Kasuti: The Mathematics of Embroidery

NISHTHA CHHABRA

This article is an attempt to understand *Kasuti* or Black-Work embroidery from a mathematical standpoint. Largely inspired by Joshua Holden's chapter in the book titled "Making Mathematics with Needlework", my article attempts to explore the subtleties of mathematics in *Kasuti* embroidery.

Kasuti - Tracing the origin

Kasuti is a thread-work embroidery that has historic ties to the Chalukyan dynasty of India. The word is derived from *Kai*, meaning 'hand' and *suti*, meaning 'cotton' in Kannada [1]. Traditionally, the artwork used silk yarns that were embroidered on pieces of cotton fabric. The embroidery derives inspiration from architecture, *rangoli*, palanquins, etc., and is often used in bedsheets, *kurtas*, sarees, table-runners, curtains and keychains [2].

Kasuti is distinct from other forms of embroidery. It is executed on a fabric which has significantly large holes that are carefully counted before the thread is passed through. Today, *Kasuti* embroidery is done on fabrics of matty or jute.

Keywords: art, craft, embroidery, mathematics, pattern, symmetry, networks

Figure 1 : Sample fabrics used for *Kasuti*

Stitches in *Kasuti*

Kasuti is a knot-less form of embroidery that entails four types of stitches -

1. *Gavanthi:* A double running stitch
2. *Murgi:* Used to form a zigzag design, akin to a ladder
3. *Negi:* A weaving stitch that uses a series of long and short lines
4. *Menthi:* A cross-stitch that literally means 'fenugreek' in Kannada

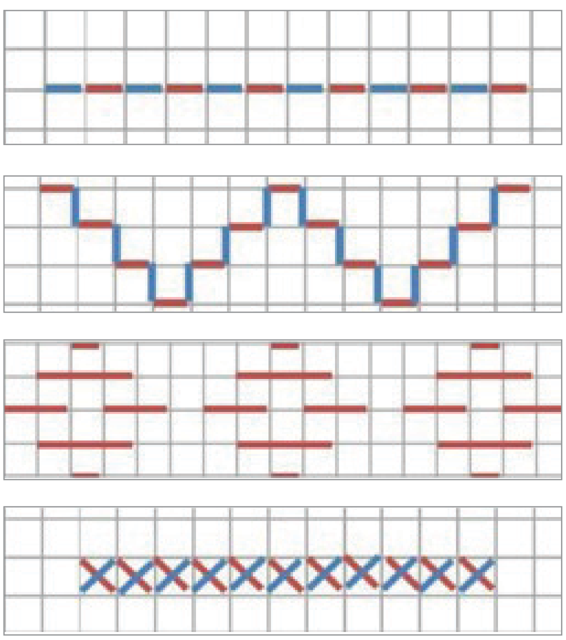


Figure 2: (Top to Bottom) *Gavanthi, Murgi, Negi, Menthi* [3]

In Figure 2, while the red lines denote the thread moving forward, the blue ones denote the stitch in the reverse direction.

Now let's take a look at a simple *Kasuti* motif.

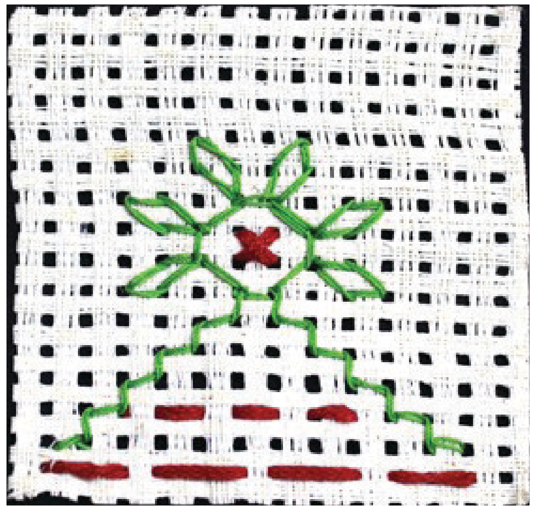


Figure 3: *Kasuti* Motif

Deconstructing the design, we identify the following stitches -

1. *Negi* - In this stitch, we keep moving forward in one direction, skipping the same number of holes every time. As a result, we get broken lines on the cloth.

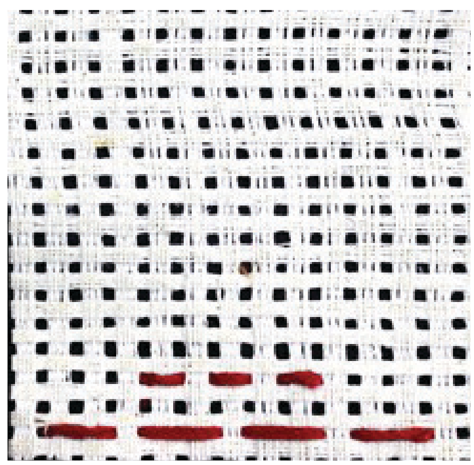
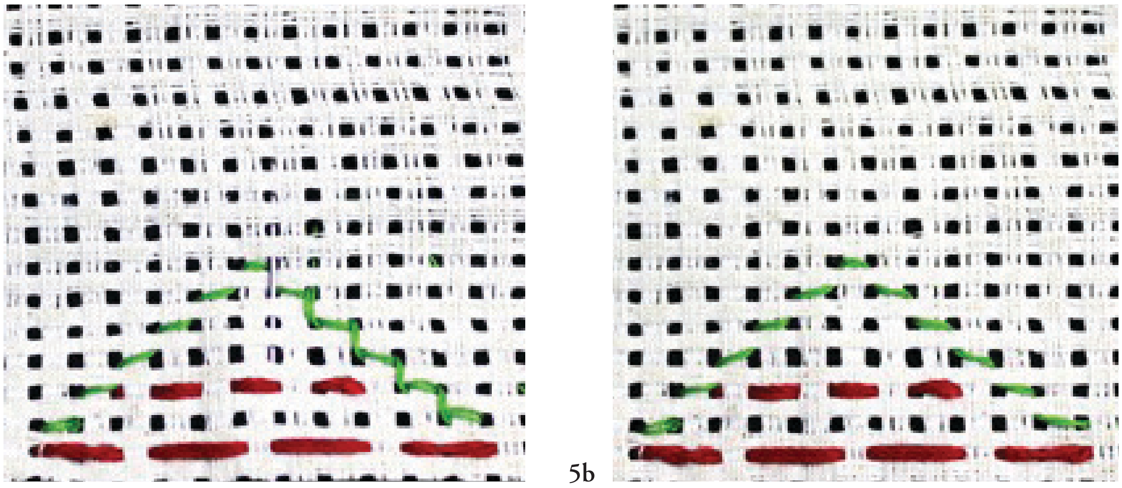


Figure 4: *Negi*

2. *Murgi* - Here, we first make the horizontal stitches (left), and then retrace the steps to create vertical lines (right). Doing this, we reach the starting point of the ladder, thereby completing the design.



5a 5b

Figure 5: *Murgi*

3. *Gavanthi* - Here, we move forward jumping alternate holes and retrace our steps. Retracing the stitch in the reverse direction produces stitches on the empty spaces that existed during the first stitch. This completes the stitch and we return to the starting point. This stitch can be performed vertically, diagonally or horizontally.

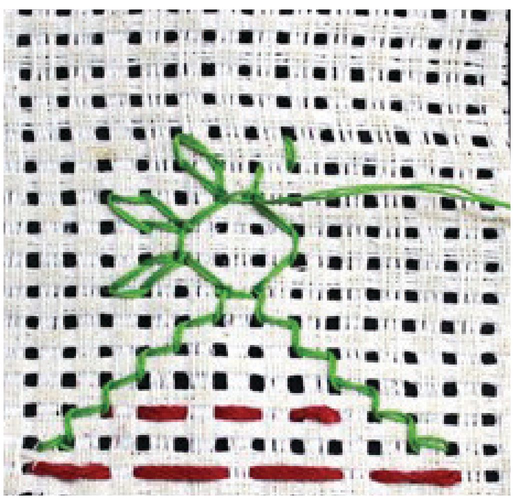


Figure 6: *Gavanthi*

4. *Menthi* - In *Menthi*, we start at one hole and move to the diagonally opposite hole. From there, we move to the hole adjacent to it and again to the hole in the diagonally opposite corner. Finally, we move to the adjacent hole, returning to the starting point of our stitch. Thus, the right side of the fabric has an 'x' appearing, whereas on the wrong side, we only have two vertical/horizontal lines.

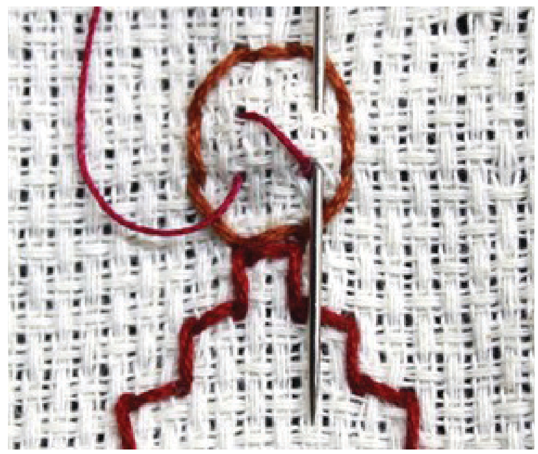


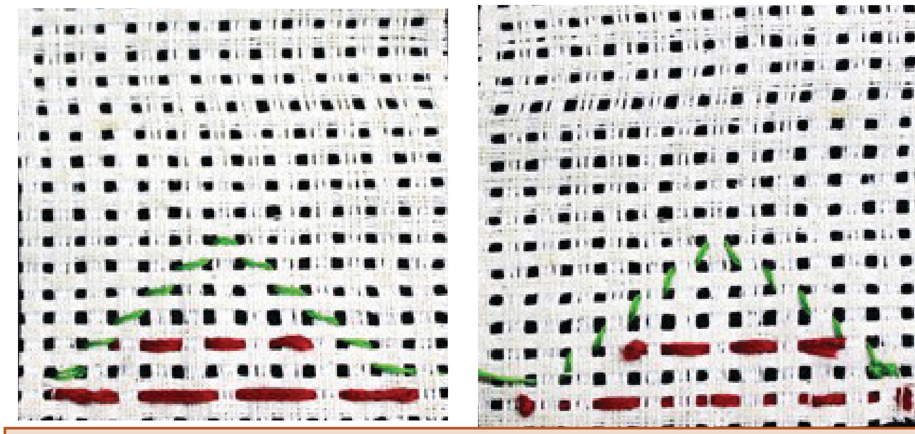
Figure 7: *Menthi*

Mathematics behind it

Symmetry

a. In *Murgi*, there is a rotational symmetry between the stitches on the right and the wrong sides of the cloth. The horizontal lines on the front side become the vertical lines on the wrong side and vice versa. In Figure 8, take a look at the green lines. The figure on the left has horizontal lines, whereas the same lines appear vertically on the wrong side of the fabric.

b. In *Negi*, there is a translational* symmetry between the stitches on the right and wrong side of the cloth. This means that the stitch moves by a few positions to the left/right on the wrong side (Figure 4). There is also a translational symmetry on the same side of the cloth.



A sneak peek at the 'Wrong' Side

In the textile industry, every fabric has a 'right' and a 'wrong' side. Often the 'right' side is smoother and is the side that is visible externally.

Figure 8: *Murgi* stitch on the right side and wrong side of the fabric respectively

c. In *Menthi*, the cross appears on the right side of the cloth and vertical lines appear on the wrong side of the cloth (Compare the red cross in Figures 3 and 9).

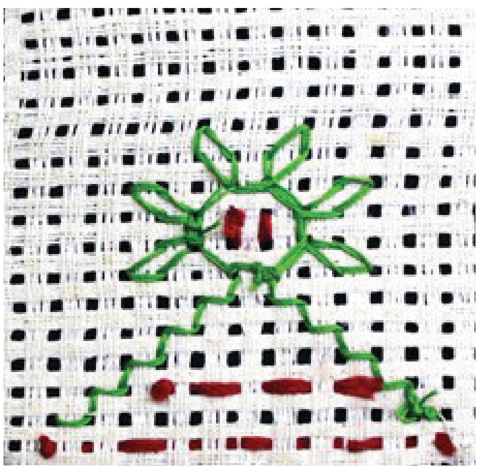


Figure 9: *Menthi on the wrong side of the fabric*

*Usually, translational symmetry is defined for infinite length. However, here we are restricted to a finite length.

Wrong is Right!

These symmetries can help to cross-check if the stitches are in the right position. One can always take a peek at the wrong side and verify if the symmetry holds.

Another way of knowing you are doing the stitch correctly, is to check if you are able to return to the starting point while using the same stitch in reverse direction.

2. Graph Theory - Graph theory is a study of vertices and edges of a drawing called 'graph'.

Figure 10 shows two kinds of graphs - undirected (wherein the edges are bidirectional) and directed (wherein the edges point in a particular direction).

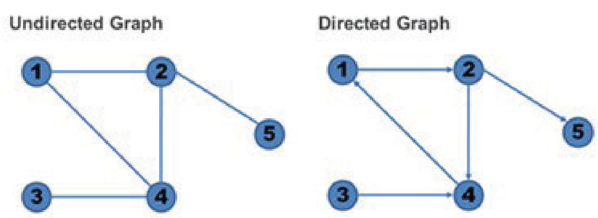


Figure 10: Types of Graphs [4]

Since *Murgi*, *Menthi* and *Gavanthi* involve returning to the same point, they form what is known in graph theory as a 'circuit'.

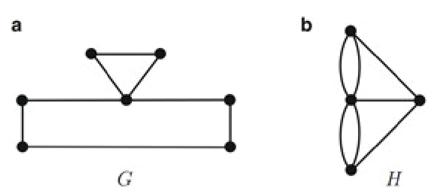


Figure 11: Eulerian and Non-Eulerian Graphs [4]

Eulerian graphs refer to graphs where it is possible to traverse across each edge exactly once and then return to the starting vertex. In Figure 11, while (a) is Eulerian, (b) is not. This means that in (b), it is impossible to traverse each edge exactly once, and return to the starting point. Note that here, there is no restriction on the number of times we can touch a vertex.

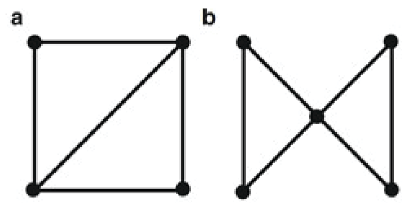


Figure 12: Hamiltonian and Non-Hamiltonian Graphs [4]

Hamiltonian graphs refer to graphs where it is possible to touch each vertex exactly once and then return to the starting vertex. In Figure 12, while (a) is Hamiltonian, (b) is not. This means that in (b), it is impossible to touch each vertex exactly once, and return to the starting point.

In *Kasuti*, all the stitches form an Eulerian circuit, i.e., we are able to touch each edge exactly once and return to the starting point. On the other hand, all the stitches in *Kasuti* are non-Hamiltonian since we touch each of the vertices (holes) multiple times.

Where do we use Eulerian and Hamiltonian graphs?

Google Maps - Imagine there is a bus driver who needs to find the shortest route possible to cover all stops. Here, the routes are edges and the stops are vertices. The driver will find an optimal route that begins at a stop, covers each stop exactly once, and finally return to the point where he started. Hence, we use Hamiltonian circuits to determine such routes.

Imagine you're taking a trip around the city to see its historical landmarks. You wish to travel along every road exactly once. Here, the places you visit are vertices and the route you take is an edge. In this trip, you are travelling across a particular route (edge) just once to come back to the place you began from. However, in this route it is possible that you touch a particular place more than once. Hence, this is an example of an Eulerian graph.

Pedagogical Suggestions for the Primary Level

Integrating mathematics with art and craft is a much-discussed topic now. *Kasuti* work is a good project for all levels right from primary, when students can follow instructions to complete (or observe) a *Kasuti* pattern to distinguish between types of lines (standing, sleeping, slanting). Understanding of Perimeter can be enhanced by counting the number of stitches (non-standard units) seen around a closed shape. Again, counting the number of squares inside a closed shape reinforces the idea of area. Meeting or interviewing a person who does *Kasuti* work after doing a project in class, will help students understand the monetary aspect of the craft, giving them real data about how much a piece of *Kasuti* embroidery is worth, how long it takes to complete, ideas of profit and loss, etc. And of course, as detailed in the article, at levels beyond primary, *Kasuti* embroidery helps students get a great introduction to symmetry, graphs and networks, topics not usually covered in school mathematics content.

References

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