Sliver Fiber Printer: Sequence Coloring on Yarn

Alice Yukari Gielen

Department of Industrial Design, Eindhoven University of Technology, The Netherlands;
a.y.gielen@student.tue.nl

Abstract

In this paper, I introduce the sliver fiber printer. This printer can dye coloring patterns into yarn or sliver to explore textile aesthetics. As a result, I present samples with various mathematical sequences explored.

Introduction

In textile design and crafts, there is a growing interest in colorful yarns that create visually striking patterns. Yet, manufacturers dictate these patterns, limiting creative agency of crafters and textile designers. Techniques like planned pooling allow some control over color sequences in pre-dyed yarns. Barb et al. mathematically analyzed stitch placement to predict and control pooling pattens [1]. Yet, planned pooling is restrictive, mainly adjusting width to fit repeating designs. Ikat, a labor-intensive yarn-dyeing process, lacks precise mathematical control. This raises the question:

What if, instead of working within the constraints of pre-existing color sequences, we could encode mathematical structures directly into the yarn itself?

This paper presents the sliver fiber printer (Figure 1), a tool co-designed with textile experts that encodes mathematical sequences into yarn through dyeing, enabling computationally driven patterning beyond planned pooling on commercially available yarns.

The following sections discuss the mathematical foundations of this method, implementing the Fibonacci and Thue-Morse sequences in textile samples. I reflect on how this method expands possibilities for mathematical patterning in textile design, offering new ways to explore mathematics (e.g., information encoding) and aesthetically within the intersection of mathematics, computational design, and craft.

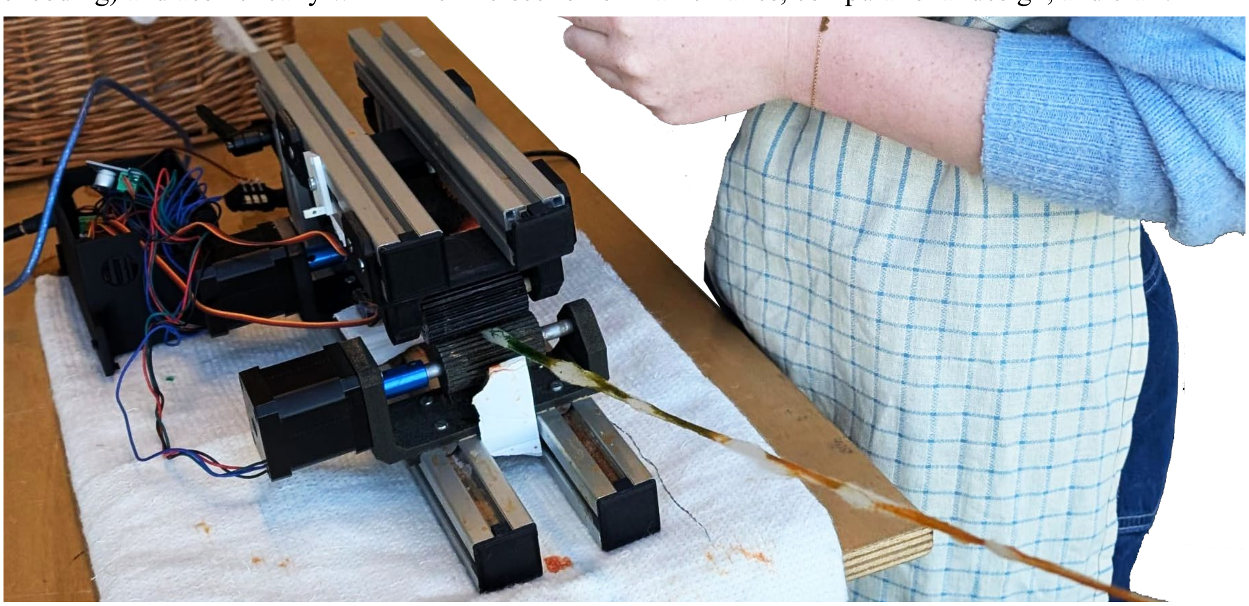
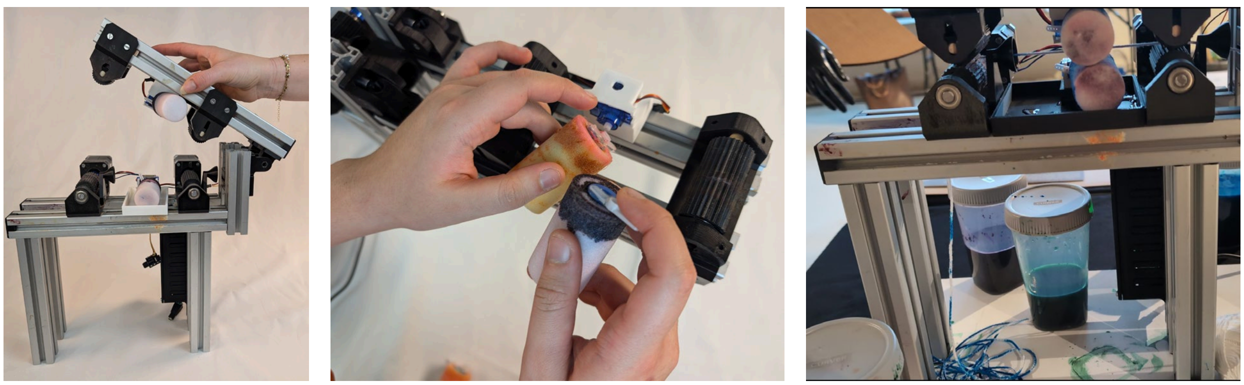


Figure 1: *The Sliver Fiber Printer in use, printing a static pattern.*

The Sliver Fiber Printer

The Sliver Fiber Printer, as seen in Figure 2(a), is a machine designed to apply dye to slivers (untwisted fiber bundles) or yarn in a controlled, computationally guided process. Inspired by the HiLo spinning machine [2] and developed in collaboration with textile industry experts and computational makers, the printer enables custom coloration for both structured textile design workflows and open-ended creative exploration. It opens up new avenues for mathematical and expressive approaches to fiber-based making, bridging textile craftsmanship and digital fabrication.

The printer consists of a set of rollers that guide the fiber past sponge-tipped actuators connected to a linear motion system. First, clean rollers are installed, and a sliver or yarn is threaded through the machine (Figure 2(b)). As the fiber moves, the printer colors it according to a programmed sequence, with the sponge actuators moving vertically to apply dye at precise points (Figure 2(c)). The dye is applied manually to adjust and explore colors as needed. These instructions can encode patterns such as gradients, morse code messages, or mathematical sequences. Once dry, the colored fiber is ready to use in textile processes such as weaving, knitting, crocheting, or felting. See video for demonstration [3].



(a) (b) (c)

Figure 2: *Sliver Fiber Printer process: (a) opening, (b) setting rollers, (c) coloring yarn.*

Mathematical Explorations

Here I talk about the mathematical explorations of embedding sequences into textile patterns. In the examples, I will use size 4 cotton yarn and a silver reed SK830 knitting machine with a size 6 setting. These are a few terms I will be using while explaining the explorations:

A *stitch* refers to a single loop of yarn that is worked into the fabric in knitting or crochet.

A *state transition* is the shift from one dyeing condition to another, marking a change in the process.

The *on-state/off-state* indicates a binary condition where the dye application is active (on) or inactive (off).

Fibonacci Sequence

In this section, I explore the Fibonacci sequence as a generative patterning method for machine-controlled yarn processing. The sequence is defined by:

$$F_n = F_{n-1} + F_{n-2}, \text{ for } n \geq 2$$

$$\text{with initial conditions: } F_0 = 0, F_1 = 1.$$

Each $F_n (n \in \mathbb{N})$ is a positive integer. I use the values of F_n to define how long the machine remains in a given state before switching—creating an expanding rhythm of ON and OFF intervals. For example, starting in a dyeing state, the machine remains ON for $F_1 = 1$ second, OFF for $F_2 = 1$ second, then ON for $F_3 = 2$ seconds, and so on, with each state length increasing according to the Fibonacci sequence.

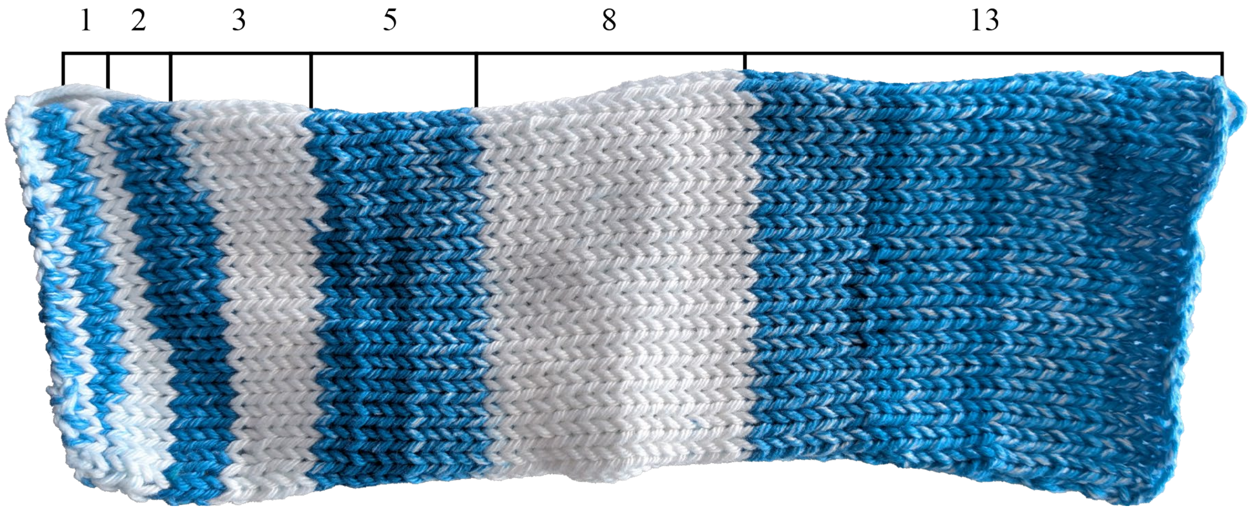


Figure 3: *Fibonacci sequence in a knit pattern.*

The width of the knit sample (figure 3) was adapted to the yarn pattern itself. The Fibonacci-driven patterning creates a rhythmic, expanding progression that feels both structured and organic. The gradual increase in segment lengths produces a sense of movement, as areas of concentrated color stretch and contract in a natural flow. The end of the sequence appears short due to the curling of the knit.

Thue-Morse sequence

In this sample, I explored the Thue-Morse sequence for structuring yarn coloring patterns. The Thue-Morse sequence is an infinite binary sequence. Each $T_n (n \in \mathbb{N})$ is 0 or 1, defined by the recurrence:

$$T_0 = 0,\ T_{2n} = T_n,\ T_{2n+1} = 1 - T_n$$

Even-indexed terms copy earlier values, while odd-indexed terms invert them. For example:

$$T_0 = 0$$
$$T_1 = 1 - T_0 = 1$$
$$T_2 = T_1 = 1$$
$$T_3 = 1 - T_1 = 0,$$
$$T_4 = T_2 = 1$$
$$T_5 = 1 - T_2 = 0$$

This yields the start of the sequence: 0, 1, 1, 0, 1, 0, 0, 1, 1, 0… The formulation allows the sequence to be built one term at a time. Unlike the Fibonacci sequence, which grows exponentially and produces longer batches of a single color, the 0s and 1s of Thue-Morse suggest a binary on-off interaction, a conceptual parallel to a machine's ability to dye or not dye yarn at specific intervals. Instead of a continuous or gradually shifting color gradient, this pattern provides a structured but hard to predict repetition that prevents large-scale periodicity, avoiding predictable banding effects that often emerge in simple alternating sequences.

By mapping 0 as state OFF and 1 as state ON, the machine can effectively dictate the application of color as an on-off mechanism, similar to how a loom selects threads to be raised or lowered. If the following number remains as 1, the sliver fiber printer remains coloring on the yarn on the following stitch until the sequence states a 0.

In the knit shown in figure 4, the Thue-Morse sequence creates a dense, interwoven pattern where individual rows blur into a cohesive whole. The high-frequency alternation of ON/OFF states prevents clear row definition, producing a structured yet unpredictable visual effect. This is especially significant in yarn work, where repetitive color pooling often produces unwanted stripes or banding. Here, the pattern avoids pooling not through randomness, but through a structured aperiodicity. The result is a fabric that appears complex and seamless, with mathematical logic embedded in its visual rhythm.

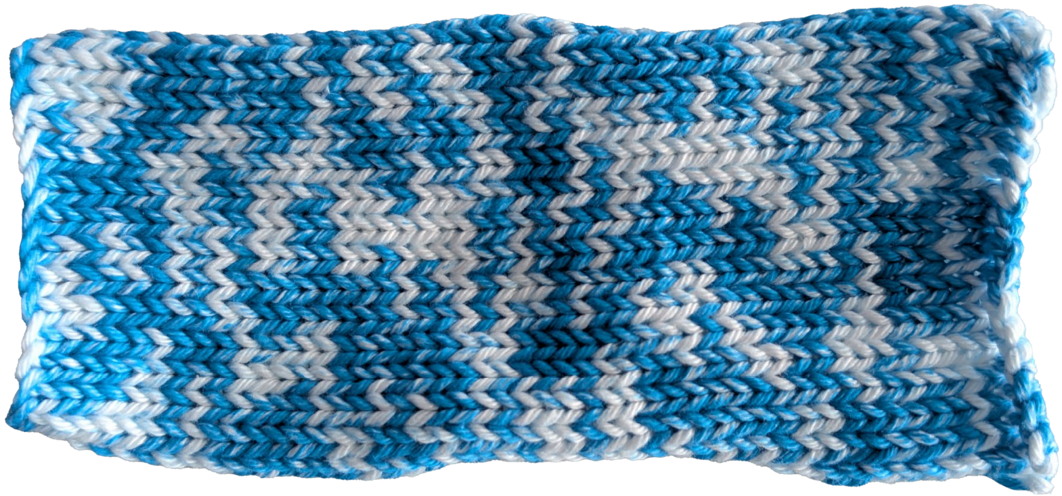


Figure 4: *Thue-Morse sequence in a knit pattern.*

Conclusions and Future Work

The Sliver Fiber Printer introduces a method for encoding mathematical structures directly into yarn through dyeing. By embedding sequences such as Fibonacci and Thue-Morse into fiber coloration, this method enables patterning that differs from planned pooling, which relies on aligning pre-dyed yarns. Instead, the system allows makers to integrate mathematical logic into their designs at a material level.

Future work will explore continuous transformations in color application, such as using sinusoidal dye modulation for gradients or matrix-based color mixing for dynamic multicolor compositions. Currently, the setup uses sponge rollers and continuous dye flow by hand, with ON/OFF states defined by time intervals at a fixed yarn speed— used simply to maintain consistent machine behavior. Moving forward, these durations could be tied to stitch count, physical length, or textile density, introducing a new dimension of pattern variability. This would align with pooling techniques that emphasize alignment between color and structure, but with greater flexibility. These approaches will deepen the connection between algorithmic patterning and material expressivity.

By encoding mathematical logic directly into fiber, this project frames textile-making as an inherently computational and artistic practice, continuing the long-standing dialogue between math and textile design. I invite further collaboration to explore how algorithmic and generative methods can expand the expressive potential of textiles beyond traditional constraints.

Acknowledgements

I'd like to give my thanks to the anonymous reviewers for their feedback, the TU/e wearable senses lab for their support in this project, the textile experts and designers for the co-creation sessions, Laura Taalman for the encouragement to submit to this conference, Tess Geerts for the insightful discussions and a special thanks to Loe Feijs for the coaching throughout the process.

References

[1] Cameron Barb, Ekaterina Birch, Jared Gonzalez, Claire Jones, Josh Makela, Abigail McClennan, Laura Taalman, and Lauren Wiermanski. "Predicting Planned Pooling Patterns." *Bridges 2024 Conference Proceedings*, Richmond, Virginia, USA, 1–5 August 2024, pp. 361–364. https://archive.bridgesmathart.org/2024/bridges2024-361.pdf

[2] Hilo Textiles. *Hilo Spinning Machine*. 2024. https://www.hilotextiles.com/hilo-spinning-machine.

[3] Sliver Fiber Printer - Demo. https://youtu.be/cbK4_GikEok