

# Graph-Theoretic Insights into Traditional Rangoli Design

Vijayalaxmi S Suvarna

Department of Mathematics & Statistics H R College of Commerce & Economics Mumbai

**Abstract-** Rangoli is the traditional art form that is drawn in the early morning and evening in front of the house and pooja places. According to Hindu faiths, it signifies positivity, beauty, health, happiness, and liveliness in a household and is drawn to welcome Lakshmi, the goddess of wealth and good luck. Rangoli is used to decorate both inside and outside of one's house. It serves as a form of floor decoration, and expresses one's creativity. It is often looked as a type of self-portraiture, it remains largely unchanged over the years, which many find beautiful and pleasing. The purpose of rangoli is beyond decoration. The paper presents an analysis of rangoli designs using graph theory. The graph theoretic principles such as planarity, connectivity, Euler graphs are used to understand, analyze and classifying rangoli designs. Thus, it helps in understanding cultural designs through graph theory.

**Keywords:** Rangoli, Graph theory, vertices, edges, connectivity.

## I. INTRODUCTION

The word rangoli is derived from the Sanskrit word Rangavalli and signifies creative expression of arts. Originally it is drawn by people of Tamil Nadu, Karnataka, Kerala, Telangana, Andhra Pradesh and some parts of Goa. Rangoli has different names in different states of India. Rangoli in Karnataka, Kolam in Tamil Nadu. In Kerala during Onam, rangoli is made with flowers and flower petals. In Rajasthan, it is known as Mandana. In Ramayana and Mahabharata this art is mentioned as people drew rangolis to welcome their Kings. To draw rangoli first of all the space where it is drawn must be swept and cleaned with water.

Typically to draw the rangoli rice powder is used. The powder is held between the thumb and the index finger and it is released slowly to draw the desired pattern. It begins with placing the dots on the floor arranged in rows and columns. Once the desired numbers of dots are placed on the floor, they are joined by either straight lines or curved lines surrounding the dots.

The curved lines that merge to become motifs. Concentration, coordination between hand and eye plays a significant role while drawing a rangoli. Through Rangoli one can draw geometric patterns, flowers, fruits, animals, birds, nature. Art of drawing rangoli is passed down from family members from

one generation to the succeeding one. These drawings have connections with the other folklore type of drawing from other places.

**Objective:** To study the connectivity, planarity, symmetry and Eulerian path of traditional rangoli designs using graph-theoretic analysis.

## II. LITERATURE REVIEW

Kolam patterns can be represented by numbers by assigning 1 to "crossing" else assign 0 and it is also possible to convert into linear diagrams. Characteristics of one-stroke pattern "Diamond carpet" is identified by converting it into a linear diagram (Yanagisawa & Nagata, 2007). Making a larger pattern out of a basic pattern is an interesting and challenging activity. All rangoli design show some kind of symmetry such as rotational, reflexive, cyclic symmetry including full dihedral symmetry (Madhuri).

By increasing or decreasing the number of points in the lattice, the scale of the drawings can be changed. The Kolam drawings created on a point lattice exhibit the use of design principles, such as symmetry, movement, rhythm, and repetition (Sarin A, 2022).

### III. REQUIREMENTS FOR DRAWING RANGOLI

#### Requirements

To draw rangoli, dry rice flour, flowers, and flower petals are used. Nowadays synthetic-colored powders are used to make the rangoli more attractive. In some cases, various pulses are also used. In certain pooja times, Pandits will draw the rangoli which are specific to specific poojas and colours are used quickly with amazing skills. This may take a few minutes to hours, by a single person or multiple people are involved when the design is large and too complicated.

There are no specific rules in drawing rangoli or Kolam. It basically depends on time, space, mindset of the person drawing the rangoli and his creativity. It also depends on the occasion at home, simple to complicated rangoli patterns can be drawn. Normally it starts drawing with an edge on the boundary of the grid. The form of the pattern is determined only according to the accumulation of the choices of whether the drawing-line goes straight or curves at each intersection of the inclined grid.

A close look at several rangoli designs we can observe the following:

- Dots also known as Chukke, pulli, which is the foundation for the rangoli design are arranged in rows and columns and normally placed equidistant from one another.
- Straight lines joining the points or curved lines and arcs are drawn enclosing the dots.
- A line is not tracing the same path in the majority of the cases.
- The line must join the dots or must surround the dots and it often returns to the initial position.
- When all dots are covered by drawing lines straight or curved, then the drawing is completed in majority of the patterns.
- Patterns contain mathematical principles such as theory of numbers, geometrical patterns, sequencing, graph theoretic properties.

Rangoli designs are broadly categorized into following types.

- Dots are drawn in rectangular or isometric lattices form and then
- they are connected to one another to form geometrical shapes, or any objects from nature.
- here curves are drawn around the dots to form geometrical shapes, or any objects from nature and these are known as Kolam.

Geometrical shapes like circles, rectangles, triangles, hexagon are drawn. Also, freehand and natural objects, or scenes from epics, history and other free shapes are drawn.

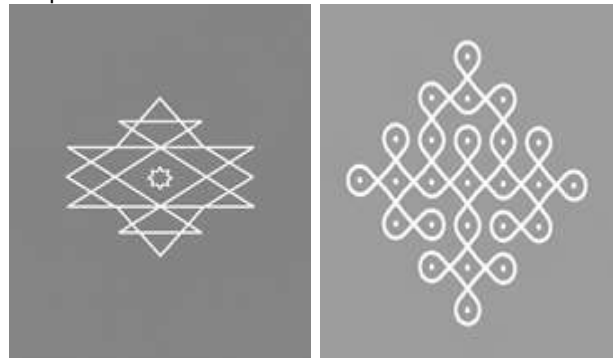


Fig1: a

Fig1: b



Fig1: c



Fig1: d



Fig1: e

In fig 1a dots are connected by straight line. In Fig1: b dots are covered by curved lines. In fig1:c the rangoli contains the circle. Fig1: d and e are drawn for pooja. Here particular colour, geometric shapes and flowers are also used. These kinds of patterns differ depending on the pooja or the festivities. Rangoli is a combination of mathematics and tradition. With finite number of dots, it provides an infinite drawing options to create different patterns with a finite set of rules.

### Notations and Definitions

A graph  $G$  is an ordered triple  $(V(G), E(G), \psi_G)$ , consisting of a non-empty set  $V(G)$  of vertices, a set  $E(G)$  disjoint from  $V(G)$ , of edges and incidence function  $\psi_G$  that associates with each edge of  $G$  an unordered pair of vertices of  $G$ .

These vertices may be the same or different. A finite graph has a limited number of vertices and edges. If either the vertices or the edges are infinite in number, the graph is known as an infinite graph. This study is restricted to finite graphs only. A trivial graph is a graph with only one vertex and no edges. All other graphs are non-trivial. A loop is an edge with the same end point, an edge that connects two different vertices is a link. A graph is planar if it can be drawn in a plane with no edges intersecting at their end points. Connected graph is a graph where there is a path between every pair of vertices.

An alternating sequence of vertices and edges say  $u = v_0 e_1 v_1 e_2, \dots \dots e_n v_n = v$  is called a walk.

A  $u-v$  trail is a  $u-v$  walk in which no edge is repeated. A vertex can be repeated in a trail. A path is a  $u - v$  walk in which no vertex is repeated, A closed trail is called a circuit. A closed path is called a cycle. A cycle of length  $K$  is denoted by  $C_K$ . Euler path is a path that visits each edge of a graph exactly once. An Euler circuit is an Eulerian Path that starts and ends at the same vertex.

A graph has a Eulerian circuit if all its vertices have an even degree and it has a Eulerian path if it has exactly zero or two vertices with an odd degree. The graph must be connected for either to exist.

Catalan numbers are a sequence of natural number's that appear in various counting problems in Combinatorics and is defined as  $C_n = \frac{1}{n+1} \binom{2n}{n}$ . The number of ways to connect the  $2n$  dots on a circle with non-crossing lines is found using Catalan numbers.

## IV. RANGOLI PATTERNS AND GRAPH THEORY

This traditional Indian art form known for its intricate and symmetrical patterns, offers a fascinating intersection with mathematics and graph theory. When rangoli is viewed mathematically, the designs of rangoli connected by dots joined by straight or curved lines.

Each dot in the rangoli represents the vertices of the graph. The straight lines joining the dots and curved lines surrounding the dots are the edges of the graph. If two or more edges are connected to the same dots then they are called parallel edges. If in the rangoli the curved line drawn begins and ends at the same vertex then it forms a loop.

The design exhibits symmetry and worldwide, across all religions, symmetrical designs are considered as a symbol of prosperity, luck and growth. Rangoli patterns are a creative way to discover symmetry, reflection and tessellation.

Rangoli is a finite graph, which may or may not contain loops. Rangoli can be interpreted as a planar graph. Rangoli curves drawn with intersection

represents a planar graph in which majority of the vertices have even degree.

As rangoli is a 2D design drawn on a surface so they are planar. It shows symmetry and closed loops. A rangoli pattern drawn without lifting the finger satisfies the conditions of a Euler path. Such designs satisfy Eulerian path. While it comes to the coloring of rangolis we can use principles of graph coloring. Rangolis often satisfy the conditions of a Euler circuit. The existence of such a path depends on the number of vertices with an odd number of connections. with the finite dots and finite rules.

Normally in a rangoli all the points are connected, so it represents a connected graph. Euler formula  $V-F+F=2$  can be applied to closed loop rangoli patterns. Using Polya's enumeration theorem we can find the number of different rangolis under the action of a symmetric group. The reflection symmetry means the design is unchanged when mirrored about a line. In the case of symmetrical rangoli design only one part and copy the same using the symmetry operations.

Drawing rangoli is challenging because it involves the active use of both the left and right sides of the brain. In addition, the coarse powder must be run through the fingers.

Looking at the rangoli the question comes to one's mind is how many distinct rangolis can be drawn with the given number of dots? And how many possible paths can one take around this dot? This leads to the study of combinatorics. If we have to select the most beautiful rangoli drawn with minimum time, then it will be an optimization problem. We can bring in other variables such as color, cost to it.

## V. CONCLUSION

Rangoli is a combination of tradition and mathematics. The art form can be used to teach mathematical skills such as counting, measuring, symmetry and understanding arrays. They often feature Eulerian path and Eulerian circuit. Unaware of the mathematical concepts in the design, the women

in south India draw beautiful rangoli which obviously make them feel good also appreciated by the neighbors and passerby. But if one goes deep into the design then one can use it to teach some concepts of basic mathematics, symmetry and graph theory. Studying the concepts in this way increases the interest of the students in the subject of mathematics. This art also increases the concentration and help the students to coordinate with space, time to give out excellent output, here in this case it is rangoli. This combination of science and tradition reflects profound and deep mathematical knowledge.

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