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Chapter 24 **Revised Version 1.1**

Digitalization of Kolam Patterns and Tactile Kolam Tools

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Kolam is a traditional and popular graphical folk art practiced in the southern part of India using rice flour for decorating courtyards. Haptic identification of Kolam however is not possible by the blind or those with low vision. This paper describes two tactile line drawing tools, which make these patterns accessible to the visually impaired. One of the two tools was developed as a Universal Designed Cube with 6 primitive patterns on each of 6 sides. These primitive patterns were found by researching how to draw Kolam and other similar traditional patterns of Celtic knot in Europe or Soma paintings in Africa.

1. Kolam patterns

In southern Indian villages, the courtyard in front of each house is decorated every morning by drawing of traditional designs called Kolam. The decoration of the floor with Kolam designs (figure 1) is carried out by women, who deftly draw with pinches of rice flour or limestone powder held between the thumb and the first finger and letting the powder fall in a continuous line by moving the hand in desired directions. On festive occasions, the Kolam designs are more elaborate and complicated. Initially a regularly arranged dot (symbolizing the origins; Pulli in Tamil) array is drawn and then lines are drawn around the dots or in connecting them. A Kolam could be made up of a single, un-segmented, closed thread of line or it could be made up of superimposition of two or more closed threads of lines, each constituting one component of the global Kolam pattern. Many Kolam designs are geometric patterns formed by means of interleaving straight and curved lines. These patterns can be classified as recursive designs and non-recursive designs.

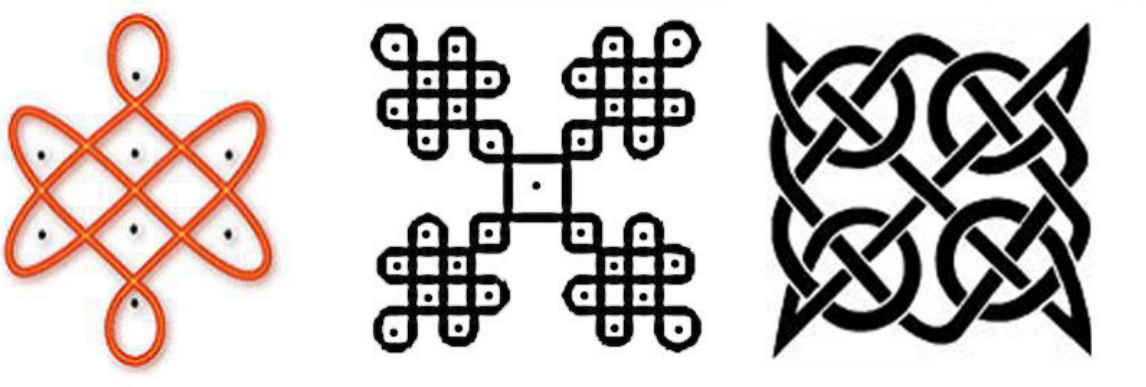


Figure.1 The right and the middle are Simple Kolam, called Kambi/Sikku Kolam with a single stroke around all dots. The center is recursive (changed the image). The left is one of Celtic knot designs with a single stroke

2. Picture language

Two-dimensional picture generating models are of interest in the area of pattern recognition by computers. Graph grammars and array grammars have been studied extensively for the description and analysis of two-dimensional structures. Rosenfeld advocated cycle grammars, as early as 1974 for the generation and description of pictures having rotational symmetry [16,17].

Motivated by the Kolam patterns, Siromoney *et al* have introduced, different types of array grammars generating array languages [10 ~ 16] and have given specific instructions for drawing certain kinds of Kolam patterns, namely Kambi Kolam, which can be represented as a single strand (literally meaning wire decoration with dots/Pulli in Tamil. (Preferred to be called as Sikku Kolam, as it needs to be identified from such another style, that all lines/curves connect all of dots. Sikku means knot or entangled and all curves pass around all Pulli). Each Kambi begins and ends at the same point, i.e. each Kambi is an unending line or a closed curve with or without loops (cycles) [14]. The approach was syntactic and the emphasis was on considering each pattern as made up of sub patterns.

Experiments were conducted by Siromoney to find out how the Kolam practitioners store such complicated patterns in their memory and retrieve them with ease while drawing the Kolam. In the course of the study, it was found that Kolam practitioners remember, describe and draw the designs in terms of "moves" such as `going forward', `taking a right turn', `taking a U - turn to the right and so on reminiscent of the "interpretations" which are used in computer graphics as sequences of commands which control a "turtle". Treating each kind of a move as a terminal sign, each Kambi/Sikku Kolam represented a picture cycle. A Kambi/Sikku Kolam is a closed curve with or without loops represented in the form of cycle, which is a string, joined at two ends. Each element of the string belongs to the set K = {F, R(1), R(2), R(3), L(1), L(2), L(3)} where F stands for "move forward one unit", R(1) represents a " half turn to the right", R(2) a" U-turn to the right," R(3) a "complete loop to the right" and similarly for L(1), L(2), and L(3).These picture cycle languages can be viewed and generated in several ways - (i) some of them may be regarded as cycles in the graph theoretic sense - as a sequence of nodes and arcs, or (ii) they may be converted into strings and generated by string grammars either Chomskian or Lindenmayer type, or (iii) as necklaces of terminal symbols. The terminal symbols may be of different types - each symbol may have a

graphic interpretation or represent simpler turtle moves or chain code alphabet with coordinates specified or not or "Kolam moves" as in [6].

This representation needs 7 codes. Therefore another representation was investigated for a more simplified model in the followings.

3. Digitalization of Kolam patterns representing with {0,1} and space filling regular polygon tile

Of the many types of Kolam patterns, a certain family of patterns (Kambi/Sikku Kolam) over square grid, is filled with a regular polygon tile with the centered dot, which has 4 edges, the lines cross at the center of each edge, or turn once around the center-dot. Nagata *et al* have given new digital representation to encode such two primitive conditions that 1 and 0 denote respectively the 'two-level-crossing, and going forward as linear line' at the edge and the 'no crossing, but turning around the dot as an arc-line' [6]. Therefore each tile has a set of four-digits at clockwise sense, and it results 16 patterns of the lines in a square tile, which include the isomorphic shapes in different orientations and posse six basic primitive shapes named as circle, drop, saddle, pupil, fan and diamond (figure 2).

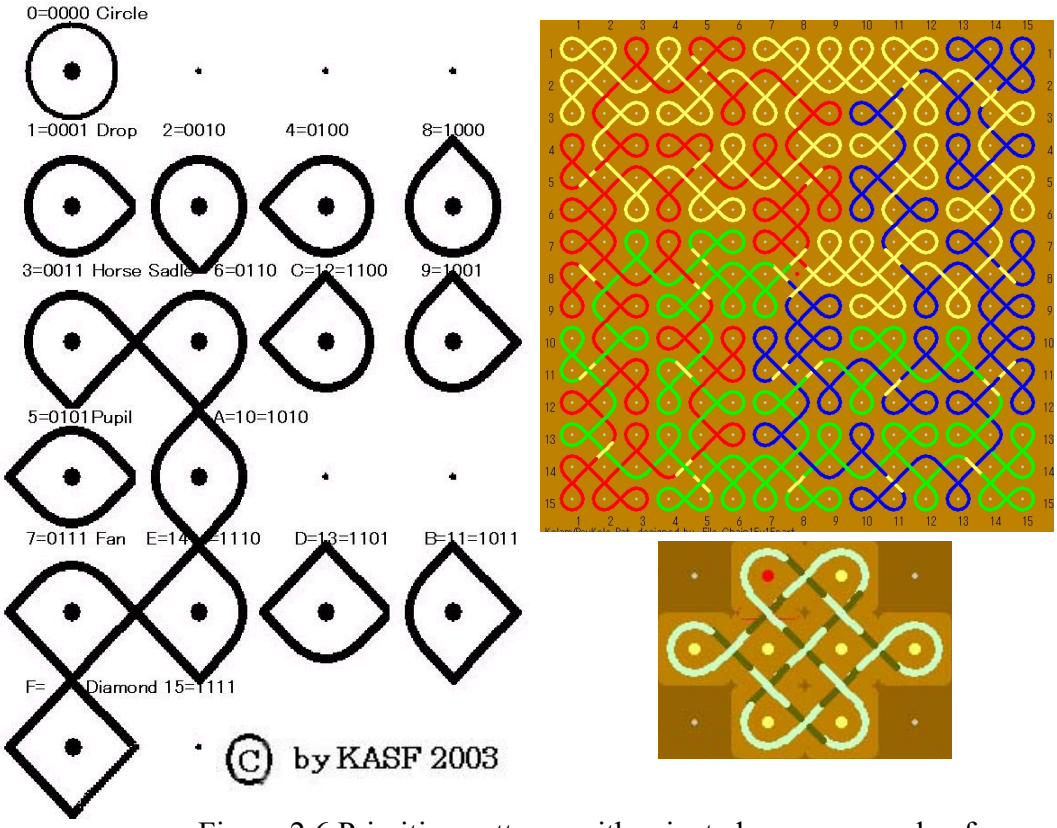


Figure.2 6 Primitive patterns with oriented ones, a sample of Swastika Kolam with a single string consisted with 4 same string chains, and a knot expression of Takara-Musubi knot

Catenations of these primitives drawn on the tiles produce single or multiple stroke Kolam patterns. According to this representation each primitive pattern has lines that run once around the center dot of the tile. Hence the circle is '0000, hex-0' while the diamond is

represented as ‘1111, hex-F’. The simplest Kolam pattern that resembles the numeral ‘8’ is represented by two tiles of hex-2 and hex-8 or by the chain code of the strings ‘00100010’ starting at the top edge of a tile, in the other sample of the infinitive symbol ”00” by two tiles of hex-1 and hex-4 or by the same chain, but starting at the right edge of two adjacent (contiguous) tiles. The other regular polygons (triangle, hexagon) allow us make other type tiles with linear lines crossing at edges and arc-lines. The direction of the stroke is alternately changed at the crossing point, on the right side or the left side against each dot and the directions of each stroke is same in the one tile.

In the above representation, Nagata *et al* also expressed on a cycle problem based on a “smooth pass” rule of tracing different from Eulerian cycle [6] and have developed Kolam-designer software that shows an animation of the tracing pattern in a computer as drawn by Kolam practitioners [6-1,6-2]. This square tiling also was discussed as Mirror-light ray curves by Gerdes[2,3] and then Jablan[4].

4. Universal Kolam Cube (UKC/PsyKolo)

A screen of a computer allows the visually disabilities with Low vision to see a Kolam pattern of computer graphics drawn on it in such conditions as fitted size and color-contract etc. However, the other are not able to see them completely and need an other drawing method.

As the only 6 primitive patterns were found to be enough to make Kolam patterns, Nagata et al embodied the idea of those primitive tiles into a tangible educational tool named KoMa (acronym for Kolam Magic, later renamed PsyKolo for Psychological Kolam, meaning cube in Japanese)[7]. PsyKolo consists of a set of wooden cubes (of 4.5 cm size each) with basic primitive shapes embossed on each of all the six sides of a cube (figure 3) with embossed lines on Microcapsule paper accessible to the disabled people. With a small magnetic element concealed in each of the 6 sides of a cube, many cubes can be attached by their-self side by side to form linear or planar formations. The cubes thus arranged can be rotated easily to a good position to form different symmetric closed curves and Kolam patterns. Two adjacent cubes differ in magnetic polarity (as opposite poles attract). The cubes with north and south magnetic polarity are identifiable with the different tactile dots embossed on a side They can be formed in Matrix formations of N x M of rectangular shaped Kolam patterns (e.g 3 x 3 cubes, figure 4) or any other formations. The cubes can be rotated to form new Kolam patterns.

The authors have improved PsyKolo cube with discrete-stimulus dotted tactile lines, which is more effective to recognize the lines, and filled each primitive with a specific colour. The author developed also such a special attaching device that any contiguous block joints together without repulsion with the right angle.

The modified Psykolo (named as Universal Kolam Cube (UKC)) gives better stimulation while tracing for the visual disability and the coloured Kolam patterns thus formed attract children with learning disabilities (LD), sighted as well as low vision ch ention Deficient/Hyperactivity Disorder and Au orming single stroke pattern and their ability to terns.

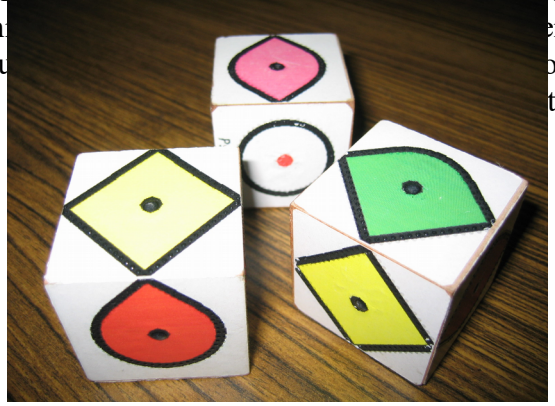


Figure.3 Universal Kolam Cube / PsyKolo

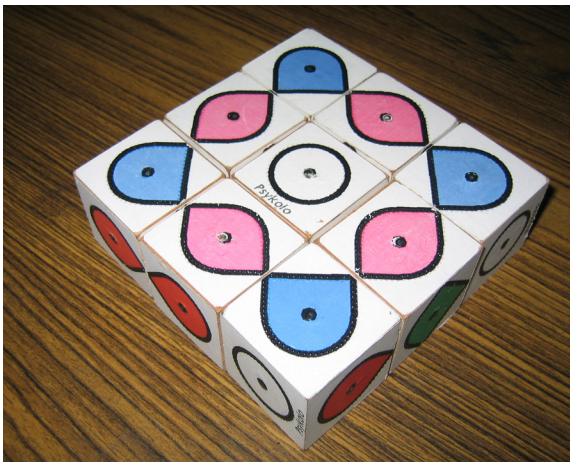


Figure.4 Kolam pattern formation

5. Tactile Kolam sheets

Tactual shape perception is a synthesis of many parameters that lead those with lower or no vision to make sense of external stimuli. Several processes, each of which has specific advantages, can produce tactile diagrams. Microcapsule paper is a special paper coated with alcohol-filled microcapsules, which expand when heated. A few experiments have investigated the effectiveness of microcapsule paper for producing diagrams (Aldrich et al, Kirkwood and Pike et al [1,5,8]).

The intricate Kolam patterns which give a great appeal to visual sense is a difficult art form for the people with visual impairment to understand and appreciate. The patterns drawn with rice flour or limestone powder get erased when a visually challenged person tries to sense it through his/her fingers. The Kolam pattern drawn with black ink on the microcapsule paper protrudes to form a tactile line when heated. The tactile drawings as tangible line graphics make this art form accessible to the visually impaired/ the visually challenged (VC).

Viewing the Kambi/Sikku Kolam pattern as a chain code representation on a square grid, a new technique of representing the hand movements in four directions is considered. Denoting by the symbol *n* the movement of one unit northward (*e, w, s* for other three directions), the pattern is represented as a word over {*n, e, w, s*} (figure 6). Representation over {*n, e, w, s*} is found to be easier by the visually impaired/VC to remember the design than the other pen command representations used in picture descriptions. They preferred this technique to record and create new Kolam designs by themselves.

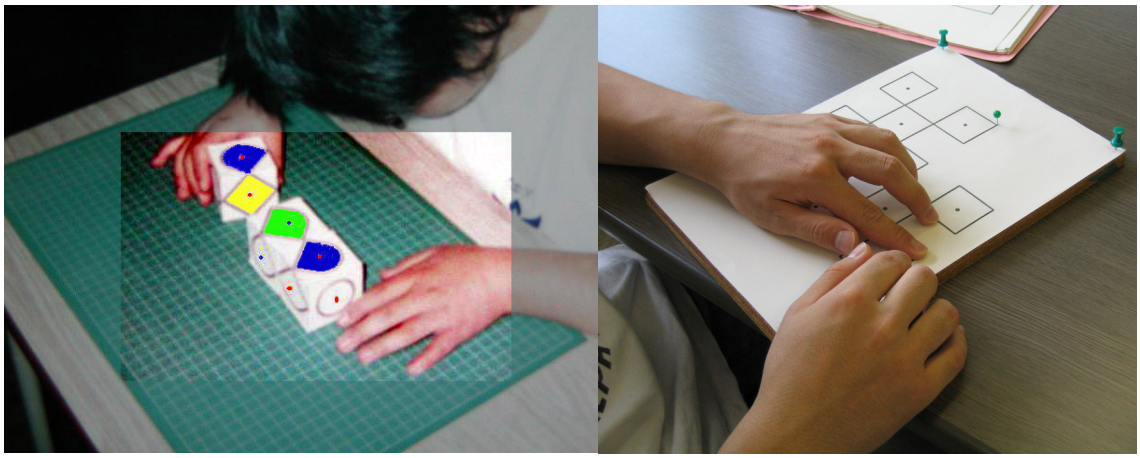


Figure.5 A child with learning disability arranging a pattern

Figure.6 Tactile recognition of a Kambi/Sikku Kolam

6. Summary

The Universal Kolam Cube (UKC) also called PsyKolo, is an educational toy developed by digitalization of the traditional religious Indian Kolam patterns as well as European Celtic patterns and African Sona patterns and designed universally. It assists the visual impaired and the blind appreciate Kolam. These patterns possess rich mathematical and geometrical features with rules different from Eulerian cycle. Any child or adult can now enjoy or wonder how (what) not only beautiful but also complex forms result from recursive use of simple rules.

The UKC/PsyKolo is a set of wooden cubes with Kolam primitive patterns on each side, containing some devices that enable the cubes to be attached and easily rotated in many combinations creating a wide variety of pattern formations. The patterns are printed and embossed with colored and tactile material in a special configuration for those with visual and other disabilities to universally recognize the lines and dots in the ground.

The authors applied these UKC/PsyKolo to let users with visual and other disabilities in South India and also Japan develop a kind of pattern/shape cognition and learn special relations as well.

The drawing of Kolam patterns practiced purely as an art form earlier is now opening new avenues in the area of computer graphics, textile industry, rehabilitating the disabled of the aged persons, special education for visually challenged, ethno-mathematics etc. The second author has an ongoing work on decorating the wall ceiling with illuminated bulbs and sound forming Kolam patterns.

It would be useful for children to understand how the structures in our Universe evolved from simple beginnings to the complex structures composed of stars and galaxies that we see today.

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