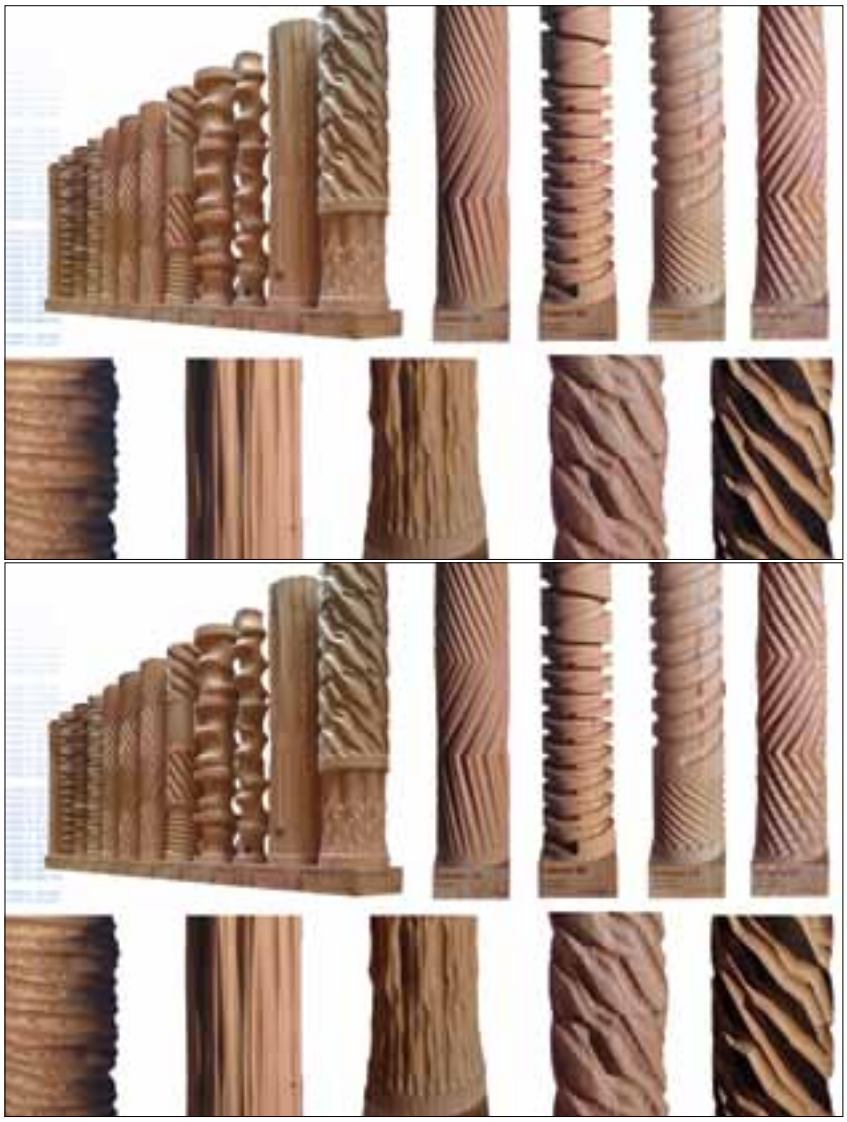

Figure 2
Columns created from repeating and rotating a spiral tool path by Hegre. Each carving resulted from modifying the machine code of the previous one.

2 HAND-DRAWN LIGHT MODULATING SCREENS

Like many, we are eager to escape the monotonous regularity of automated repetition. One method we employed was to use hand-drawn lines as a generator to create panels with surfaces and apertures vary with changing light. This was inspired by Digitiles (Breen & Stellingwerff 2007) and algorithmic holes (Bonwetsch et al. 2007).

We took gestural sketches created with an Anoto digital pen into 3D modeling and then carved them with the router. Outlines simplified and closed with Adobe Illustrator retained the random idiosyncrasies created by the physiology of the hand (Von Sommers 1984). The impulse to use hand-drawn lines is akin to the relief sketchy rendering and digital rust techniques provide from the slickness of photorealistic rendering. Departing from Bezier curve precision takes the work out of the realm of pure geometry. Like variable-width brushstrokes in vector-based illustration, a hand-drawn line's gestural expression can have an idiosyncratic vitality that can satisfy in a different way than geometric resolution.

In figure 1 (left), flat, sketched loops become deep funnels that reveal the depth of the wood. It is true to the line drawing, yet completely transformed by the machine. Stair steps are visible both in depth and at the perimeter of the parallel tool marks. Waveforms in figure 1 (center) highlight the variable angle of the wood grain with irregular fuzziness.

The signature quality of hand-drawn lines can invigorate a digital project. An accessible digitizing pen allows quick input of vector lines that can be easily transformed for 2D cutting and 3D form generation (lofting, Boolean operations, etc.). This produces more creative variations than 3D modeling, whose complex interfaces trigger linear rational thinking, constraining creativity.

But hand-drawn lines are limited. They do not gracefully spawn related forms; they lack defined geometric relationships. For example, loosely drawn circles and ellipses have no centers for generating concentric forms. Looped or kinked lines can generate problematic surfaces that cannot easily be offset. And while excessive rehearsal or editing can temper spontaneity in sketched lines, they can still be more interesting than geometrically precise curves.

3 TOOLPATH MANIPULATIONS

Co-author Erik Hegre investigated how a CNC router with a 4th axis uses movement to generate form. Playing with G-code, Hegre observed the results of incremental code changes on machine movement, and documented the physical results. This allowed him to emulate gestures in the language of the machine. The column variations started with a simple spiral path, generated by rotating the cylinder while moving a router bit along its length, like a lathe creating a bolt thread. As Hegre methodically divided motions into smaller increments and adjusted variables (i.e., rotation, axial distance, height), he created a family of forms.

As in a chess game, each step was chosen by looking at the set of previous steps. The process developed a strong feedback loop between the emerging form and the machine code used to generate it. Then, the designer and co-author Erik Hegre, used visual judgment to enhance the next machine operation. From a quantity of data aspect, both of these examples used the smallest amount of information needed to create a larger effect—the tool bit and tool path are perfectly optimized to generate the emerging form.

We may be able to discover new horizons in design by utilizing simple methods, making modifications, and seeking unique results. Margaret Wertheim (2009), whose Institute for Figuring network is crocheting coral reef geometry, argues that even "the highest levels of abstraction…can be engaged with, not just through purely cerebral algebraic symbolic methods, but by literally, physically playing with ideas."

4 ANALYSIS: MOTION AND PLAY AS PATHS TO DISCOVERY

We can explore actions, as opposed to pre-conceived form, through sketching, finishing, and coding. These activities precede process as a driver of design and encourage playful experimentation. Rather than the question, how can the tool make my form? We need to ask, what can this tool make? And, how can I tool towards interesting form?

Designing with physical engagement can foster the mind-to-hand connection, broadening crafting knowledge and material understanding. Sociologist Richard Sennett argues that as designers stray from hand drawing, they will lose a connection to their work. Using the machine as an extension of our hand, we can empathetically experience its movements, while benefiting from the machine's precision and ability to replicate. The medium records both hand and machine tool movements as memory traces or engrams.

We want our community to enrich digital precision with the knowledge and serendipity of handcraft. By pursuing the sensitivity of handcraft without its labor, we can use digital fabrication as a catalyst for design instead of just a means of production. Our explicit interest in the hand-drawn line, material properties, and tool path motion has allowed us to expose playful design opportunities. Each product's meaning comes from a specific context. They may look trivial to the observer, but to the creator, they act as a means of discovery. As playing with chains and weights was a first step for Antonio Gaudi's catenary vaults, we hope these exercises plant seeds for ideas that come to fruition later.

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