PARAMETRIC CRAFT TECHNIQUES
DESIGN METHODOLOGY FOR BUILDING ON EMBODIED CULTURAL KNOWLEDGE

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1. CRAFTS AND DESIGN; A FORK IN THE ROAD

Throughout history and across the world, crafts have drawn inspiration from the beauty of nature and mathematics. Complex, algorithmic patterns can be seen across disciplines from Islamic geometric tiles to Nicaraguan pottery to the architectural forms of Gaudi.

While these natural, mathematical forms have inspired embodied skills in countless unique cultures, many of these crafts face extinction as globalization and digital prototyping take our focus away from the handcrafts that have been passed down through the generations.

Simultaneously, designers are embracing algorithmic and generative designs across disciplines. Starting with architecture and now progressing into industrial design, parametric tools are making visual scripting accessible to all, creating a barrage of visually noisy artifacts with little design basis as we learn what these tools are truly capable of. This raises the question: can design use modern, advanced parametrics that allow direct engagement with mathematics to highlight the many skill-based crafts that are in danger of fading away?

It is the position of this paper that the celebration of handcraft and ability to merge it with future-facing, generative tools can create greater awareness and connoisseurship, increasing the value placed on historical craft and knowledge embodied in parametric designs.

2. CAD AND CRAFT

With the advent of CAD (computer-aided design) programs, starting with Sutherlands Sketchpad in 1963, modeling and representing ideas digitally has become an invaluable tool for design across the board. The invention of AutoCAD in 1982, for example, meant that, instead of redrawing a blueprint to change a feature, one could simply move it in the program and re-export it.

Currently, designers have many more modes of digital modeling, a few of which this paper deals with that often get confused. For the purposes of clarity, the following definitions can be used for further discussion:

Algorithmic Design:
Design based on a logical, mathematical equation. The equation results in on or multiple designs.

Generative Design:
Design created by one or more inputs. Although this can be algorithmic, it can also be any other input, be it digital or analogue.

Parametric Design:
Design made by inputs defined by their stable relationships. These relationships are used to update the results, thus making the model dynamic.

As generative programs that create designs from mathematical inputs, have come on the market, most notably Grasshopper 3D, started as “Explicit History” in 2007, we moved beyond using a computer to complete our work quickly, to using a computer to create work we otherwise may not.

Before, such ideas were within the realm of possibility, but were complicated, time-consuming and expensive to make. Similarly, the tools are not entirely new. Parametric techniques have been used for centuries. These types of natural mathematics-based forms, including hanging chains, can be seen throughout Gaudi’s work with La Segrada Familia, designed primarily in the late 1800s and early 1900s (Sagrada Família, 2017) (Figures 1 & 2). As Daniel Davis points out, Gaudi’s techniques built on the work of Robert Hooke and other basic mathematic principles (Davis, 2017). It was Gaudi, however, who used these principles to create an analogue parametric model, where moving the chain origin affected the result.

Figure 1. La Sagrada Familia.
Image: en.wikipedia.org/wiki/Sagrada_Família#/media/File:Sagfampassion.jpg

Figure 2. Gaudi’s Hanging Chain Model for La Sagrada Familia.
Image: KK Clark. http://1.bp.blogspot.com/-lJKiMgirqFU/ T7P4wwihD9I/AAAAAAAAApc/B1CmkBIS86U/s1600/DSC00764.JPG

Now, with modern parametrics, a designer can create forms based on centenary curves, or most any other mathematical form, for that matter, without spending many hours and mental exertion that it took Gaudi. While this access and ease is generally a positive, there are critical learnings that are inadvertently evaded. While these learnings may seem enigmatic, anyone who has learned a physical making skill knows them well. As Malcolm McCullough points out, "Psychologists and social scientists have studied this inarticulable knowledge extensively, and they have many names for it: operative, action-centered, enactive, reflection-in-action, know-how. The most common word is *skill*." (McCullough, 1998. p.3). Skill is not something that lies exclusively on the back of instructional knowledge or even in extensive practice. Embodied in the crafts we practice is all the knowledge of the generations that came before us, and Without ways to keep this learning intrinsic in parametric programs, the objects that are created will be devoid of the history that we have created over centuries.

The ability to build on the knowledge and practice of our ancestors lies at the heart of humanity. It is what separates us from other species, and defines individual cultures around the world. UNESCO (United Nations Educational, Scientific and Cultural Organization) approaches the ever-evolving identification of this as Intangible Cultural Heritage, with one of the most important aspects being cited as "…the wealth of knowledge and skills that is transmitted through it from one generation to the next." (UNESCO, 2017).

It is clear in the complexity of many crafts that the work was developed on the shoulders of others. One of the oldest knit artifacts from 100CE can be contrasted with the complexity of knit lace from the 19th century (Figures 3 & 4). Still, the simplicity of the stockinette stitch is far surpassed by the knit Shetland lace that follows some generations after.

Figure 3. Early knit sock found in Egypt from 1000CE
image: http://www.knitty.com/ISSUEspring06/FEAThistory101.html

Figure 4. Knit Lace from the Shetland Islands made in the 19th century. Image: V&A's collections item T.137-1966

While the aesthetics of generative tools may be interesting and novel, much of the usage has been haphazard and comes from pure exploration. Can these tools be used to design with purpose, embodying the skills that have come before us? How can we better use our digital tools and our handcrafts together? Following are two case studies of techniques that combine hand-craft techniques and digital parametrics.

3. PARAMETRIC KNITTING WITH SEMI-RIGID MATERIALS

Knitting is a universal craft with no known origins that has been traced across the globe as both a profitable craft to families and as a hobby or teaching tool. With no existing samples, the best historians can do is place the origin around 200 CE, although there are varying theories of it arriving earlier. The earliest perhaps lies in the legend, "...it is said to have been known forever, and that the pattern on the serpent's back was knitted by Eve." (Thomas, 2013. p.1).

While knitting has some regional differences defined by history of usage and availability of local materials, most knitting globally is simple combinations of knit and purl stitches and can, at this point, be considered a universal craft. It would be very unusual to find a person who has not come across a knit artifact, and although they may not be able to articulate the differences between knit cloth and other cloth, most would have a familiarity and inherent understanding. As such, it became fertile ground for developing parametric techniques that could be used by many.

Using the basic geometry of a single stitch, paneling tools in grasshopper allowed for an alphabet of shapes to be created. These blanks create different forms in two ways. The designed shape of the blank creates varying form when knit together. Secondly, the form can be created by knitting the working blank from the front of the previous row to create a purl stitch or kitting the working blank from the back of the previous row to create a knit stitch. Depending on these pattern choices, the end form has the possibility to be flat, curved, folding, or have alternating curvatures.

This technique allows for knit structures to be created with novel materials from soft fibers to semi-rigid materials That have been cut or stamped. This allows for multiple methodologies ranging from open-source, to truly global manufacturing that can be produced anywhere en masse. Below are just three possibilities of the types of products that can be created (Figure 5).

Figure 5. Various knit forms made with bamboo veneer using paneling methods with Grasshopper 3D. Designs and Images © 2016, Lisa Marks.

4. MORPHING LACE WITH FUTURE POSSIBILITIES IN 3D LACEMAKING

Parametrics can be applied to many ubiquitous crafts using similar techniques of analysis and manipulation using parametric tools. The analysis helps to understand the structure of the craft and how it's made in detail. The manipulation provides new patterns and forms to make. Lace presents as another interesting option for this methodology given that it ubiquitous is many different regions, has a long history of hand-craft, and it can create a wide variety of design possibilities.

To begin, an analysis of form and generation of equation was done on multiple patterns of lace. Below is the algorithm for a basic ground stitch in lace-making called the Whole Stitch, one of the more prevalent stitches in lace. The size of each stitch can be controlled easily as well as the number of stitches in each direction (Figure 6).

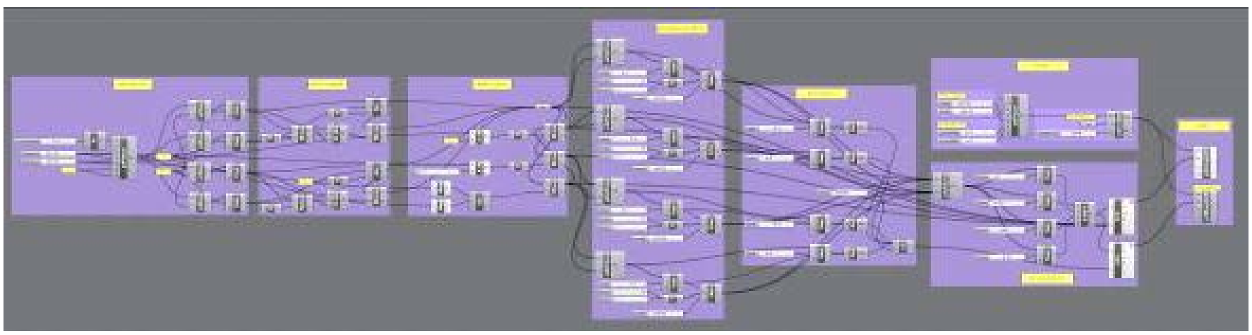

Figure 6. Grasshopper equation representing the Lace Whole stitch with morphing capabilities. Image © 2017, Lisa Marks.

The equation includes the ability to add attractors and detractors that would morph the fabric into unique patterns. These patterns include the same types of marks and points that are traditionally used in lace making, but these marks are now part of an algorithmic design that can be changed in a matter of seconds to create different shapes and patterns. These patterns can also be mapped onto both two-dimensional and three-dimensional forms.

By making the lace over a mold in the same shape as the three-dimensional model, three-dimensional fabric without seams is produced. Because of the attractors in the patterns, the lace stitch became an optical illusion; a flat piece of lace may look more three dimensional than it is and a three-dimensional piece may look flatter than it is.

Eight patterns that have been generated are shown in Figure 7 on the following page. On the left side, a two-dimensional representation of the pattern that is generated from grasshopper, and on the right the hand-made, three-dimensional outcome.

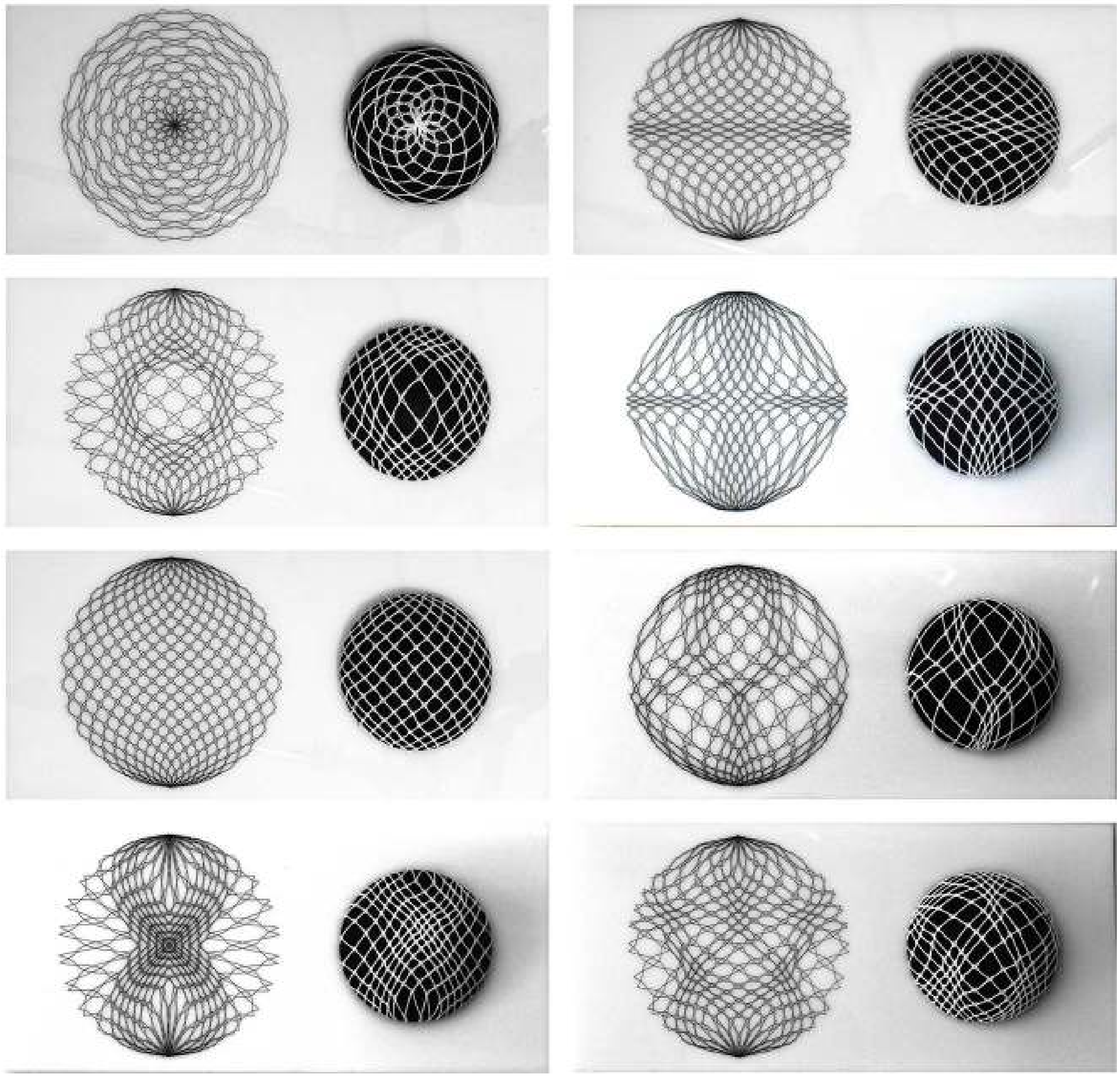

Figure 7. Grasshopper patterns and hand-made, 3D results. Image © 2017, Lisa Marks.

Uses for this include customizable seamless undergarments and clothing, housewares, and more. By using parametric technology to build on embodied cultural knowledge that is inherent in craft, people can continue to make progress in humanity and culture. It should not be ignored that people enter art and design fields out of a love of making, and this process of making with their hands is how designers learn about their materials, their end users, and themselves. “There was a time when the work we did with our hands helped us define where we belonged in our world” (Wax, 2014. P.193), and that can continue with digital tools if done thoughtfully and with purpose. By involving digital parametrics in hand-craft, designers and educators can help the techniques stay current to our times, and by involving hand-craft in parametrics, they can help our technology build on the knowledge that has been developed for centuries.

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