TurtleStitch: Exploring Shapes and Curves with Coded Embroidery

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Abstract

TurtleStitch is a web based programming environment using *Turtle Geometry* primarily to design embroideries which can be made on a digital embroidery machine. The designs are made by writing code: child friendly *blocks* are clicked together to specify the instructions. Mathematical *functions* and *concepts* are built in as in most programming languages; mathematical *ideas* can be explored by experimenting with the code. This workshop gives participants the experience of making a mathematical artwork, a piece of embroidery reflecting their own explorations.

Introduction

Turtle Geometry, as a simple yet powerful metaphor, was introduced in 1969 two years after Logo [11] was invented as the first programming language for children. Imagine a turtle with a pen under its belly which can be set in modes *up* and *down*. Instructing the turtle to move and turn, creates drawings, first on screen, later on paper (see [6] for a very early physical *turtle* in action).

Machine embroidery is even older: the relevant Wikipedia page [12] mentions Tajima 1964 as the starting point. It took several decades for these machines to be available as consumer machines that could be controlled from a personal computer. Tens of different brands of machines use tens of different formats for the files used to instruct the machines.

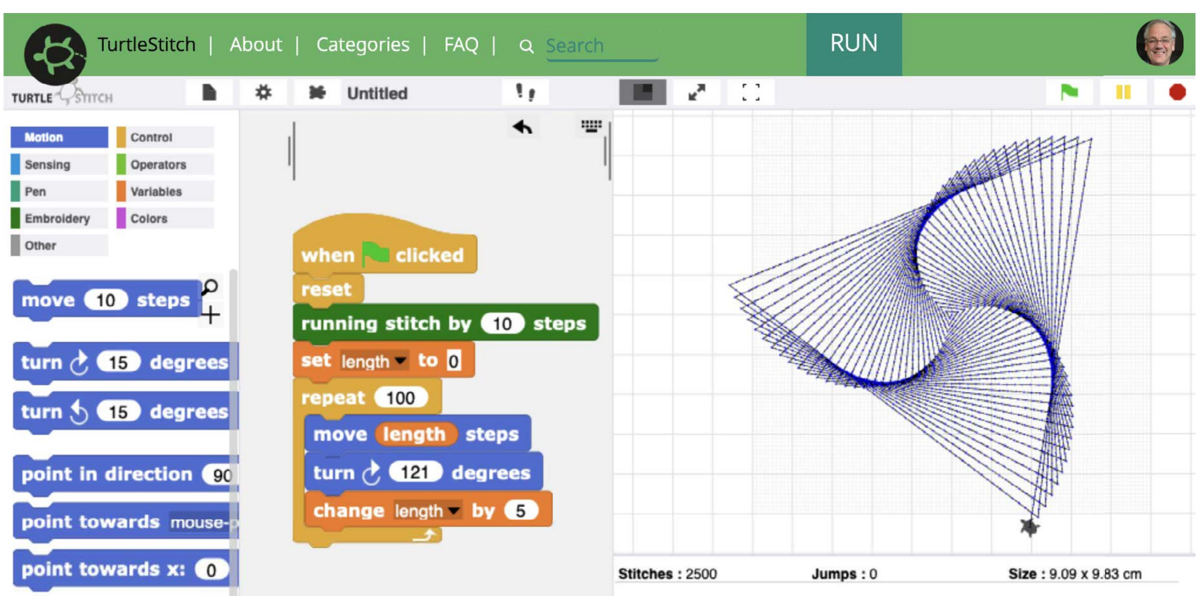


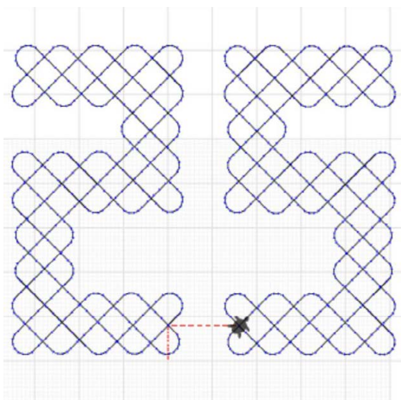
Figure 1: *The TurtleStitch environment, with program pieces to the left, programming area in the middle and output to the right.*

TurtleStitch [8] combines drawing and stitching by offering the option to export the *Turtle Art* as a file, readable by embroidery machines. The extra option to export as *scalable vector graphics (SVG)* opens connections to other ways of fabrication, e.g. laser cutter. An example of the TurtleStitch programing environment is shown in Figure 1.

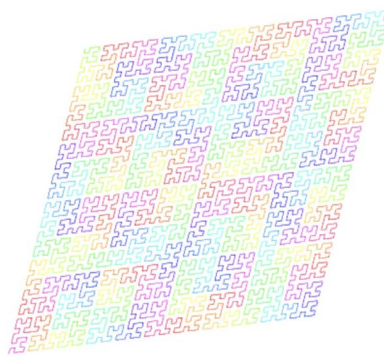
Vienna based artist Andrea Mayr-Stalder started using these embroidery machines in artistic ways from 2008 onwards. For a video of a performance: see [14]. From 2014 onwards, the project was redeveloped as an educational tool [13] and revealed to the world in 2015 during a master class at Waag Society, Amsterdam.

Mathematics

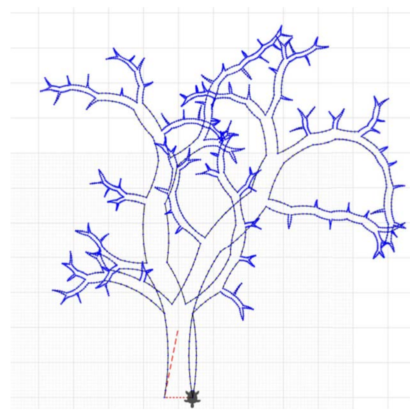
Below are mathematical concepts we came across in the TurtleStitch community. They show very different ways to create mathematical inspired drawings that can be embroidered. The results can be both aesthetically pleasing and intellectually inviting. Either way embroidery is a way to communicate mathematical ideas.



(a) *Kolam*



(b) *Hilbert Curve*



(c) *Tree*

Figure 2: *Some examples of designs made with TurtleStitch*

Kolam

At CMSC 2024 we learned about Indian efforts [7] to use the culture of drawing *Kolams* for use in math education. It inspired us to make a lesson plan to explore these patterns with the ambition to stitch them. Figure 2a shows an example.

Szpakowski

The work of Polish architect Wacław Szpakowski during the first half of the twentieth century, his so called *Rhythmical Lines* [1], only reached an audience after his death. Decoding the mathematical rules controlling these lines can be a joy, Figure 8 shows the stitching of such a line.

Superellipse

The generalisation of an ellipse to a superellipse [10] or even Gielis's *superformula* [2] opens a huge family of mathematical curves. See Figure 8, to the right for some nested superellipses.

Recreating Computer Art

In 1965, scientists in Stuttgart, Germany hosted the first exhibition on computer art. Machinery and languages used to make these artworks are hard to find in working condition. Joachim Wedekind is *saving* these works by exploring how to recode them in *Snap!*, the language from which TurtleStitch was derived [9]. Many of these works can be embroidered.

Recursion

The Dragon Curve (Figure 9), Koch Snowflake (Figure 3) and Hilbert Curve (Figure 2b) are just a few examples of compact code resulting in interesting designs.

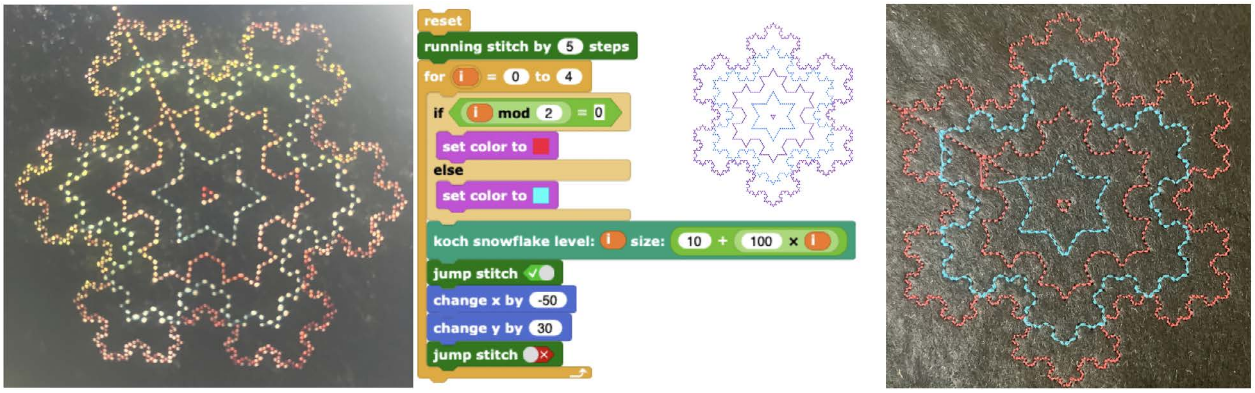


Figure 3: *Embroidery of concentric Koch snowflakes. Backlight emphasises the stitching points.*

Embroidering natural forms

Trees (Figure 2c), flowers, snow flakes and more incorporate ideas on *symmetry*, *recursion* and *Fibonacci numbers*.

Lissajous

Yet another curve that is fun to explore parametric functions and see stitched by a machine.

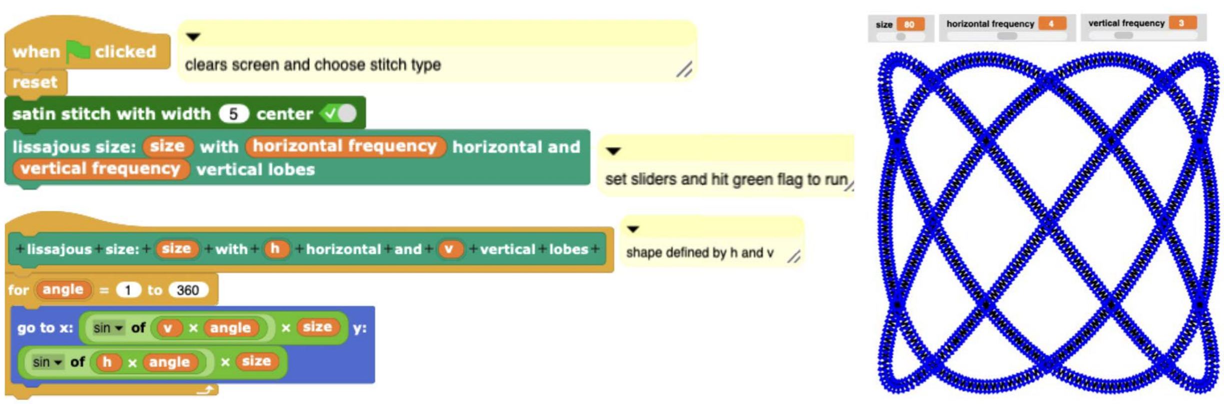


Figure 4: *A Lissajous function controlled by sliders on screen*

Workshop

The workshop is divided in three parts. In the first 15 minutes the programming environment is explained as well as two mathematical concepts in the context of TurtleStitch. The participants then have an hour for exploration on their own. Handouts are available and can be downloaded from the TurtleStitch website [8]. The last 15 minutes is for a show and tell.

Getting started

The TurtleStitch website has several resources to learn the basics of the working environment. We use cards designed by Jadga Hügle which can be downloaded from [3]. At the workshop we provide sets of these cards. Five minutes is taken to introduce the working environment as shown in Figure 1. Participants can code along on their own laptop. Free registration at the TurtleStitch website makes it easy to save and share work.

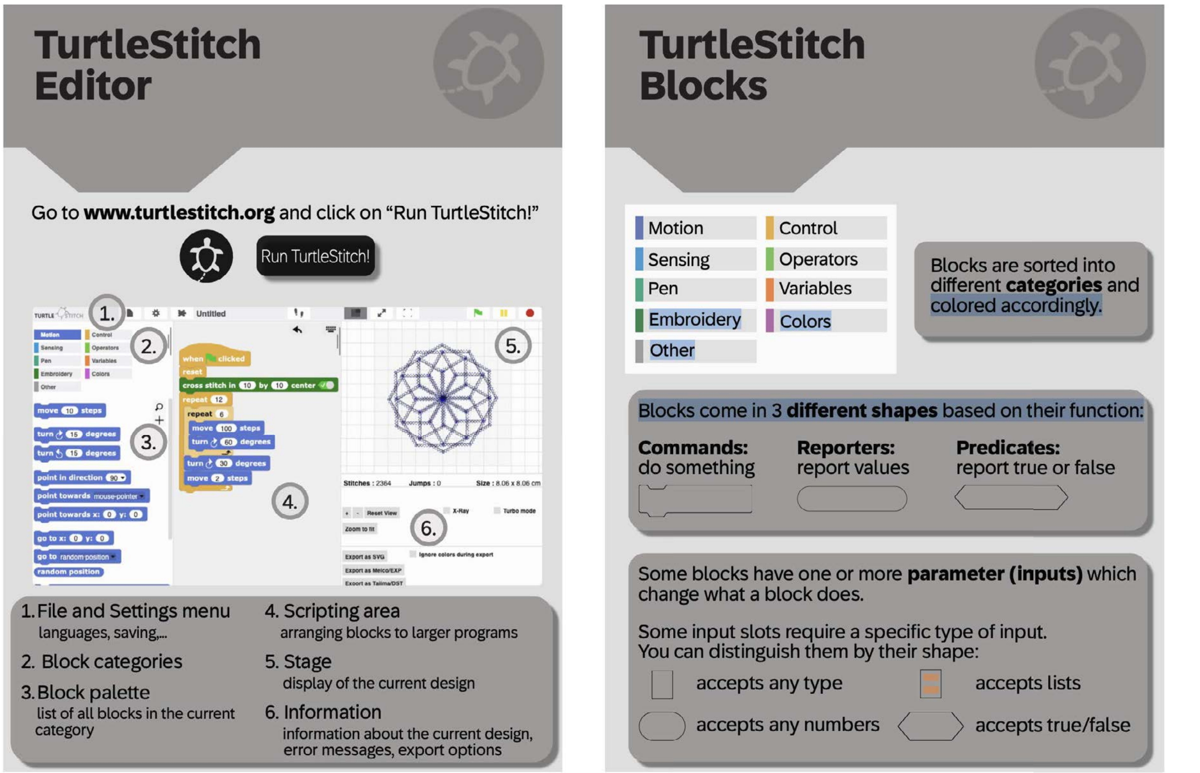


Figure 5: *A sample card introducing the TurtleStitch environment.*

Abstraction and generalisation

The idea to name procedures, that is to extend the programming language with new words is a powerful technique enabling more complex programming while keeping control. We take five minutes to explain how in TurtleStitch extra blocks are created and how input parameters facilitate generalisation.

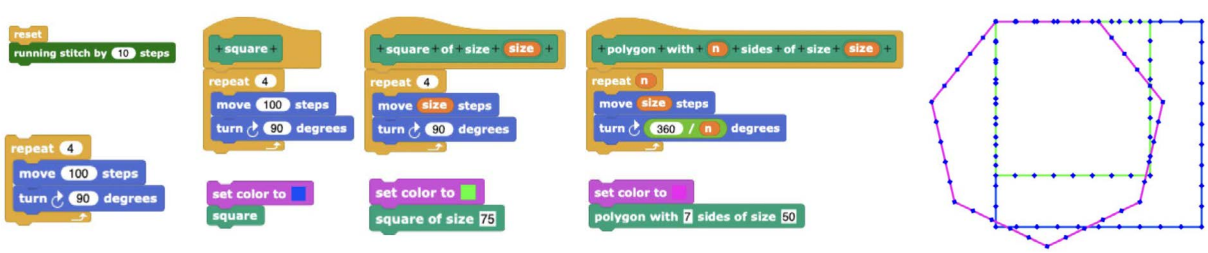


Figure 6: *Abstracting details into procedures, generalised with parameters.*

Recursion

The next five minutes is used to show how the mathematical concept recursion can be used to re-create the spiral design shown in figure 1. We create a procedure (a new block) called `line` with parameters `size` and `angle`. Calling the block three times with parameters 100 and 120 will draw a triangle with sides of 100 pixels or 20 mm when embroidered. The block can be made recursive by calling itself in its definition. Reducing the length at each call will introduce a spiralling effect. Without a *base case* the program will run forever. We'll introduce a test to make the program stop when that condition is reached.

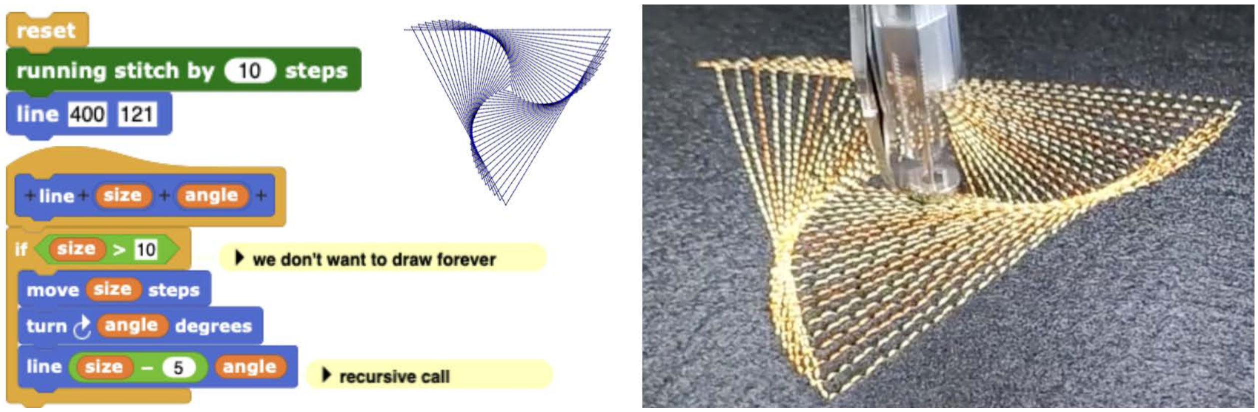


Figure 7: *Triangular spiral from first page recoded recursively, based on [4]*

Technical

As TurtleStitch runs in the browser, the only thing participants need is a laptop or tablet with an internet connection, although it can be installed for offline use. Materials needed to stitch the designs on embroidery machines are fabric and thread. The embroidery machines used during the workshop are single thread consumer machines for sale at around a thousand dollars. We do not encourage buying such a machine privately. We do encourage schools, libraries and maker spaces to buy such a machine for public use. It's perfectly possible to use TurtleStitch without having access to an embroidery machine. We've learned from several users that they *print* their design on paper and then use that for embroidery by *hand* by framing the print with fabric in an embroidery ring.

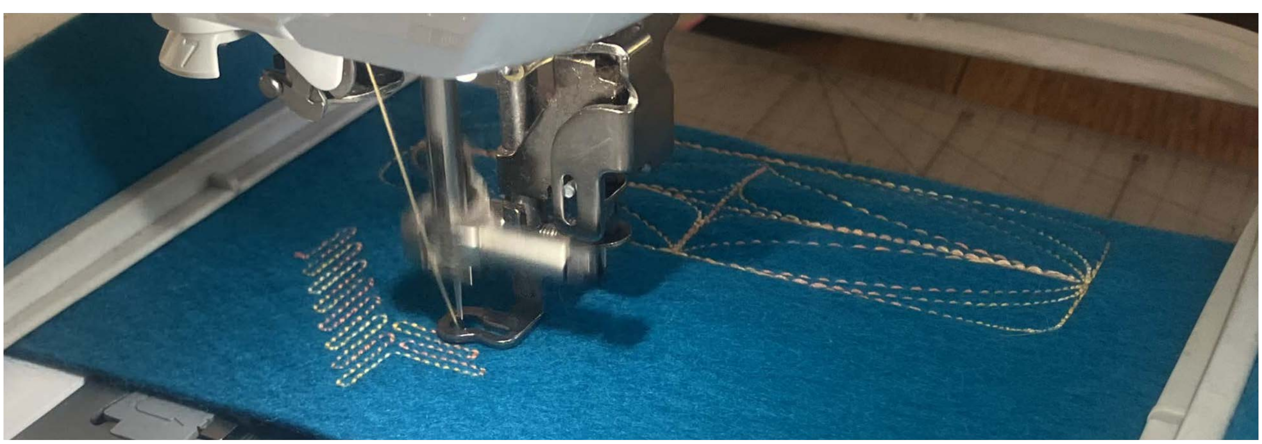


Figure 8: *Embroidering bookmarks with superellipses and Szpakowski's A1 (1930).*

Figure 9: *Embroidered Dragon Curve.*

References

[1] S. Cowan. "Rhythmical Lines." In *Paris Review* February 15, 2017 https://www.theparisreview.org/blog/2017/02/15/rhythmical-lines/.

[2] J. Gielis. "A Generic Geometric Transformation that Unifies a Wide Range of Natural and Abstract Shapes". *Amer. J. Botany*, vol. 90, no. 3, pp. 333-338, 2003.

[3] J. Hügle. TurtleStitch Manual Cards, 2024 https://make.turtlestitch.org/2024/11/08/new-2024-manual-cards/.

[4] M. Low. *Pattern To Code* https://www.warwick.ac.uk/turtlestitch/patterntocode.

[5] S. Klimczak and C. Solomon. *TurtleStitching: At Least 20 Things to Do with a Computer and a Computerized Embroidery Machine*. 2022 https://logothings.github.io/logothings/documents/turtlestitching_%2020%20things%203%2012%2022.pdf.

[6] S. Papert and C. Solomon. "Twenty things to do with a computer" *MIT Artificial Intelligence Memo*, no. 248, 1971 https://dspace.mit.edu/bitstream/handle/1721.1/5836/AIM-248.pdf?sequence=2

[7] R. Thamburaj, K. Desikachari and G. Thomas. 2025. "Tactile Kolam Patterns – Communicating Art and Mathematics to Students with Vision Impairments". In: Fernau, H., Schwank, I., Staub, J. (eds) *Creative Mathematical Sciences Communication*. CMSC 2024. Lecture Notes in Computer Science, vol. 15229. Springer, Cham. pp 66–73. https://doi.org/10.1007/978-3-031-73257-7_5

[8] TurtleStitch, 2015-2025 https://turtlestitch.org.

[9] J. Wedekind. *Codierte Kunst*, 2018 http://digitalart.joachim-wedekind.de/ueber-das-buch/

[10] E. W. Weisstein. "Superellipse." From *MathWorld–A Wolfram Web Resource*. https://mathworld.wolfram.com/Superellipse.html

[11] Wikipedia. *Logo* https://en.wikipedia.org/wiki/Logo_(programming_language).

[12] Wikipedia. *Machine embroidery*. https://en.wikipedia.org/wiki/Machine_embroidery

[13] Wikipedia. *TurtleStitch*. https://en.wikipedia.org/wiki/Turtlestitch

[14] Youtube (user chmod1234). *Stitch Performance* https://www.youtube.com/watch?v=RQ1tIIyy5JY