

# eLoominate: Tools for Casual Creation in Hybrid Craft

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## Abstract

Hybrid Craft is a form of combining digital media and physical creation. eLoominate is a hybrid craft system that combines hardware and software where the designs of both are inspired by casual creators. eLoominate aims to simplify Fair Isle knitting—a technique for creating patterns using multiple colors of yarn. The process requires a crafter to take their eyes away from their work to read a pattern, which slows down knitting and is prone to errors. We introduce a novel physical tool that embeds individually-addressable LEDs into a circular knitting loom to provide row-by-row patterning instruction. This physical tool works with software we have developed to allow users to quickly design their own repeating patterns and download them to the loom. We argue that the combination of our novel digital and physical tools are required to create a casual creator appropriate for hybrid craft.

## Introduction

With the eLoominate project, our goal was to create a casual-friendly tool that could be used to aid in the creation of a style of knitting known as Fair Isle knitting. Fair Isle knitting is a technique that uses multiple yarns to create multi-color patterns that is typically done with knitting needles but can also be done on knitting looms (Fig. 1). These designs are known for being more difficult—introducing multiple yarns into the design adds more possibilities for errors and additional complexity that casual users may find challenging.

To achieve this goal, we found that we needed to create both physical and software solutions that work in tandem to create a casual creator experience. In this paper we will describe both the physical and software aspects of the eLoominate project, as well as describe the design decisions that helped shape the final system. Additionally, we will discuss how both the physical and software aspects of the project aid in creating a complete casual creator.



Figure 1: Fair Isle knit hat.

## Related Work

Hybrid crafting has been described as “where beautiful and meaningful artifacts are produced by a machine and craftsperson working together, not by a machine or craftsperson alone” (Zoran et al. 2015) and “everyday creative practices of using combinations of physical and digital materials, techniques or tools, to make interactive physical-digital creations” (Golsteijn et al. 2014). Novel tools are needed to develop new processes and make new artifacts with both physical and digital qualities. A subset of these tools that explore the relationship between craft and digital fabrication are those that are digitally-augmented to assist novice users with craft techniques.

Research includes smart carving tools that track the position of a hand-held milling device and adjusts its speed in relation a pre-selected the 3D model (Zoran and Paradiso 2013) as well as using projection on the crafter’s sculpture to indicate where they need to add and remove material to form the intended digital model (Rivers, Adams, and Du-

rand 2012). Both of these tools allow the user to sculpt in a natural way, but other systems guide users to construct their sculpture as a 3D printer would and explore the tension in a collaboration between the computer and human (Devendorf and Ryokai 2015). These examples focus just on the fabrication of a pre-designed digital model, whereas our system allows the user to both design and fabricate their design.

Research has also shown how parametric and computational design can be used to develop software that allows novices to learn to design wearable objects that are produced using digital fabrication tools such as laser cutters (Efrat, Mizrahi, and Zoran 2016) (Jacobs and Buechley 2013). The generative methods of these tools are one of the design qualities of the genre of Casual Creators—tools that allow quick and creative exploration through possibility spaces of artifacts (Compton and Mateas 2015). Casual Creators have been used to solve some of the issues of wider populations being interested in personal fabrication systems such as 3D printing but lack the experience to design objects that meet all the requirements to be printable (Compton 2019). We used the ideas of casual creators and applied them both both the physical and digital aspects of eLoominate.



Figure 2: eLoominate knitting loom.

### eLoominate Design

Our goal with eLoominate was to create a tool that made complex techniques more approachable for casual users, in particular Fair Isle knitting. As discussed above, a major challenge of Fair Isle knitting is the error-prone and time-consuming nature of the designs. In particular, when using a knitting loom, these challenges are due to the pattern and loom being in two physically different spaces, causing the user to divide their attention between the two locations and remember details of each. Therefore, our solution was to create a device that integrated the pattern within the tool

(Fig. 2). Since the pattern is now part of the tool itself, we also chose to allow the user to generate or design new patterns that could be stored within the tool.

### Physical tool

When considering the design of eLoominate, we looked to knitting looms as inspiration, as they are an existing tool designed to be a casual counterpart to knitting needles. Knitting looms are physical crafting tools that are made up of a circle of specialized pegs mounted into a rigid (often plastic) form. The looms are used by wrapping yarn around the pegs and using a special tool to hook the loops over each other to form stitches. These looms are generally made in circular or rectangular shapes and used to create small items like hats, scarves, and socks. Casual users can easily knit their own items with the looms, but the designs are typically limited to one color of yarn. Traditional knitting looms offer no guidance in patterning. Therefore the knitter must read a pattern, remember that pattern as they redirect their focus to the loom, execute that pattern, then look back at the pattern and remember their place. This slows the pace, lowers confidence, increases frustration, introduces opportunities for errors. On the other hand, constraining the designs to a single color critically limits the possibility space of the system. All of these are at odds with the definition of a casual creator as an “interactive system that encourages the fast, confident, and pleasurable exploration of a possibility space” (Compton and Mateas 2015).

Knitting looms are made in a variety of sizes and number of pegs. If a pattern needs to seamlessly repeat around the circular form of a hat, the number of pegs needs to be evenly divisible by the number of stitches in a pattern. It was important for the loom we made to have a number of pegs that was highly divisible. 48 pegs was ultimately decided on for this reason. The availability of an existing 48-peg knitting loom in a 5/8” gauge allowed for the option to create a mold instead of 3D printing a new loom. The spacing between the pegs closely matched LED strips available in 60 LEDs per meter densities. Several techniques for making molds were tested, as well as options for creating separation between the pegs to prevent the light from the LEDs bleeding into neighboring pegs.

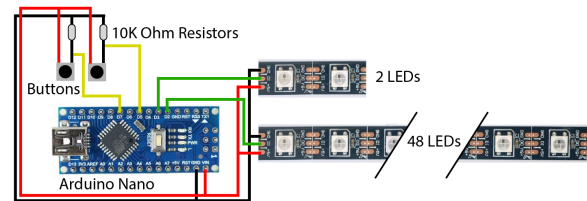


Figure 3: Schematic for eLoominate electronics.

The microcontroller we chose for the prototype is an Arduino Nano due to its smaller physical size with enough memory to store the entire pattern (Fig. 3). We added two buttons that have associated programmable RGB LEDs that are used to interact with the physical loom. The buttons are

context sensitive. In knitting mode, the green button advances to the next row, while the red button goes back a row. In programming mode, the buttons change colors to represent the two colors of yarn.

The software for the microcontroller needed to receive a pattern as well as display that pattern row by row. When receiving serial data, the microcontroller stores the incoming data as the colors for the pegs, how many stitches wide and rows tall the pattern is, followed by the bits determining the stitches in that pattern. This data is stored in the microcontroller's EEPROM so the pattern can be retrieved even after the device has been restarted. The Adafruit NeoPixel Library is used to help control the individually-addressable LED strips, which change in response to the crafter pressing one of the two buttons.

To give the users more flexibility in what patterns they could create, we chose to make eLoominate programmable. Initially the prototype explored the possibility of the knitter being able to program the pattern directly on the loom without needing a separate software interface. When the loom was turned on, the knitter had the ability to enter their own pattern using the two buttons. The user would press one button to increment how many stitches wide and tall their pattern would be, then press the other button to confirm these dimensions. Once the dimensions were determined, the buttons would change colors and be used to key in the pattern for every row. While this approach allowed users to knit custom patterns, it did not assist in the design of new patterns.



Figure 4: eLoominate design software

## Software

Designing patterns for this technique offers its own set of challenges. If a pattern is meant to be repeated, the number of pegs on the loom must be evenly divisible by the number of stitches in the designed motif. Based on our own experiences of designing patterns, it is important to view the designed motif repeated because positive and negative spaces are created along the edges where the pattern repeats that can't be seen when the motif is viewed as a single unit. It is also important to see the full pattern to be able to see the scale of a motif compared to the entire object. Repeatedly drawing a motif is time consuming, and any adjustments would require editing each one.

These experiences with loom knitting have revealed challenges in both the design and knitting process that could be

alleviated by digital media. The binary nature of knit patterns allow them to be easily stored and repeated, edited by a custom design software, and used as data to be displayed by a microcontroller. eLoominate was designed to address the issues in loom knitting using the affordances of programmable media.

There is existing software for computer aided design for hand and machine knitting, but casual users who want to design new patterns for eLoominate would benefit from a software designed for the possibility space of patterns that can be knit on this specific loom. DesignaKnit (SoftByte 2019) is a knitwear design software that could be used to design patterns for eLoominate, but this software is designed for experienced and professional knitters, provides advanced and superfluous functionality, and is expensive. DesignaKnit allows users to download patterns to select knitting machines, but would not be able to download to eLoominate. Custom software would allow casual users to quickly and easily design patterns for eLoominate. The software currently constrains design motifs to dimensions that seamlessly repeat around the loom, but future iterations may consider other design principles including awareness of *floats*—when not knitting with a particular strand of yarn for several stitches results in long strands of yarn that form on the back side of the fabric.

## eLOOMinate

### Step 1: Connect eLOOMinate

### Step 2: Design

Start by selecting your yarn colors and how many stitches wide and tall your pattern will be. The software will automatically and seamlessly repeat the pattern.

Choose two colors:



Number of  
Stitches:

8

Number of  
Rows:

14

Click on the stitches on your canvas on the right to design your pattern. While you're designing, you can alternate between a zoomed in view of your swatch or the seeing entire repeat.

Give me a suggestion

Clear Pattern

### Step 3: Knit

Figure 5: eLoominate Software instruction panel



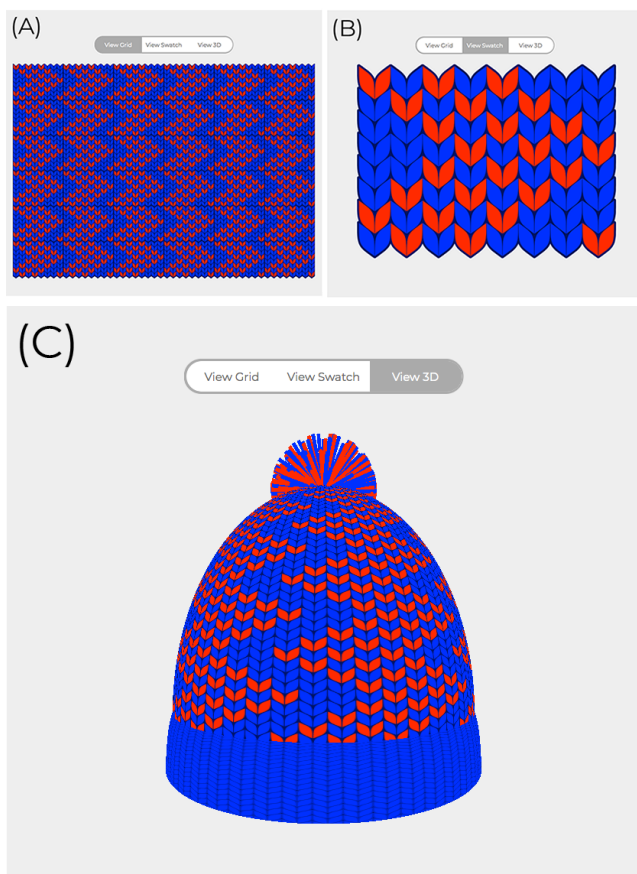


Figure 6: Different view options in eLoominate design software: Grid(A), Swatch(B), 3D(C).

We developed the online design software to assist the crafter in the design process as well as provide step-by-step instructions to guide users through the knitting process (Fig. 5). It runs in the user's web browser and is built with HTML, CSS and the p5.js and p5.serialport.js libraries for JavaScript. The software allows users to draw their own pattern and view it in a repeat (Fig. 6A), as an isolated motif (Fig. 6B), or as a three-dimensional hat preview (Fig. 6C). This software allows designers to quickly make changes and preview many options. The crafter can use the software to download the pattern to the loom through a standard USB port. If the loom stays connected to the computer, the software is alerted by the loom when the knitter presses the buttons to work through the pattern and shows their progress in the browser window.

## Reflection

We plan to conduct user studies to evaluate the eLoominate hardware and software, but our own experiences as crafters have provided initial feedback during the iteration of prototypes. We designed a pattern and knit a fair isle hat prior to building the first prototype to identify how eLoominate could make a more enjoyable crafting experience. Knitting with eLoominate (Fig. 7) resulted in fewer mistakes when the LEDs signified which color of yarn to use. However,

when the LED pattern signified different types of stitches, such as knit or purl, mistakes were made more often. The techniques for creating the physical loom have improved based on our own feedback. The initial looms were cast with resin using molds made with silicone putty. The putty was easy to use but the resulting looms were rough and the yarn would catch on the pegs. Smoother looms were then cast from molds made from a pourable silicone rubber. We are currently designing a new iteration of the loom with additional 3D printed pieces to better hold the electronic components for eLoominate.

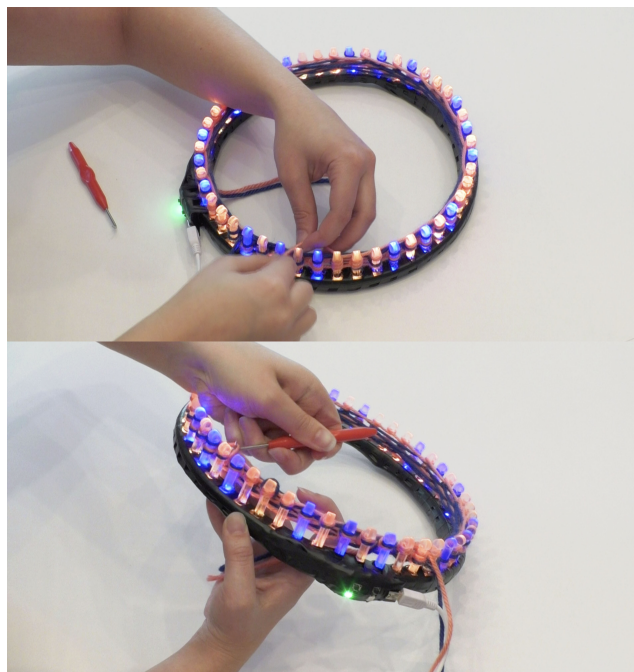


Figure 7: Knitting with eLoominate. Top: Wrapping yarn around corresponding pegs, Bottom: Using hook to form stitches.

## Conclusion

We designed eLoominate to alleviate some of the perceived difficulties of Fair Isle knitting that may make it unapproachable to casual knitters. By embedding LEDs into the physical device, eLoominate offers a visual representation of the pattern on the device itself, thereby increasing efficiency and reducing errors. The loom works through a design one row at a time, allowing the user to create their patterned hat, scarf, or fabric aided by the loom. While the initial focus of this research was on the development of a novel digitally augmented knitting loom, the design process brought forward the question of how software designed for this crafting tool can further support novice knitters. The software we developed has limited design functionality compared to commercial knitting software, just focusing on quickly designing patterns for this specific loom. We plan to conduct user studies to evaluate how the software and hardware assists users and what benefits are experienced from using an integrated hardware/software system that cannot be gained from only one part of the system.

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