Fabric Sculpture - Jacob's Ladder

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Abstract

This paper develops ideas from a paper folding idea known as Jacob's Ladder into a fabric sculpture. It shows how, as an artist, I became aware of mathematics in my work. Translating origami concepts into fabric constructions, the nature of fabric affects the form. The opportunities fabric creates suggest possible developments.

I have always loved the pattern making side of maths. I trained in constructed textiles in the mid 80's, specializing as a weaver. After leaving college, I set up my own business teaching quiltmaking, making quilts to commission & originally making soft furnishings for bread & butter. As a textile artist I have always been intrigued with both mathematics and structure, most recently through origami. The work I am describing here combines all of these - using a paperfolding technique called Jacob's Ladder which I have stretched and developed in fabric.

1. Mathematics in my work

Early on in my career, I was asked to submit work to an exhibition called Mathematical Magic. I made two pieces, one based on decimals, "Decimal Rainbows" and the other on primes, "Prime Factors". As a result, I have been developing a mathematical colouring system. I hope my third book will be on this, with the second on Fibonacci inspired textile art.

Later I was commissioned to make such a quilt 'in perspective' (figure 1), although every triangle is straight edged, they appear curved, out of this my spiral quilt series on circular grids developed (figure 2)

Figure 1, Come and see, Creation series no 4, 1997

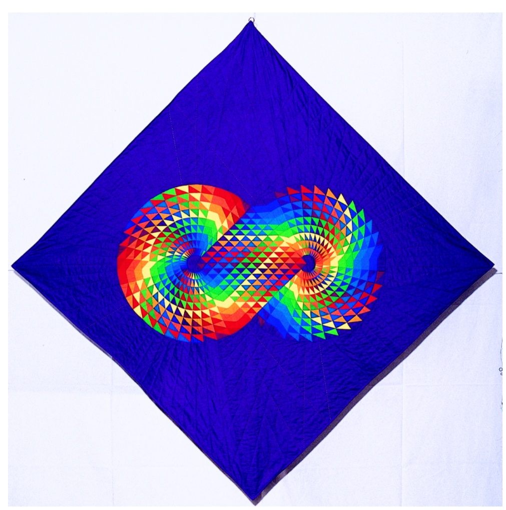


Figure 2, Infinity, Creation series no 7, 2000

In 2002 I was invited to be part of an exhibition in central London, one demonstration day, John Sharp came to see the exhibition. We have been collaborating ever since. He has been showing me the geometrical methods I could envision as structures, but didn't know how to achieve.. For example, I wanted a long, equilateral triangle effect like Toblerone boxes, but circular. John showed me how to work out the grid for a curved structure and coined the term 'Toblercone', a name I adopted. John recognised the shape to be based on a conical construction. The three dimensional fabric sculpture that resulted was coloured according to my mathematical system resulting in spiralling colour bands. It is shown in figure 3.

Figure 3, Toblercone Rings 1. 2004

I have recently written a book with another textile artist, Wendy Lowes, called *The Quilter's Guide to Twists and Tucks* which takes basic origami shapes, or existing quilting folds and pushes them a lot further in fabric. The Jacob's Ladder piece I am describing in this paper (see figures 8 - 11) is the final & the most complex of my design projects in the book. Since the book's readership is not particularly mathematical, this paper gives me a chance to describe some of the geometrical properties. Please note that this is **not** the Jacob's Ladder of traditional quilt-making which is a flat pieced patchwork block

2. Origami Jacob's ladder

I played with origami as a child. Then forgot about it. When I met Wendy and her fascinating work through quilting circles, she recommended joining the British Origami Society. I dithered for years until the book commission came, when I subsequently attended two of their biannual conferences. Heinz Stobl was the key guest at my first conference, I was riveted by his work and stretched myself to attend even the advanced lessons. At the time I recognised how amazing his constructions were, but it was the techniques he taught in order to construct his interconnected boxes that interested me. He demonstrated a technique for folding that I know as 'Jacob's Ladder'. I promptly forgot about it, until the deadline for my book proposal.

The structure has many names around the world.

“In Holland this is called a "muizentrapje" (mouses' staircase), in Germany a "hexentrappe" (witches' staircase). Sebastian Kirch calls it in English "witches' staircase" and Heinz told me he heard English and American people call it "witches ladder".” [1]

The Jacob’s Ladder is constructed as shown in figure 4. It is made from two strips of paper.

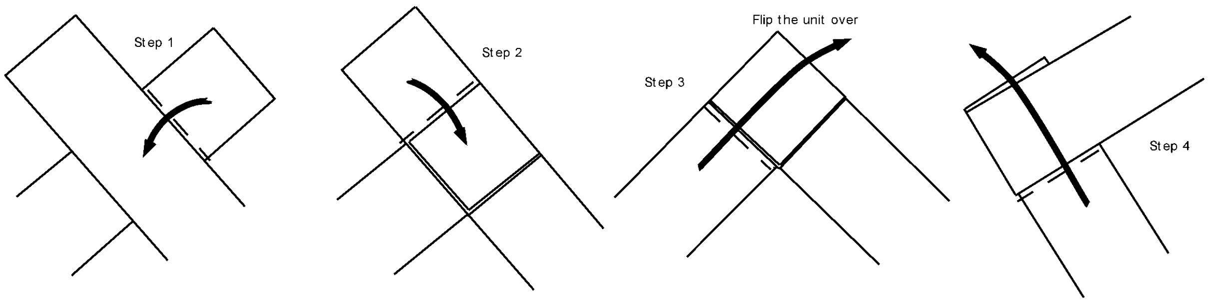
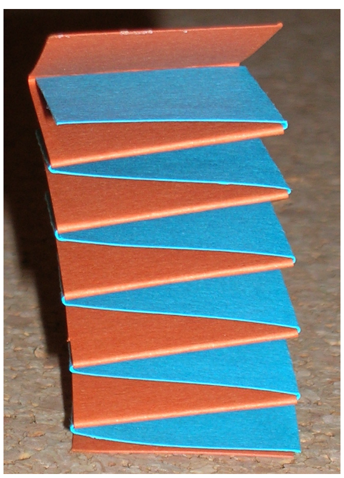


Figure 4, paper construction

Step 1 Lay your two strips on top of each other. Fold the under strip over the top strip so the edges match
Step 2 Fold the top strip back over the first fold so outer edges match
Steps 3 & 4 Turn over the unit & fold the strips alternatively over one another until the whole lengths are folded together. Glue ends together



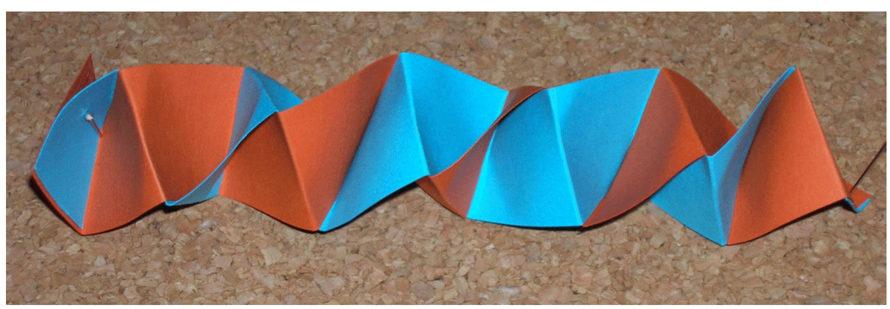


Figure 5a, closed paper Jacob’s Ladder **Figure 5b,** open paper ladder

The paper version has specific properties:

- Paper, being stiff, will crease well when you force it to, but it will also crease when you don’t want it to and any mistakes in your accuracy of folding exist forever.
- If the paper gets very wet it will rot away completely, if damp it will distort, buckle across the surface and lose it’s pristine condition.
- Paper can be slotted together to create sturdy constructions. The Origami purist never glues anything. Everything must be made with interlocking joins.
- Paper ladders are the same colour on both sides. Unless you find a double-laid specialist paper, printed origami paper, or glue two sheets together - which makes folding difficult.

- Paper ladders have a ‘natural’ extended position. When they are extended to full capacity the outer edges spiral gently down the length. If more stretch is added, you risk tearing the paper and the beauty of their structure.

A fabric version has different properties:

- Fabric on the other hand is drapable. So while it will crease well when intended, between finger nails or under an iron, it will not retain a sturdy shape on it’s own. Mistaken creases can mostly be ironed out.
- Fabric is not destroyed by moisture. Indeed it is usually designed to be washed. Though it may loose some qualities obtained by specialist treatments if washed e.g. glazed cotton.
- Fabric will not slot together. It is too slippery. So Fabric Origamists consider it acceptable to use stitch or bonding agents to hold units together. In experimenting with my Jacob’s Ladder, I was soon to discover that the stitching was essential to achieving the ‘compartments’.
- Stiffening fabrics is essential if you want a rigid structure. The stiffening process depends on the effect you want and whether you need to be able to sew through the stiffening. For my Toblercone pieces I used a plasticised fibre for a very rigid effect since I was mostly only stitching through the multi-fabric pieced quilt top, which was stretched over the structured base. While to quilt it I had to pre punch holes with a large needle. For Jacob’s Ladder, I needed to stitch through the stiffening and along the edges, so I needed a softer stiffener. I used fast2fuse, which is an American product. While this does not give me as stiff an effect as I would have liked - the wrinkles on the surface annoy me - because of folding the strips, and hand stitching intersections, I could not use my stiffest support. I am still looking for a better substance for future pieces.
- Fabric ladders can be two coloured. Because you need the middle, stiffening layer, so you may as well use two different fabrics. Besides which it adds to the design possibilities.
- Fabric ladders are comfortable beyond the ‘natural’ extended position. Since fabric is fluid, other parts of the structure take the strain when distortion occurs and so the new shape remains beautiful.

Folding the fabric version

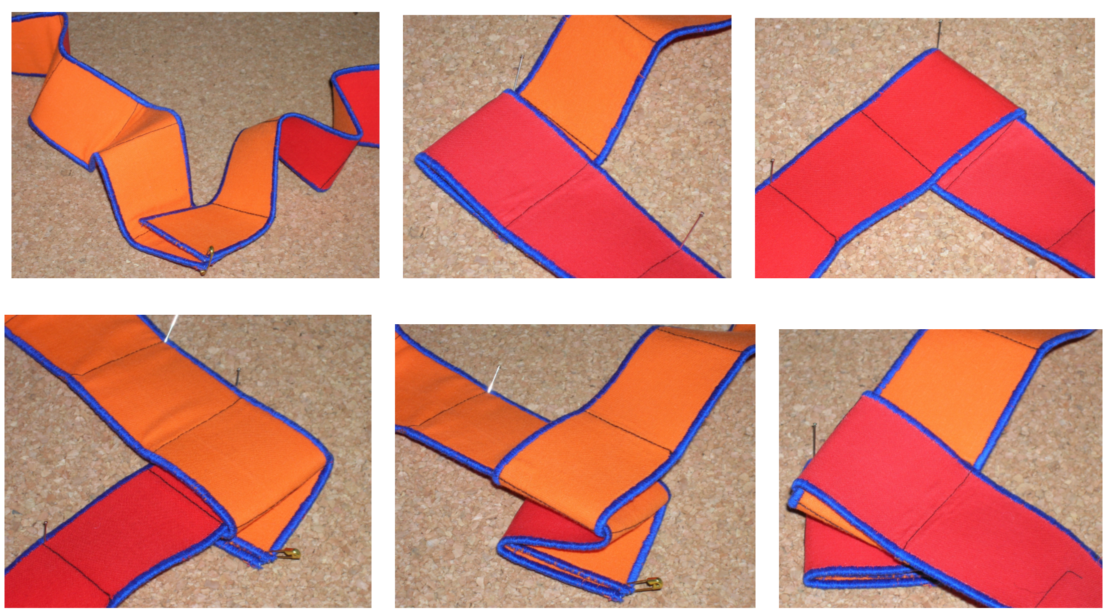


Figure 6a - e, the fabric version of a single strip showing the two colours interchanging

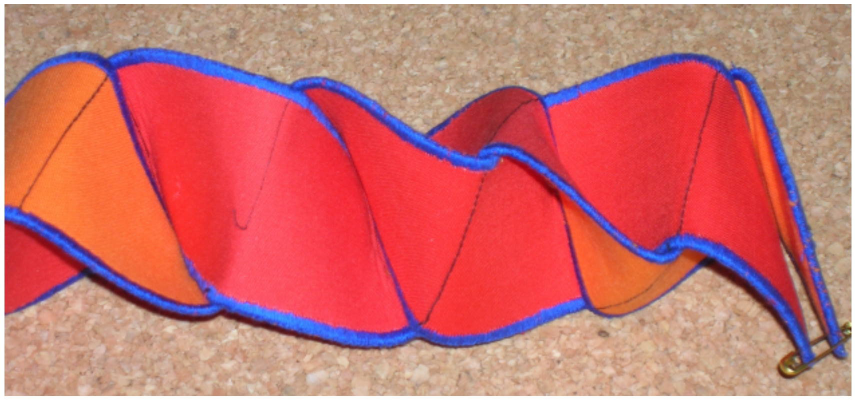


Figure 7 The folded unit before sewing at intersections

3. Making the final piece

Instructions are in my book [6]. These occur as photographic staged instructions. They may be summarised as:

- Cut same width strips of fast2fuse and two pieces of fabric per strip, in several colours.
- Iron each strip of fast2fuse to the two chosen fabric strips.
- Draw regular perpendicular lines the same width as your strip, to create squares.
- Stitch along the lines with a short, straight stitch in contrasting thread.
- Stitch all around the edges of the strips with a close satin stitch on your zig zag settings.
- Fold your strips together along the sewn lines.
- Fold alternate strips clockwise and anticlockwise.
- Sew ends of strips together at top and bottom.
- Join the strips together at the ends of the horizontal straight stitched lines.
- Lay strips in your chosen sequence.
- Join midway along the side of each compartment, as seen in the top section of Jacob's Ladder.
- Alternatively, join compartments several spaces apart to allow for spiralling to occur.
- Hang from small rings attached to the top of the piece.

In reality the instructions are far more intricate in order for it to work.

4. The Mathematics

When I made the piece, I did not initially recognise the mathematical implications of the structure. I had prepared the strips for the first photoshoot for the book and had no idea how to proceed. Several things soon became clear:

a) Using two separate colours on the first strip and two different colours on the second strip of each pair was too chaotic for what I wanted to achieve, which in this case was a sharp rainbow sequence. This was resolved by making two sets in the same colour pairing for each unit.

b) In terms of the smallest number of colours I could use so they would not come up against themselves (4 colour map theory), could I change colours every third strip in this structure?.

c) When the pairs were folded together it was difficult to see how they could be joined together, so I had to alternate clockwise and anticlockwise folding techniques. The piece therefore, involves symmetry.

d) In order to add more interest I used an <u>odd number</u> of colours, in this case 13. Each colour comes up against two other colours.

e) When you fold a paper ladder, the structure appears square, end on, because you fold the strips squarely across each other, though they may spiral above one another if badly folded. When I started to manipulate my fabric ladders, I discovered they appeared triangular in cross section, end on, when stretched beyond the 'natural' extended position of the ladder. Figure 7

f) Fabric ladders have more than one comfortable extended position. Which can be exploited for a variety of effects.

g) At natural comfort position, the outer corners of the unit lie along a line facing 90 degrees from each other

h) At maximum stretch, the corners face opposite directions another 90 degrees. In paper this in uncomfortable but not in fabric, where the outer edges of the compartments take on a curved appearance to accommodate the stretch.

i) When the ladders are extended fully compartments lay flat on the front of the piece, but there are triangular peaks on the reverse (see top of piece).

j) Folded units can also be sewn with the pyramids on alternate sides:

VVVVVVVVVVVVV   Λ Λ Λ Λ Λ Λ
                        V V V V V V

k) The links with DNA structure are obvious, if you imagine DNA as a strip of paper twisted where the edges give two helices. The sculpture in Newcastle is a good interpretation (Figure 12).

l) Three helices are generated by my folded structure, similar to the sculpture by John Mayne outside National Theatre, London [5] shown in figure 13

m) Several other questions also arise: Does the number of squares affect the results in terms of rotation? How many strips can be folded into a structure? Or how few? One strip twisted gives two spiralling edges, another interesting structure in itself. Can three strips be successfully plaited? Cords can, but how would flat pieces work?

Figure 8a The triangular cross section *and* **8b** The compartments seen on the back

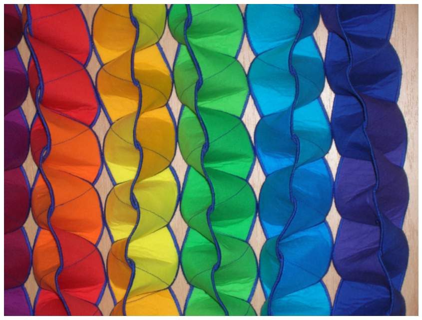


Figure 9 The triangles on the front (fully stretched) **Figure 10** Partially stretched units

Figure 11 Angled view from the top of the sculpture showing the difference in structure in the two halves of the sculpture

Figure 12 The DNA like sculpture in Newcastle

Fig 13 The triple helices section of John Maine's sculpture in London

9. How my structure could be used

There are a number of ways I envisage these sculptures being used:

- Art pieces in indoor public spaces
- Design collaborations with a metalworker?
- Room dividers/screens
- Hanging sculptures within spiral staircases or similar

I will continue to focus on making three dimensional quilts. Along with my Toblercone pieces and a five way picture (i.e. it has five distinct viewing positions like Jaacov Agam's painting technique, which I became aware of in the Pompidou, Paris c 1995 and consolidated in an exhibition with painter George Printezis, from Inverkip Glasgow, who creates similar effects by different methods)

I will be experimenting with the structures. What happens if the units get curved or become circular? What happens if extra strips are added to the unit? How large or small can I make them? I will continue to experiment with stiffening techniques. Or, what happens if the structure is made without stiffening at all?

I will continue to collaborate with other people – John Sharp, other mathematicians and artists in my bid to seek ever more interesting structures and theories. If you do anything with these techniques or ideas, please respect and acknowledge my copyright and send me a copy of your work, for possible inclusion in a future book. Thank you.

11. References

[1] http://home.tiscali.nl/gerard.paula/origami/knotology.html#knippen
[2] www.sermons4kids.com/instructions-ladder-chain.htm
[3] educ.queensu.ca/~fmc/june2002/JacobsLadder.htm
[4] Charles Jencks, architect, sculpture by Life Centre, Newcastle built by local craftsman
[5] John Maine sculpture outside Royal Festival Hall, South Bank, London
[6] Louise Mabbs and Wendy Lowes, The Quilter's Guide to Twists and Tucks, publisher Collins & Brown, ISBN 1843403110, Origami Quilts: 20 folded fabric projects, publisher That Patchwork Place, ISBN 1564776247
[7] For a fascinating collection of DNA inspired items go to www.ncbe.reading.ac.uk/DNA50/ephemera1.html

All photos by Louise Mabbs except figure 3. Shipley Art Gallery