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Generative Crochet:
Using computational methods to augment handicraft

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Generative Crochet:
Using computational methods to augment handicraft

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Kira Ayana Street

Report

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Dedication

To Patricia Maycock, who taught me how to crochet and the value of making.

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Abstract

Generative Crochet:
Using computational methods to augment handicraft

Kira Ayana Street, M.F.A.

The University of Texas at Austin, 2018

Supervisor: Kate Catterall

Crochet is an old craft with a rich history that spans many regions and cultures. Although historically it has been the work of men and women in the form of fishnets, clothing, and accessories, it is now largely associated with the feminine arts. Its historical applications were a means for women to gain an independent income and be productive in the home, and because of this association, it has been practiced in the domestic sphere to create forms appropriate to that context: lace, edgings, clothing, and towels for example. However, by engaging in the theory of craft, in particular with the idea that invention can come through experimentation and play, and by employing algorithmic assistance, crocheters can break out of making the same items for the same applications and begin to find new forms and applications for the craft.

In the last two decades, a diverse range of disciplines, such as fine arts, architecture, and mathematics, have demonstrated radical new approaches and applications for crochet. Free-form crocheters use the organic nature of crocheted pieces to create intricate pieces of art and to present elaborate organic sculptures of natural

scenes. Architects and mathematicians use crochet as analog models for larger structures or theoretical forms to better understand how they can be constructed or how they perform. The precedent set by these applications begs the question of how else crochet can be applied, specifically for use in the realm of the product design world. Furthermore, how might we discover these new applications, and how might we encourage people, within the craft community and beyond, to use crochet or craft to augment their established practices and open the door to invention?

In order to explore these questions, I have designed an algorithm that randomizes typically formulaic crochet patterns and that encourages crocheters to make new, unconventional forms unlike existing patterns. By engaging in this "uninhibited play", my hope is that crocheters can use this algorithm to spur inventive crochet applications from furniture to lighting to structures. I am also in the process of building an interdisciplinary crochet community engaged in using this algorithm to experiment with crocheted form and to make and display the pieces in an online gallery. In this way, the iterative nature of the process can reach beyond the algorithm, prompting a culture of remixing generated crochet patterns and forms. The principles behind this platform can even reach beyond crochet by encouraging those of other disciplines to use the idea of craft and play for innovation.

Keywords: crochet, pattern, generative design, generative crochet, play, multidisciplinary, experimentation, craft, generation, process, explore, material, digital fabrication, DIY culture, creative agency, amateur, yarn, 3D print, handicraft, product design, architecture, invention, innovative.

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MY CROCHET STORY

Why crochet?

When I was twelve years old, I wanted to learn how to crochet. There was an older woman from my church, a Ms. Patricia Maycock, who knew almost every type of craft imaginable, from knitting to embroidery to scrapbooking, and I wanted to learn these techniques. I asked if she was willing to teach me how to crochet, and she cheerfully obliged. After that, every Sunday afternoon, I diligently went to her house for about two hours to learn. Instead of having me practice by making multiple swatches with different stitches, she introduced me to crochet through a practical application—a shawl with many different stitch types and intricate layouts. She taught me the basics of how to hold the hook and the more intermediate skill of switching colors. I still have that shawl, and although I never wore it outside my house, it stands as my first crochet project (Figure 1).

Figure 1: Shawl from Street's personal collection

After completing that complex project, I felt a sense of accomplishment. I quickly became fascinated with crocheting and searched for ways to practice my newfound skill. Because of a booming online crochet community, I found many patterns for a variety of items, including beanies, stuffed animals, bookmarks, and much more. For a time, I was satisfied with these patterns; just knowing that I had made something on my own was enough for me. However, after twelve years of growing in my technique and skill, the patterns I once found exciting became less so. Many of the objects and applications were minor variations on the same themes, with many different patterns for the same kind of

hat or sweater or stuffed toy. I wondered how I could find something new to rekindle that sense of love, wonder, and accomplishment I had when I was twelve.

Beyond crochet, I have explored other creative techniques, mostly relating to product design. These include 3D printing, woodworking, and CNC machining. In the same way that crochet offered me a sense of accomplishment and joy, I have found a similar excitement in working with digital tools and computational machinery. Within digital modeling, opportunities for integration and augmentation with other methods of making are endless. Coupling these new technologies with old ones, like crochet, makes it possible to fabricate almost anything imaginable.

Due to my deep interests in furniture and small consumer product design, I wanted to combine my interests in crochet with product design. I sought to answer the questions, "How might crochet be expanded beyond its feminine associations and applications?" and “How might that expansion draw from and influence other disciplines and methods of making?"

A BRIEF HISTORY OF CROCHET

From the beginning to the present

To understand why there are so many patterns for the same kinds of things crochet, I looked to its history. The word crochet refers directly to its tool; it comes from the French *croche* and the Old Norse *krokr* meaning "hook."[1] Although its origins are somewhat mysterious, it is accepted that its history comes from two main sources: from shepherds who would collect stray strands of wool from their sheep and loop them into fabrics for blankets, shawls, other and clothing; and from lace making where crochet was used to imitate the more arduous process of actual lace. For this reason, crochet was also known as "poor man's lace" or "Nun's lace."[2]

As crochet began to rise in popularity in Europe, it became a symbol for wealth, power, and splendor. In Ireland, crochet was taught in convents and schools as part of the curriculum. Since the basic technique was relatively easy to learn, it was taught to children, and people of means were willing to pay a premium for crocheted articles because of their beauty. Families saw crochet as a skill needed to survive while in poverty, so every member of the family was involved. Irish crochet (Figure 2) was comparatively less expensive than traditional lace, easier to learn than its predecessor, and more durable when transported. Although crochet was done mostly by women and children in Ireland, once the famine came, all parts of the family were involved. Men came to the schools to learn crochet as well, and it became the pride of Ireland since it was known to be cost-effective and lucrative.

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[1] "Crochet." Merriam-Webster.com. Accessed April 20, 2018. https://www.merriam-webster.com/dictionary/crochet.

[2] Potter, Annie Louise. *A Living Mystery: The International Art & History of Crochet*. A.J. Publishing International (1990). p. 108

Figure 2. Example of Irish Crochet, Accessed April 24, 2018, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=24943

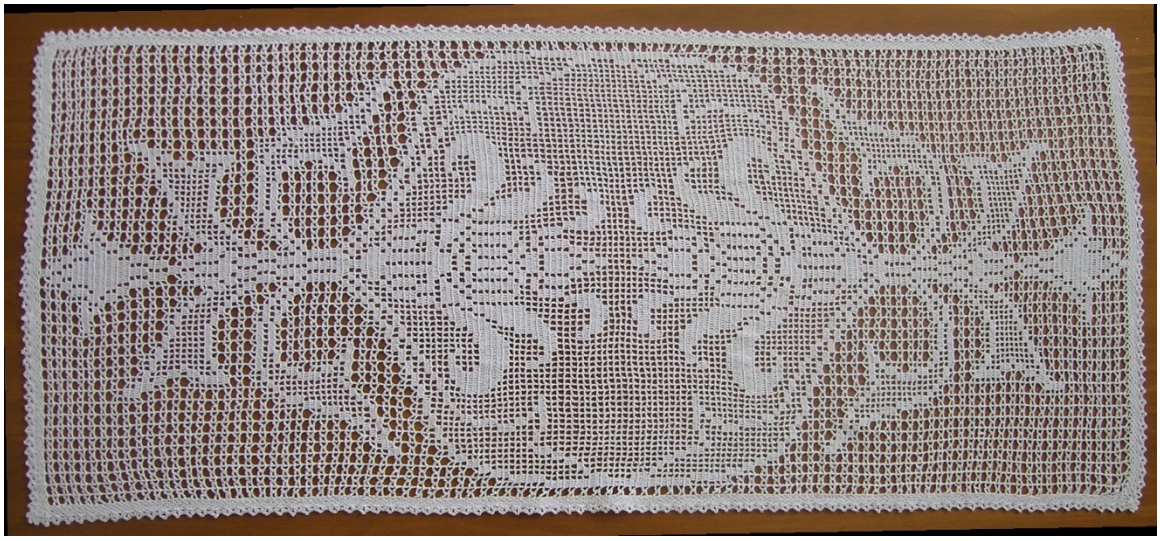

Figure 3. Example of filet crochet, Accessed April 24, 2018, By Cgoodwin - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=3185754

In the 16th and 17th centuries, filet crochet (Figure 3) grew in convents in Rouen, France. The nuns would use crochet to show their dedication to God and as a testimony of their faith. It was seen as a God-given talent to be used for beautification and for missionary work. This "ecclesiastical crochet" resulted in "dresses, caps, marriage gowns, christening robes, gloves, runners, tablecloths, altar mantles" and more[3]. As they taught crochet to the daughters of wealthy families, crochet became known at the time as something a "well-bred" young lady would know how to do, an expected skill in order to be considered a high-class woman in society.

When it came to distributing patterns, people passed down actual crochet samples that their children would attempt to copy without real instructions. However, in the mid-1800s, a Frenchwoman named Mademoiselle Riego started publishing instructional books for crochet and lace work. She was known as the authority on needlepoint, crochet, knitting, and lacework. At a time when women were not revered in leadership roles, she was highly respected as a maker and businesswoman. She was shrewd in her dealings with royalty and courtiers, teaching them crochet and enacting business deals to sell her publications. She was a source of inspiration and a resource for other women of the time who wanted to make a living off of needlework for leisure or for their own home. As a designer, she wanted crochet to be seen as art on its own merit.[4]

In America in the 1800s, women were doing more knitting, sewing, and weaving than crocheting, particularly because crochet was more associated with luxurious European laces and not seen as appropriate for pioneer life. Quilting and weaving warm articles were the priority. But crochet did flourish in some circles in early America. As Irish and English immigrants came to America, they brought the craft with them and

[3] Potter, *A Living Mystery,* 84
[4] Ibid. 87-89

continued to crochet, making domestic articles and clothing for their homes, because the international market for them was relatively dry.[5] Additionally, manufacturers started producing materials, like different kinds of cotton, that were more conducive to colonial applications, and crochet steadily became a popular means of making.

Even after crocheting was not necessary for income, women would crochet articles for the home for pleasure or relaxation. Traditional European motifs remained, but were also often blended with motifs from other cultures to create designs that mirrored the American colonial spirit of freedom and revolution. It was during this growth in America that crochet became "firmly fixed as a textile commodity and as a leisure art".[6] However, it was still a highly feminine art, and magazines and publications that published instructions and images of crocheted pieces described it as such; for example, Sarah Josepha Buell Hale wrote in *Ladies Magazine* in 1827 that "Every husband may rest assured that nothing found in these pages shall cause her (his wife) to 'usurp station' or encroach upon the prerogatives of men."[7] Crochet, as well as other forms of textile making, became a way to keep women productive and in "their place", namely in the home.

Following World Wars I and II, crochet's image began to change. Crocheted lace and trimmings were thought of as old-fashioned and symbolic of the old aristocratic era. With the growth of the middle class and a democratic society, those symbols of European monarchy and luxury fell out of favor. But by 1960s after World War II, crochet entered a revival, resulting in a change in appearance and application. The pieces during this time were colorful and bold in look and application; new designs for granny squares and

[5] Ibid, 127, 128. At this time, King George II of England had enacted harsh penalties to anyone who imported needlework from the colonies.
[6] Ibid, 12
[7] Ibid, 129

crocheted textures became popular and these colorful styles worked their way into the "hippy" culture of the time. At this point in time, more men also took part in crochet, continuing to find new contexts to apply it to and challenge the idea that crochet is only for women. Crocheters like William Elmore experimented with color, textures, and techniques to crochet more efficiently.[8]

As can be seen in this brief summary, crochet has a varied past as both a craft of luxury and of practicality. However, its most known history is as a craft of femininity and domesticity, and the application of crochet as a textile technique has changed very little. However, in recent years, there has been an explosion of interest and exploration within the contemporary crochet community and this has led to applications that were never before imagined.

Contemporary crochet responses

Contemporary artists and designers have responded to crochet's feminine and domestic applications in different ways. Some have used crochet in atypical applications, usually by changing material, environment, or scale. In the crochet world itself emerged free-form crochet (Figure 4) which uses yarn to make sculptures or unconventional designs. It is often described as "painting with yarn".[9] There is no pattern to follow and, in some processes, crocheters make pieces called "scrumbles"[10] to later join together to

[8] Ibid, 136

[9] Solovay, Amy. "Throw Out the Patterns and Rules to Create Freeform Crochet Art!" The Spruce Crafts. November 07, 2017. Accessed April 20, 2018. https://www.thesprucecrafts.com/freeform-crochet-978563.

[10] Ibid. "Scrumbles" is a term used to refer to free-form crocheted pieces that are made with different colors, textures, or stitches. They can be stitched together to form a larger finished piece. The shapes of scrumbles are often organic and used as individual patches for a larger work.

form larger pieces. Because crochet lends itself well to organic shapes, there are also communities devoted to crocheting natural environments like coral reefs.[11]

Figure 4. Close-up of a free-form crochet piece by Prudence Mapstone (http://www.knotjustknitting.com/)

[11] Crochet Coral Reef. Accessed April 20, 2018. http://crochetcoralreef.org/index.php.

In the field of mathematics, Professor Daina Taimina of Cornell University discovered that hyperbolic surfaces, previously impossible to make physically, could be modeled using crochet.[12] By crocheting in the round and increasing the stitches exponentially (e.g. doubling the stitches in each round), the resulting fabric would push up against itself resulting in a doubly curved surface. When this process was continued, the surface would to warp and ripple into frills. In this way, she found that crochet could be a viable method of modeling complex mathematical formulas, geometries, and systems.

In the field of architecture, textiles have long been established as a method of form exploration. Gottfried Semper, a German architect, described textiles as a type of enclosure, and that understanding the underlying structures of braiding, weaving, and looping, can lead to making and designing architectural structures.[13] Architects have used crochet at a larger scale to see how the loops perform as a structure for things like yurts or domes. For example, Alexander Worden explored the utilization of crochet to see how it could aid in the creation of space, form and structure.[14] He manipulated crocheted pieces by stretching them and adding stiffening agents to study how the structure performed and how that could be applied for architectural spaces (Figures 5 and 6).

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[12] Taimina, Daina. *Crocheting Adventures with Hyperbolic Planes: Tactile Mathematics, Art and Craft for All to Explore*. Boca Raton, FL: CRC Press, Taylor & Francis Group, 2018.
[13] Semper, Gottfried, and Harry Francis. Mallgrave. *The Four Elements of Architecture: And Other Writings*. Cambridge: Cambridge Univ. Press, 1989.
[14] Worden, Alexander Gabriel. *Emergent Explorations: Analog and Digital Scripting*. Blacksburg, VA: University Libraries, Virginia Polytechnic Institute and State University, 2011.

Figure 5. Studies in the structure of crocheted forms and structure (Worden, 2011).

Figure 6. Studies in using materials to stiffen crocheted forms (Worden, 2011).

By combining crochet with these other disciplines and exploring ways to tweak the material, scale, or application, the reach of crochet expands beyond its domestic applications. And when these three variables are pushed far enough, its topology, how crochet is physically made and arranged, and its typology, the types and forms of crochet, have the capacity to change. If crochet can be combined with the disciplines of art, math, and architecture, it can also be used in product design. Crochet may not need to always be made with a continuous, looped thread, but can expand into different materials, both physical and virtual, for use in consumer products.

RESEARCH

The theory of craft

In order to develop a process to change the topology and typology of crochet, I needed a framework behind my study. In my research, I came across a useful body of theories related to craft. Contemporary writings have discussed how craft does not only need to refer to handicraft, which is defined as objects made almost exclusively by hand and non-industrial tools. Rather, as Howard Risatti states in *A Theory of Craft*, craft emphasizes an iterative mental process and learning by doing. By playing with materials, the maker experiments and learns about their limitations and performance and in the process, may discover a new form or application. As Anni Albers writes, even things that haven't changed for generations can be innovated on through play.[15] Therefore, craft—as a process—can include tools or methods that are not exclusively done by hand.

So, what other tools could be used to engage in the idea of craft and to facilitate a playful process? Malcolm McCullough in *Abstracting Craft* suggests that digital tools and computation have made play even easier for the craftsperson. Because of its impermanence, it is easy to manipulate several variables that can quickly be reverted if there is a mistake. Makers can subvert the tools and their outputs in order to create something unexpected. Therefore, handicraft and digital processes can unite in the definition of craft, where both are able to coexist and inform one another as they progress. Neither needs to be removed for the advancement of the other in fact, they should augment each other. As McCullough states:

> We have reached a point in the history of technology where it is especially important to take pride in human abilities. We must not only defend against

[15] Albers, Anni. *Selected Writings on Design*. Hanover: Wesleyan University Press, 2000.

> further deskilling, but also direct inevitable technological change in a more human-centric direction…And if and when any chaotic fantasy and fugue comes true, and the conditions of work grow more post-whatever, there are likely to be unwitting digital artisans on the scene, making fairly good use of their hands. (McCullough, 1996)

As technology advances, craft will always remain. Designers and artisans will find a way to keep craft, whether in making or thinking, in their work. Additionally, craft as a way of working promotes patient mastery of the work, a sense of enjoyment and accomplishment. Perhaps a digital intervention in the process of craft can catalyze exploration of form and application. In the world of crochet, Matt Gilbert, a visual and sound artist, combined digital and handmade by designing an algorithm to output a seamless crochet pattern for a sweater.[16] The pattern is so complex that it is difficult to follow the written version. Rather, the maker has to follow along with the digital simulation in order to make the sweater (Figures 7 and 8). Digital and handmade techniques work together to create something that could not exist without the input of the other.

[16] Gilbert, Matt. "Crochet Pattern Generator." Crochet Pattern Generator. Accessed April 23, 2018. http://www.mattgilbert.net/projects/crochet_pattern/.

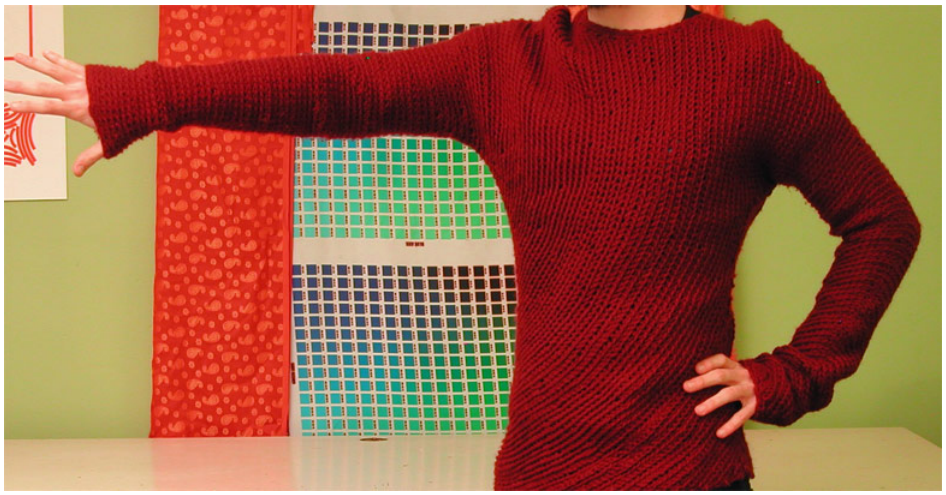

Figure 7. Example of a sweater made by Matt Gilbert's algorithm (Gilbert, Matt. "Crochet Pattern Generator." Crochet Pattern Generator. Accessed April 23, 2018. http://www.mattgilbert.net/projects/crochet_pattern/.)

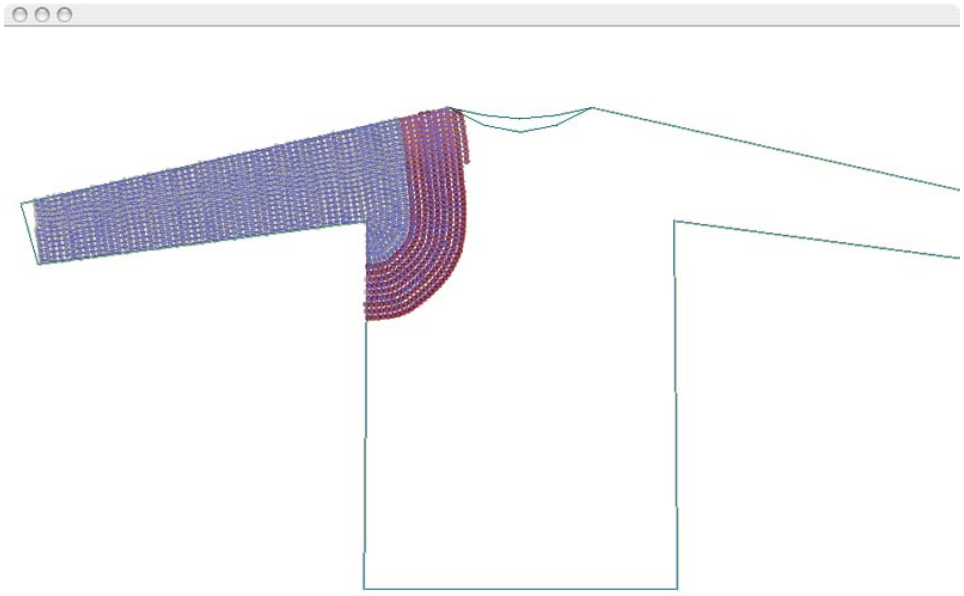

Figure 8. Example of the crochet algorithm. (Gilbert, Matt. "Crochet Pattern Generator." Crochet Pattern Generator. Accessed April 23, 2018. http://www.mattgilbert.net/projects/crochet_pattern/.)

In analyzing how crochet is done and how patterns are made, I gathered that the simplest way to incorporate a digital tool would be in the crochet pattern rather than in the making itself. The act of crocheting is primarily a handmade thing, in contrast to knitting or weaving which, thanks to Basile Bouchon and Joseph Jacquard,[17] are easily mechanized. Because of the complex movements and looping of crochet, to date, there is no true crocheting machine that can accurately mimic the human hand.[18] When it comes to crochet patterns, there are many written and visual patterns with familiar typologies that exist for the crocheter to use in their designs. Certain forms work better for certain applications, and those forms are recycled if the application is the same. Some stitches may be changed for decorative purposes, and the maker can decide material, size, and color of the piece according to their desires, but crochet forms and patterns are usually taken from what is already known. Therefore, I worked on ways to digitally generate crochet patterns that have the potential to output new typologies.

Initial solutions

My first attempt to generate new patterns to encourage invention was through designing a code for free-form crochet pieces. Because of its focus on not using patterns at all, I found free-form crochet to be an adequate starting point. During my undergraduate studies, I had designed two algorithms for crochet patterns: one for granny

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[17] Dalakov, Georgi. "Basile Bouchon." History of Computers and Computing, Automata, Basile Bouchon. Accessed April 24, 2018. http://history-computer.com/Dreamers/Bouchon.html.
Dalakov, Georgi. "Joseph-Marie Jacquard." History of Computers and Computing, Automata, Joseph-Marie Jacquard. Accessed April 24, 2018. http://history-computer.com/Dreamers/Jacquard.html.

[18] Ann, Kathryn, Pavlina, Natasja King, Nicole Swan, Cathyescrochet, Phil, and Kathryn Vercillo. "Is There Such a Thing as a Crochet Machine?" Crochet Patterns, How To, Stitches, Guides and More. March 23, 2018. Accessed April 23, 2018. https://www.simplycrochet.com/2011/06/is-there-such-a-thing-as-a-crochet-machine/. Although "crochet machines" exist, what they produce is not at all like handmade crochet. If a product is crocheted, you know it was made by hand.

squares and one for free-form pieces (Figures 9 and 10). For the latter algorithm, I created symbols to represent standard free-form scrumbles. The main idea at this time was to view the crocheter as the computer going through the program and following its directions to generate a free-form pattern. The rules were designed so that there was some determinism in how each element related to each other, but there was enough freedom so that makers could break the rules if they chose to and so that each pattern would be different. The crocheter could choose the material, color, and size for the final piece, and they could potentially deviate from the pattern in a similar way that traditional free-form crocheters do.

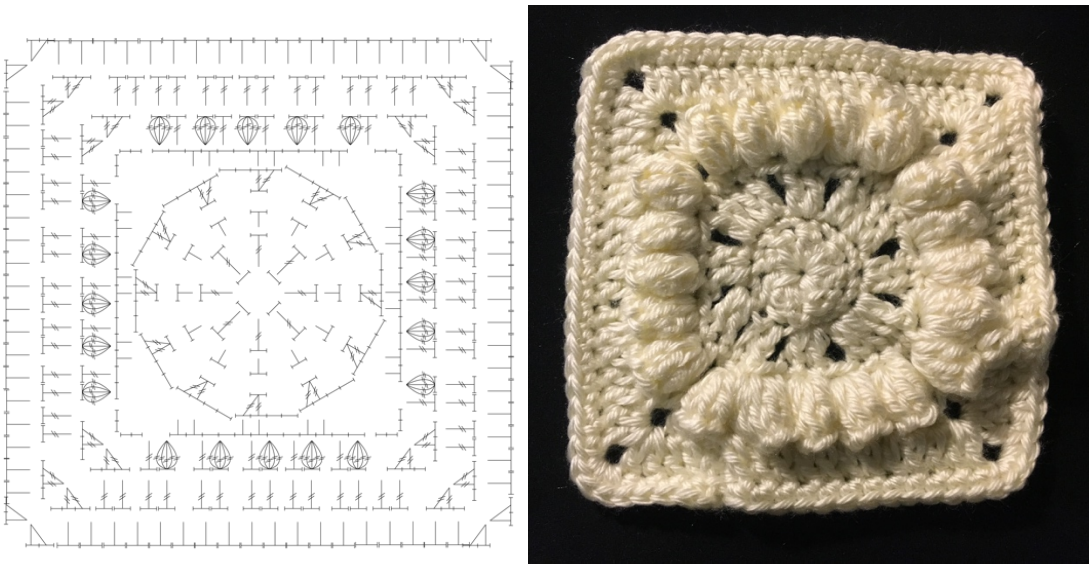

Figure 9. Generated granny square pattern using a version of the crochet symbols and corresponding piece.

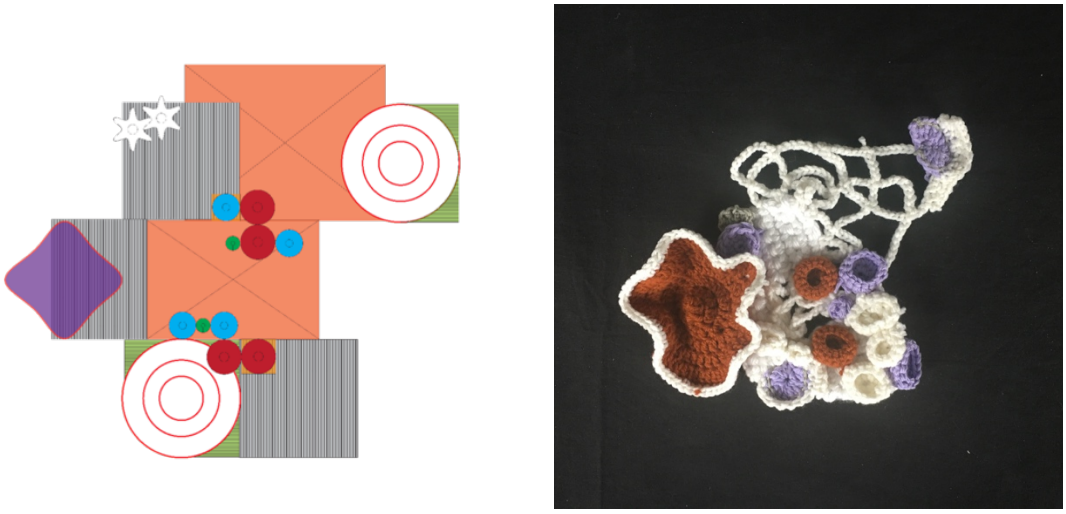

Figure 10. Generated free-form pattern using designed symbols for scrumbles and corresponding piece.

As a graduate project, I focused more on how to teach this method in order to encourage crocheters to break from familiar typologies. I made a workbook (Figure 11) for the algorithm and taught the process to a crocheter to test its comprehensibility and its ability to encourage deviation. She designed a pattern using the scrumble symbol cards and following the rules of the algorithm (Figures 12-13). We then crocheted part of the pattern together during the workshop, and she finished the rest of it at home (Figure 14-15). After teaching the workshop, I realized that she understood the algorithm well and followed it correctly, but she did not deviate as expected. This method of pattern computation did not exactly promote discovering new forms or applications. It was more successful for introducing novice crocheters to the concept of free-form crochet. But one key takeaway was that crocheting as a community can be an important thing. Just as there are online communities, crocheting in person or with a group of people can also be valuable when it comes to designing pieces as a group. Each person can add their own ideas and thoughts to the process.

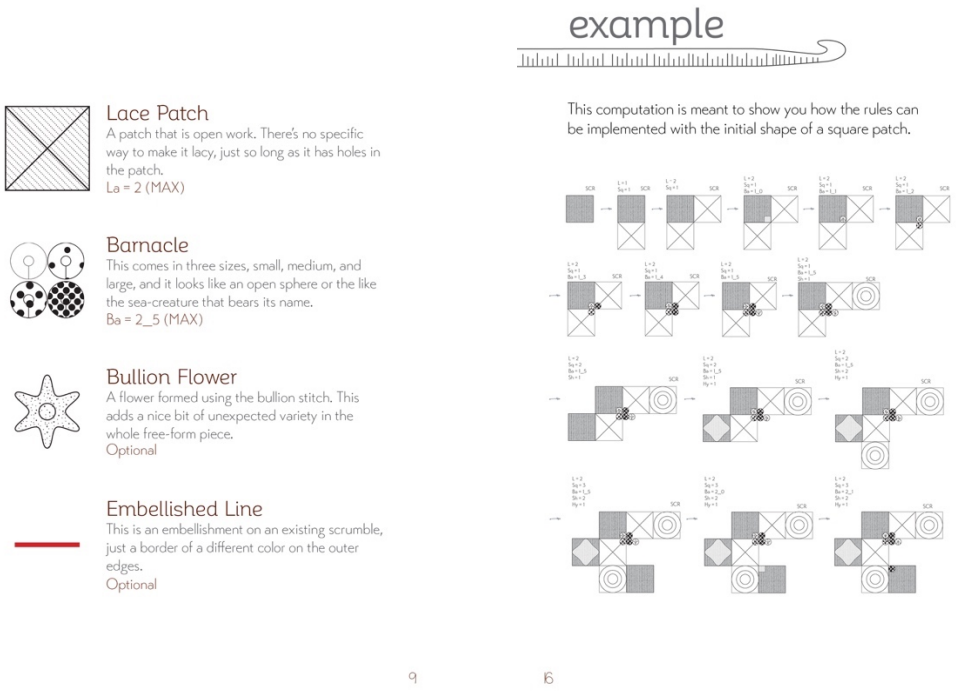

Figure 11. Examples from crochet workshop manual explaining the symbols and computation.

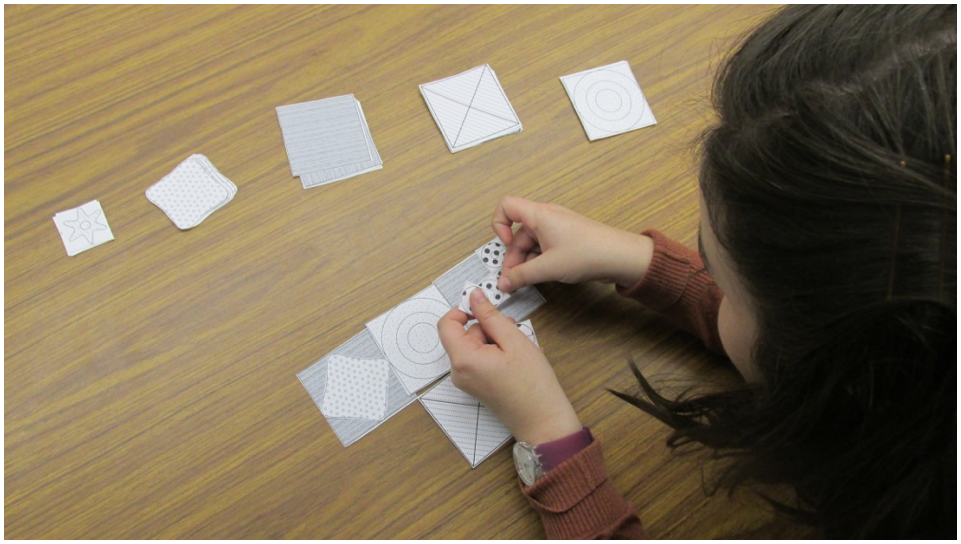

Figure 12. Crocheter designing a free-form pattern. Photo credit: Ekin Levent.

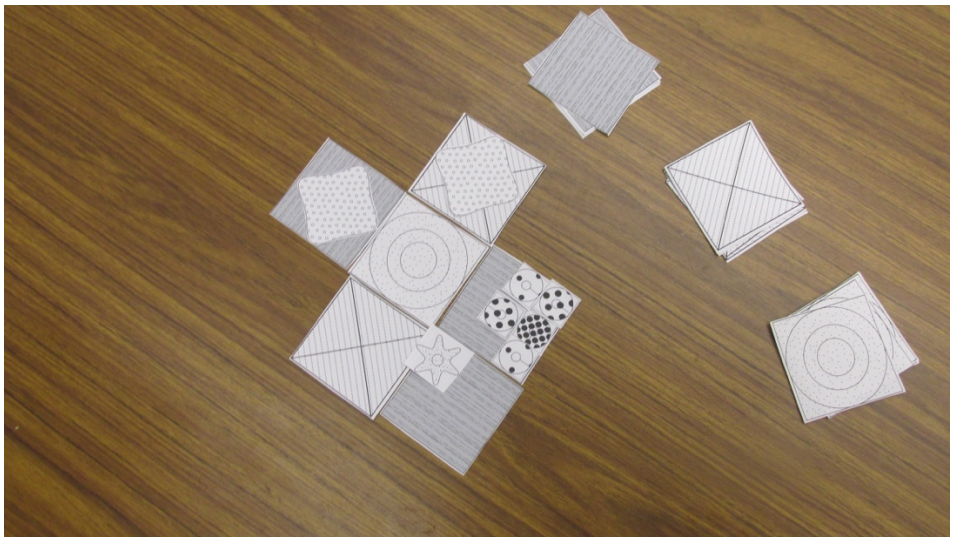

Figure 13. The final free-form pattern design. Photo credit: Ekin Levent.

Figure 14. Participant crocheting part of the free-form pattern. Photo credit: Ekin Levent.

Figure 15. Final crocheted piece, made collaboratively.

My second attempt included 3D modeling in the process of making the free-form crochet pieces since with digital tools, I can quickly generate and model interesting forms. I used Rhino, a 3D modeling tool, and Grasshopper, a parametric modeling plugin for Rhino, to generate different patterns using different symbols for the crocheted pieces (Figures 16 and 17). This also proved unsuccessful since the forms that were generated were somewhat rigid and of a similar design language. However, the parametric nature of making the patterns was something valuable I discovered in this prototype. The crocheter could quickly generate many different patterns by changing one or two parameters and then choose a few to iterate on themselves.

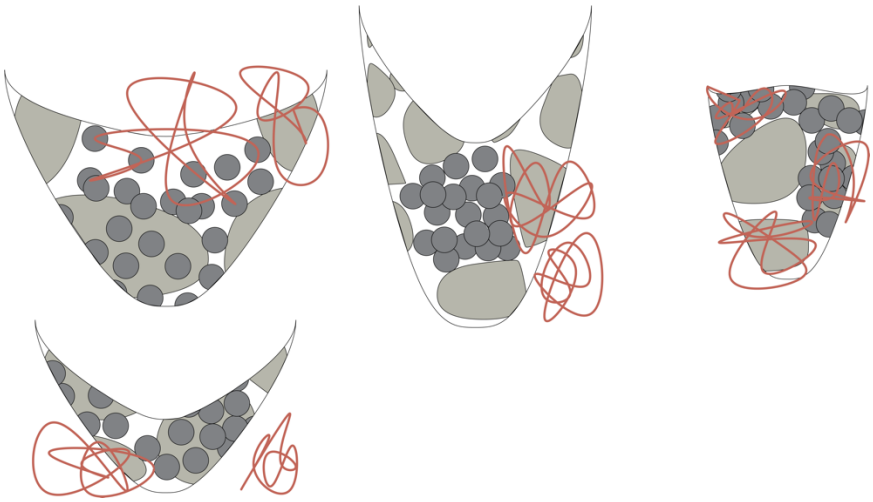

Figure 16. Pattern generations using Grasshopper and Rhino. The bounding curve represents a jig to crochet on top of, the light gray areas are crochet patches, the dark gray circles are barnacles, and the red scribbles are the hyperbolic surfaces.

Figure 17. Example of piece made using the last pattern in the previous figure. Uses a laser cut jig of chipboard.

Although informative, these initial solutions were not helpful in discovering new applications to crochet. Perhaps there was too much determinism in shape or method. Also, with these algorithms, there is a learning curve to understanding the rules and methods of making patterns. However, through these prototypes, I learned about the importance of a crochet community and about parametric and generative design. From this point, I decided to work with something more familiar to crocheters, like the universal stitch symbols,[19] instead of designing my own crochet language. Then I would include elements of parametric and generative design in the algorithm so that crocheters could quickly generate and make the patterns.

[19] "Yarn Standards." Crochet Chart Symbols | Welcome to the Craft Yarn Council. Accessed April 23, 2018. https://www.craftyarncouncil.com/standards/crochet-chart-symbols. Stitches may have different symbols that mean the same thing (e.g. the symbol for the single crochet stitch can be either a cross or an "X" symbol. Both are used equally).

GENERATIVE CROCHET

Designing the generator

After deciding to work with the stitch symbols, I looked for existing platforms that use them for generating crochet patterns. The two programs I found were Stitch Fiddle and Stitchworks Software. Stitch Fiddle[20] is an online platform for making all kinds of charts for knitting, crochet, and cross-stitching (Figure 18). Its aim is to be an accessible platform for crafters to quickly design their own patterns. Users can sign in to save and export their projects. For crochet its key features include:

- Multiple pattern-making modes (including Tunisian crochet, filet crochet, row by row crochet)
- Color pattern design
- Free-form stitch placement
- Ability to export and share the charts

Stitchworks Software[21] is an open source desktop application for designing crochet patterns, both normal and free-form (Figure 19). Its key features include:

- Free-form stitch placement
- Row by row or wedge by wedge (for circular patterns) design
- Ability to export the charts
- Color legends

[20] De Bruijne, Janneta, and Sander De Bruijne. Stitch Fiddle. Accessed April 19, 2018. https://www.stitchfiddle.com/en.

[21] O'Brien, Tim. "Stitchworks Software." Stitchworks Software. Accessed April 19, 2018. http://stitchworkssoftware.com/.

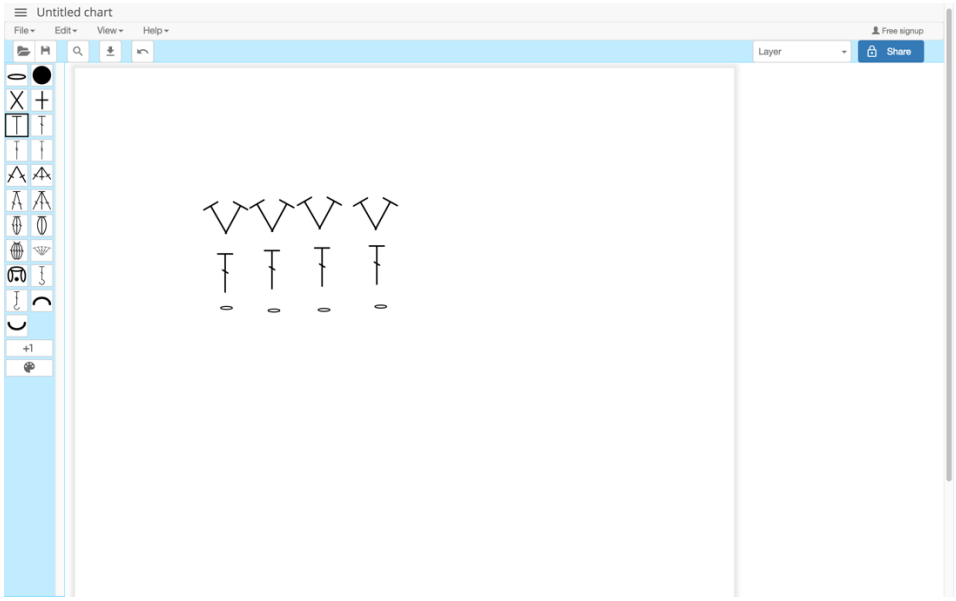

Figure 18. Screenshot of Stitch Fiddle's interface.

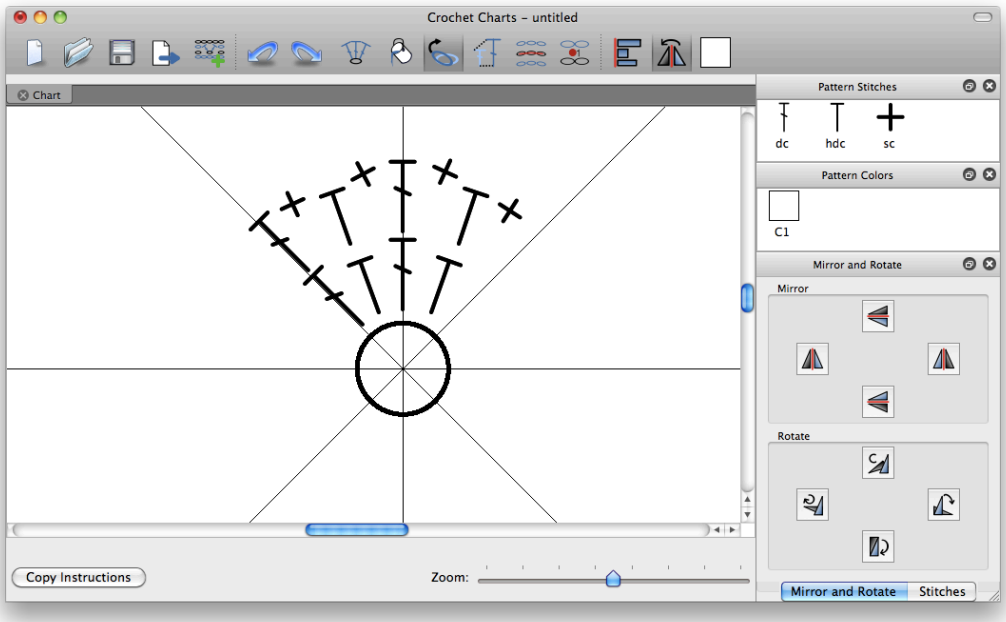

Figure 19. Screenshot of Stitchworks Software's interface (screenshot by Tim O'Brien is licensed under CC BY SA, http://stitchworkssoftware.com/).

After using these programs, I found them to be cumbersome in designing crochet patterns. The blank canvas was daunting and building a pattern stitch by stitch was a slow process. Additionally, designing these patterns require a certain amount of knowledge of how crochet stitches work together to create different forms. With these limitations, I sought to see how designing a pattern could be faster and better encourage crocheters to make different forms.

Rather than having the crocheter build a pattern from scratch like in the previously mentioned programs, I wanted to use computational design methods to generate a pattern that can be further iterated on by the crocheter. Using these existing platforms as a guide, I decided to design my own pattern generator with similar, but fewer features. By only including the minimum of what a pattern needs, there will be enough room for freedom of interpretation. The parameters for the patterns for Generative Crochet are:

- Pattern mode (randomize vs. normal)
- Construction type (row vs. round)
- The number of rows/rounds
- The number of initial stitches

In Generative Crochet, the crocheter does not design the pattern, but the pattern is generated for them. Part of the generative nature of the process comes from both how the pattern is made and how the maker interprets and iterates on the pattern. In the pattern mode, there is an option for both a randomized pattern, where the stitches in each row/round are chosen at random, and a normal pattern, where the stitches are arranged to normally increase each row/round to make a rectangle or circle. The normalize mode is there as a control, to display typical crochet typology of a circular or rectangular patch. When it comes to the construction type, crocheting in a row or in the round are the two

most basic methods of crocheting. The number of rows/rounds and initial stitches indicate how large the pattern is.

The visualization of the pattern is in the main area of the generator, and it uses the universal stitch symbols of crochet (Figures 20 and 21). Any crocheter familiar with them can understand the pattern. The program also includes a simple word pattern that outlines the number and type of stitches in each row/round for crocheters who don't use or understand visual patterns. The generator is currently live and able to be used.[22]

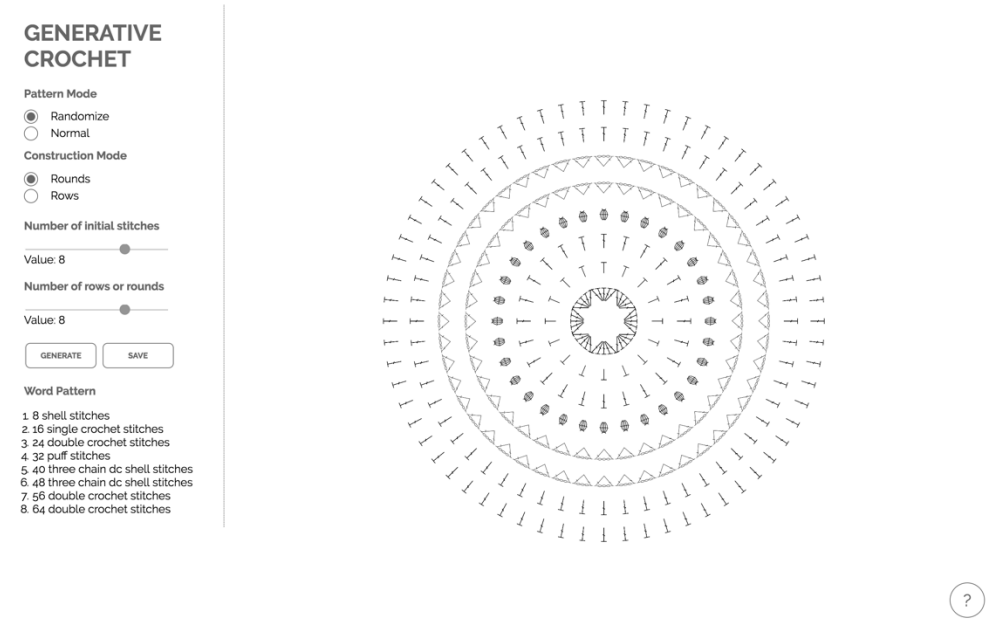

Figure 20. Generative Crochet pattern generator. Example of a randomized round pattern. With corresponding word pattern in the bottom left-hand corner

[22] The generator is hosted on Github at https://kirastreet.github.io/crochetGenerator/crochetGenerator.html

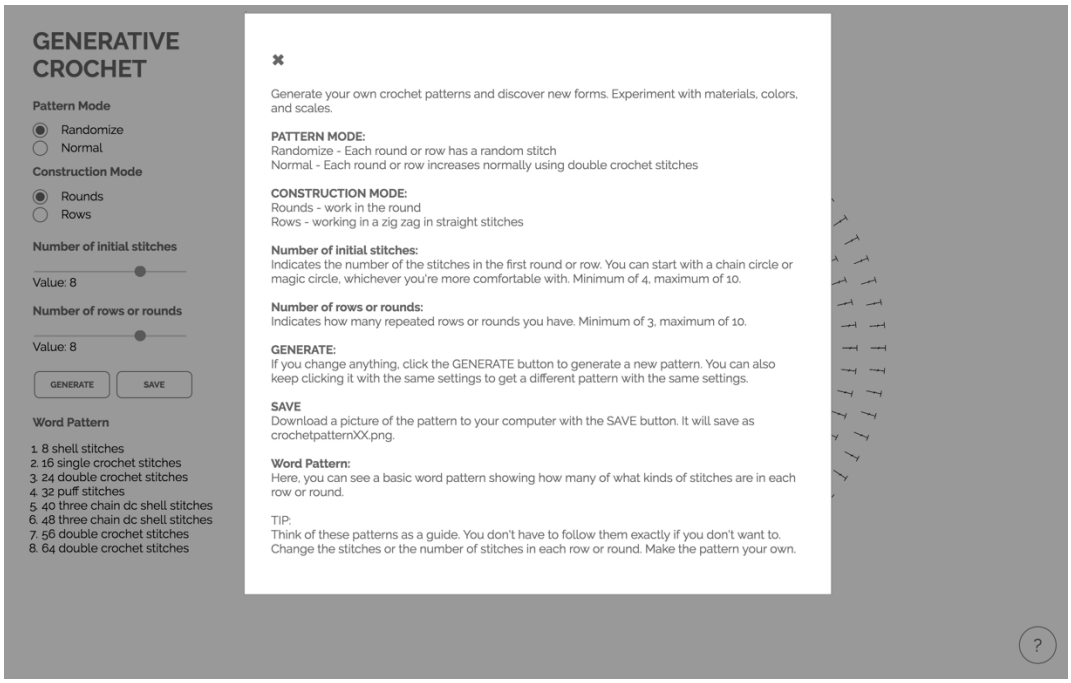

Figure 21. Help screen explaining how the generator works.

Prototyping objects

As I worked on the generator, I saved multiple patterns to crochet later to demonstrate the potential of the program (Figures 22-24). To prototype the forms, I used worsted weight acrylic yarn, one of the most available and economical materials for crochet, and a J/10 (six millimeter) size crochet hook. Because these were randomly generated patterns, sometimes it would be difficult to crochet the exact pattern. Therefore, as the crocheter, I had to insert my own solutions and translations into the pattern, perhaps adding stitches not explicitly visualized in the pattern or crocheting more or fewer stitches in each row/round than indicated.

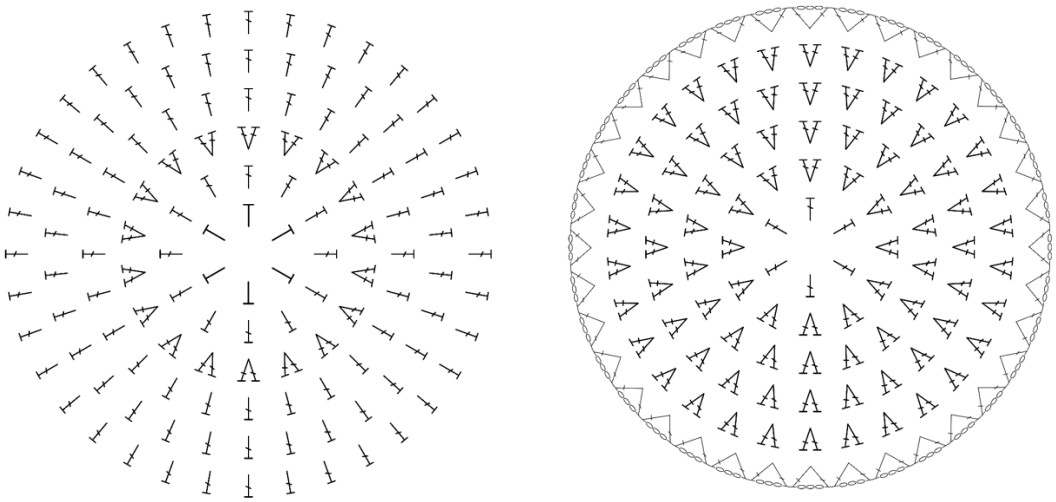

Figure 22. Examples of randomized generated patterns.

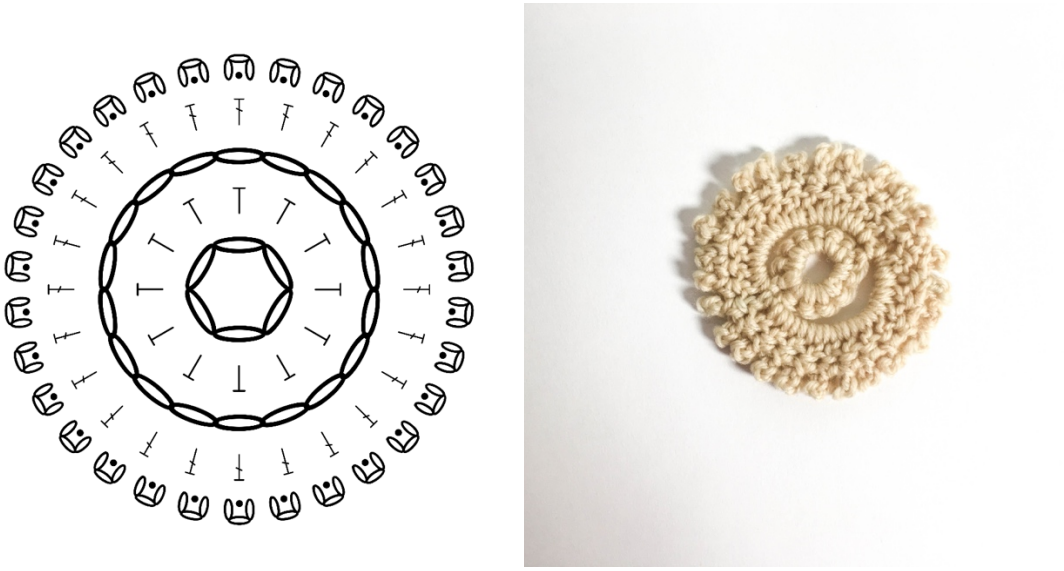

Figure 23. Dynamic pattern with corresponding crocheted piece made with worsted weight acrylic yarn.

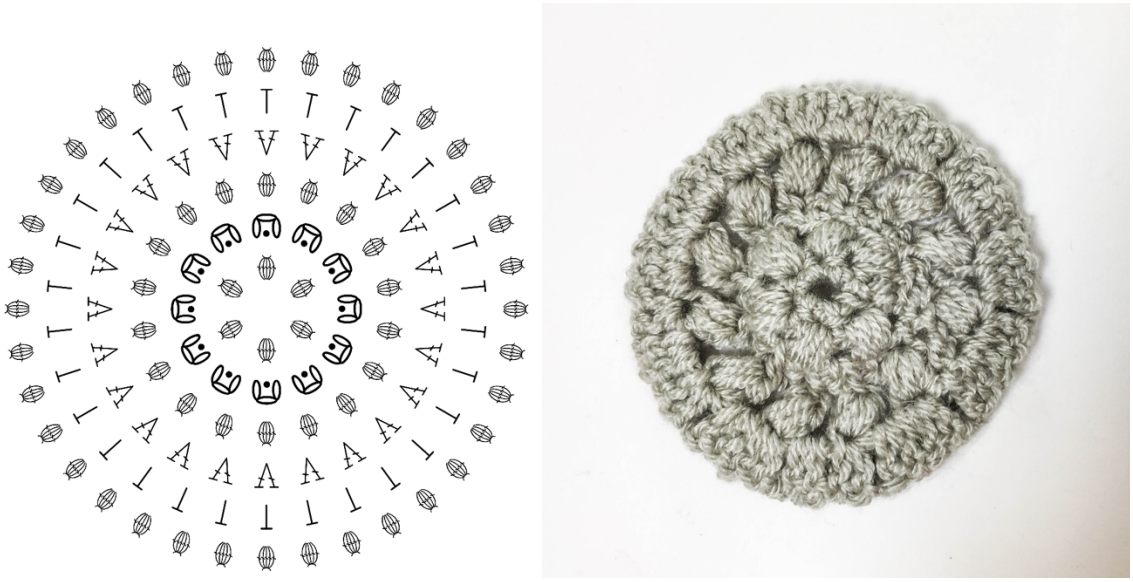

Figure 24. Puff circle pattern with corresponding crocheted piece made with sport weight acrylic yarn.

I then made the same patterns using different weights and types of yarn to see how they would perform, even going beyond yarn into more industrial materials like MDF and PLA for 3D printing (Figures 25 and 26). Interestingly, some patterns performed differently depending on the material; for example, some objects laid flat when made with acrylic yarn or something similar, while others curled up into a more three-dimensional form when made with flat ribbon.

For the pieces made with industrial materials, I 3D scanned them and manipulated them in Rhino. In order to explore this method of making, I needed to accept the limitations of the scanning software. Only the textures were preserved in the scans and at times, the resolution made the form look like it wasn't crocheted at all. But the high-level form itself was preserved and I was able to use some forms to design product proposals (Figures 27-29).

Figure 25. Dynamic pattern crocheted with acrylic yarn, 3D printed with PLA, and milled from MDF.

Figure 26. Dynamic pattern crocheted with ribbon that has wire inside it.

Figure 27. Rendering using 3D scanned crocheted circles aggregated to form an enclosure. Could be used for a planter or lighting.

Figure 28. Rendering using the dynamic pattern model as earring designs.

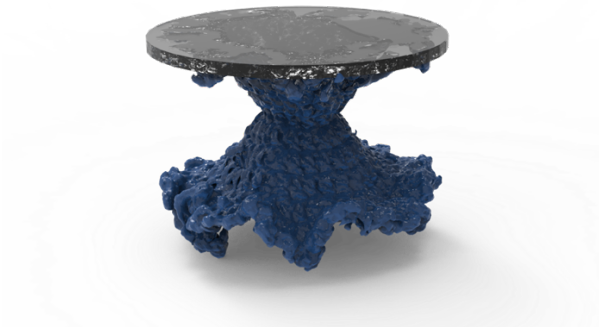

Figure 29. Rendering using the cone pattern to design a table.

Altogether, I used several different materials for both the prototypes and the final objects:

- acrylic yarn
- crochet thread
- bamboo yarn
- cotton rope
- paracord
- ribbon
- fabric yarn
- mercerized cotton yarn
- PLA (3D prints)
- MDF

In this iterative process, both human and machine collaborate on the pieces to be made. By using these randomly generated patterns, the crocheter learns about and makes different crochet typologies. Once they become familiar with them, they can be more adventurous by innovating on the patterns and discovering new typologies to use in their own designs. Even if the forms are not scanned or rendered digitally, stiffening agents can be used on the crocheted forms to give them structure and durability for product designs.

EXHIBITION

Exhibiting the story and process of Generative Crochet was my main goal for the exhibition. I wanted to show the iterative nature of designing and fabricating the objects and propose potential product designs.

Therefore, the exhibition is in three sections. First, the crocheted prototypes are displayed with their corresponding patterns (Figure 30). Four pieces are included with each pattern to show a variety of different materials and interpretations of the respective pattern. In this way, viewers can see how the form of the piece changes with the material. Next is the interactive crochet pattern generator (Figure 31). This was placed after the prototypes so that viewers could interact with the site in the context of what has been made. Viewers can play with the generator, changing the parameters to generate different patterns. Lastly are the final product proposals (Figures 32 and 33). These products use the same patterns from the beginning but use different fabrication methods to focus on the form of the piece.

Figure 30. Crocheted prototypes from generated patterns.

Figure 31. Interactive website with pattern generator.

Figure 32. Display of final products, including lamps, desktop products, furniture models, and jewelry

Figure 33. Close-up of final products.

CONCLUSION AND NEXT STEPS

Generative Crochet is a personal exploration in rekindling a love for crochet and an academic study in how digital tools can augment, extend, or transform a traditional craft form, such as crochet. It is a process that can serve the contemporary crochet community as well as any community who values the hybridization of design and the craft of iterative making. This process can be a mechanism for almost any field and can help in departing from the tried and tested routes and encourage invention through the idea of craft and learning through making.

In order to share this process with others, I have participated in the Un.Incubator, a program that supports people who want to start small businesses, especially those that have a social impact. The program runs for three months and teaches basic business principles to get our businesses off the ground. At the end of the program, we are to launch a minimum viable product (MVP) of our idea and continue working on it after the program. My goal is for Generative Crochet to become a platform for like-minded crocheters who are interested in designing their own pieces and an inspiration for others who want to see how craft and computational methods can work together in design. The social impact is mostly community-driven; I am aiming to connect and encourage makers who want to go beyond their traditional craft and innovate to other applications. My MVP is a website to attract other crocheters who want to use the generator, a gallery for the pieces that are made, and a basic shop for the products that are designed. In the long-term, this would become a community of crocheters, makers, and designers to invent and iterate together.

Much like in crochet, designers and makers are caught up in using the same typologies for the same applications, and there needs to be an opportunity for designers to

break convention, for creativity is nearly impossible in a vacuum. Although digital modeling and fabrication tools have made it easier to make atypical forms, generative and computational design techniques can push creativity even further. Generative Crochet offers a way to do just that through the idea of craft and play, where the maker can collaborate with the computer and create designs not previously imagined. With this platform, other makers can see how digital tools can augment handicraft and vice versa, and then use similar techniques to innovate in their own field. I hope to continue this journey of creativity, exploring crochet form and function and inventing new ways to use craft in design.

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