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PRODUCT REQUIREMENTS DOCUMENT

Kolam Design Pattern Recognition and Recreation System

Smart India Hackathon 2025

PROBLEM STATEMENT ID
25107

ORGANIZATION
AICTE - Indian Knowledge Systems (IKS)

CATEGORY
Software

THEME
Heritage & Culture

1. PROJECT OVERVIEW

1.1 Project Vision

Develop an intelligent system that can analyze traditional Indian Kolam designs, identify their underlying mathematical and geometric principles, and recreate authentic patterns while preserving cultural heritage through technology.

1.2 Problem Statement

Kolams (known by other names as muggu, rangoli and rangavalli) are significant cultural traditions of India, blending art, ingenuity, and culture. The designs vary by region, and consist of grids of dots, with symmetry, repetition, and spatial reasoning embedded in them. The Kolam designs provide a fascinating area of study for their strong mathematical underpinnings.

The challenge is to develop computer programs (in any language, preferably Python) to identify the design principles behind the Kolam designs and recreate the kolams.

2. PROJECT OBJECTIVES

2.1 Primary Objectives

- Identify and classify different types of Kolam designs (muggu, rangoli, rangavalli) with high accuracy
- Extract and analyze mathematical principles embedded in traditional designs including symmetry patterns, geometric relationships, and spatial reasoning
- Recreate authentic Kolam patterns programmatically using identified design principles
- Preserve and digitize cultural heritage through systematic documentation and analysis
- Create an educational platform that bridges traditional art with modern technology

2.2 Secondary Objectives

- Develop an educational tool for learning about Indian mathematical traditions and cultural practices
- Enable cultural preservation and systematic documentation of regional design variations
- Provide pattern analysis capabilities for academic research in mathematics, art, and cultural studies
- Create an interactive design creation platform for artists and enthusiasts
- Facilitate cross-cultural understanding through accessible digital heritage preservation

3. TARGET USERS

3.1 Primary Users

Cultural Heritage Researchers and Scholars

Academics and researchers studying Indian cultural traditions, mathematical heritage, and traditional art forms who need systematic analysis and documentation tools.

Educational Institutions and Students

Schools, colleges, and universities teaching mathematics, art, cultural studies, and computer science who can use the platform for interdisciplinary learning.

Artists and Designers

Traditional and contemporary artists interested in understanding, preserving, and innovating upon traditional patterns and mathematical designs.

Cultural Preservation Organizations

Museums, cultural centers, and heritage preservation societies working to document and maintain traditional Indian art forms and practices.

3.2 Secondary Users

- Mathematics educators seeking real-world applications of geometric and symmetry concepts
- Art therapy practitioners incorporating traditional patterns into therapeutic practices
- Tourism and cultural promotion agencies showcasing Indian heritage
- General public interested in learning about and creating traditional Indian designs
- Mobile app users seeking creative and educational content

4. KEY FEATURES SPECIFICATION

4.1 Core Features

1. Pattern Recognition and Analysis Module

- Advanced image analysis of existing Kolam designs using computer vision
- Automatic classification by type (Kolam, Muggu, Rangoli, Rangavalli) and regional variations
- Mathematical pattern identification including symmetry detection, geometric analysis
- Grid structure recognition and dot pattern analysis
- Support for various image formats and quality levels

2. Intelligent Design Recreation Engine

- Algorithmic pattern generation based on identified mathematical principles
- Customizable parameters for size, complexity, style, and regional variations
- Real-time preview and interactive editing capabilities
- Traditional rule-based generation ensuring cultural authenticity
- Multiple output formats (SVG, PNG, PDF, step-by-step guides)

3. Mathematical Analysis and Visualization Tools

- Comprehensive symmetry detection and classification
- Geometric property extraction and mathematical relationship identification
- Pattern complexity metrics and statistical analysis
- 3D visualization and interactive geometric exploration
- Mathematical concept explanation and educational content

4. Cultural Documentation and Heritage System

- Comprehensive database of designs with cultural context and historical significance
- Regional variation mapping and comparison tools
- Traditional stories, meanings, and ceremonial usage documentation
- Multi-language support for cultural content (English, Hindi, Telugu, Tamil)
- Collaborative contribution system for cultural experts and practitioners

4.2 Advanced Features

5. Interactive Learning and Educational Module

- Step-by-step drawing tutorials with visual guidance
- Progressive difficulty levels from beginner to advanced patterns
- Mathematical concept explanations integrated with design learning
- Cultural storytelling and historical context integration
- Assessment and progress tracking for educational users

6. Advanced Visualization and Technology Integration

- Three-dimensional pattern representation and manipulation
- Virtual Reality (VR) and Augmented Reality (AR) compatibility
- Animation capabilities showing pattern construction process
- Interactive manipulation of geometric parameters in real-time
- Time-lapse creation showing traditional drawing techniques

7. Mobile Integration and Accessibility

- Native mobile applications for Android and iOS platforms
- Camera integration for real-time pattern analysis and recognition

- AR-based pattern overlay and projection capabilities
- Touch-based drawing interface optimized for mobile devices
- Social sharing capabilities and community features
- Offline functionality for basic features and downloaded content

5. SUCCESS CRITERIA AND METRICS

5.1 Technical Performance Metrics

Pattern Recognition Accuracy	**≥ 85% for diverse Kolam designs**
Design Recreation Similarity	**≥ 95% visual similarity to authentic patterns**
Processing Time	**≤ 5 seconds for pattern analysis**
System Response Time	**≤ 2 seconds for design generation**
Concurrent User Support	**≥ 100 simultaneous users**

5.2 Content and Cultural Metrics

Design Database Size	**≥ 500 authenticated traditional designs**
Regional Coverage	**≥ 10 different Indian regions represented**
Cultural Accuracy Validation	**Expert review and approval process**
Educational Content Completeness	**Mathematical and cultural context for 100% of patterns**

5.3 User Experience and Adoption Metrics

User Satisfaction Rating	**≥ 4.5/5.0 average rating**
User Retention Rate	**≥ 60% monthly active users**

Educational Institution Adoption	**≥ 25 schools/colleges using platform**
Mobile App Downloads	**≥ 10,000 downloads within 6 months**
Community Contributions	**≥ 100 user-contributed designs verified**

6. PROJECT CONSTRAINTS AND ASSUMPTIONS

6.1 Technical Constraints

- Primary development in Python programming language as specified
- Cross-platform compatibility requirement for web and mobile
- Open-source libraries preference for cost-effectiveness and transparency
- Cloud deployment capability for scalability and accessibility
- Real-time processing requirements for interactive features
- Mobile responsiveness and touch interface optimization

6.2 Cultural and Content Constraints

- Cultural authenticity must be maintained throughout the system
- Expert validation required for cultural content and design accuracy
- Respectful representation of traditional practices and beliefs
- Multi-language support for diverse user base
- Community involvement in content creation and validation

6.3 Project Assumptions

- Availability of sufficient high-quality Kolam design images for training
- Access to cultural experts and traditional practitioners for validation
- User access to modern browsers and mobile devices
- Stable internet connectivity for cloud-based features
- Educational institutions' willingness to integrate digital cultural tools
- Community interest in preserving and learning traditional art forms

7. RISK ASSESSMENT

7.1 High-Risk Items

- **Cultural Misrepresentation:** Risk of inaccurate interpretation or inappropriate use of cultural elements
- **Technical Complexity:** Advanced computer vision and pattern recognition challenges
- **Data Quality:** Insufficient or poor-quality training data for machine learning models
- **Expert Availability:** Limited access to cultural experts for content validation

7.2 Medium-Risk Items

- **Performance Scalability:** System performance under high user load
- **User Adoption:** Acceptance by traditional art practitioners and educational institutions
- **Content Licensing:** Rights and permissions for traditional design usage
- **Technology Changes:** Rapid evolution of underlying technologies and platforms

7.3 Mitigation Strategies

- Early engagement with cultural experts and community representatives
- Incremental development with regular cultural validation checkpoints
- Comprehensive testing with diverse datasets and user groups
- Flexible architecture allowing for technology updates and improvements
- Strong community engagement and feedback incorporation mechanisms

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This document serves as the official Product Requirements Document for the Kolam Design Pattern Recognition and Recreation System