



# To Design an Automated Embroidery Design Search and Generation System

Gulnaj Sayyad<sup>1</sup>, Abhishek Mahajan<sup>2</sup>, Akanksha Lokhande<sup>3</sup>, Tejas Pawar<sup>4</sup>, Vijay Sonavale<sup>5</sup>

<sup>1</sup>Professor, SRCOE, Department of Computer Engineering, Pune, Maharashtra, India.

<sup>2,3,4,5</sup>Student, SRCOE, Department of Computer Engineering, Pune, Maharashtra, India.

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**Abstract:** Managing and retrieving embroidery patterns from large textile datasets is a challenging task in the textile and fashion industry. Traditional embroidery design searching methods are manual, time-consuming, and inefficient for handling large collections of patterns. To address these challenges, this paper presents the design and implementation of an AI-based Embroidery Design Matcher Using Deep Learning system for intelligent embroidery pattern retrieval using image-based, text-based, and hybrid search methods. The proposed system utilizes the CLIP model for generating semantic image and text embeddings and employs FAISS (Facebook AI Similarity Search) for fast and efficient similarity matching in high-dimensional vector spaces. Additionally, OpenCV-based color and texture feature extraction techniques are integrated to improve retrieval accuracy through hybrid similarity scoring. The system also incorporates a Stable Diffusion-based Generative AI module for creating new embroidery patterns from text prompts. The implementation provides a secure and user-friendly web application with efficient data management and scalable retrieval performance. Experimental results demonstrate that the proposed system improves embroidery pattern search accuracy, reduces retrieval time, and provides an effective solution for textile and fashion industry applications.

**Key Words:** Embroidery Design Matching, Deep Learning, CLIP Model, FAISS, Computer Vision, Image Retrieval, Generative AI.

## I. INTRODUCTION

The management and retrieval of embroidery patterns have become an important challenge in the textile and fashion industry due to the rapid growth of digital embroidery datasets. Traditional embroidery design searching methods mainly rely on manual browsing and keyword-based techniques, which are time-consuming, inefficient, and unable to accurately identify visually similar patterns. As the number of embroidery designs increases, these conventional methods struggle to handle large-scale datasets efficiently, resulting in poor search accuracy and reduced productivity. With the advancement of Artificial Intelligence, Deep Learning, and Computer Vision technologies, there is now an opportunity to develop intelligent systems capable of automating embroidery pattern retrieval and improving overall search efficiency.

Recent studies show that Deep Learning-based image retrieval systems provide highly effective solutions for large-scale visual data management. Technologies such as multimodal embedding models, vector similarity search, and feature extraction techniques have demonstrated significant improvements in image understanding and semantic matching. In particular, models like CLIP (Contrastive Language-Image Pretraining) enable efficient image and text understanding by converting visual and textual information into high-dimensional vector embeddings. Similarly, FAISS (Facebook AI Similarity Search) has emerged as a powerful framework for performing fast and scalable Approximate Nearest Neighbor (ANN) search on large embedding datasets. These technologies have shown promising results in applications such as image retrieval, recommendation systems, and multimedia search.

Traditional embroidery pattern retrieval systems mainly depend on manual categorization or simple image comparison techniques. However, such approaches often fail to capture detailed texture, color, and semantic relationships between embroidery designs. They are prone to inaccurate results, slow retrieval speed, and poor scalability when managing large textile datasets. Additionally, many existing systems focus only on image-based search and do not support intelligent text-based or hybrid retrieval methods. To overcome these limitations, modern Deep Learning and Computer Vision techniques provide scalable and accurate solutions for efficient embroidery pattern matching.

In this work, we present an AI-based Embroidery Design Matcher Using Deep Learning system that combines image retrieval, text understanding, and Generative AI technologies for intelligent embroidery pattern management. The proposed system integrates the CLIP model for semantic embedding generation, FAISS for fast similarity search, and OpenCV-based feature extraction techniques for improved matching accuracy. Additionally, the system incorporates Stable Diffusion for AI-generated embroidery pattern creation from textual prompts. The proposed framework aims to improve embroidery design retrieval accuracy, reduce search time, and provide an efficient and scalable solution for textile industries, fashion designers, and embroidery recommendation systems.

## II. PROBLEM STATEMENT

To Design Embroidery Design Matcher Using Deep Learning.

## III. OBJECTIVES

- To develop an AI-based system for accurate embroidery design matching using deep learning techniques.
- To extract meaningful visual features from embroidery images using a CNN-based model.
- To implement efficient similarity search using feature embeddings for fast retrieval of similar designs.
- To build a user-friendly interface for uploading images and displaying matched results.
- To improve search accuracy compared to traditional keyword-based methods.
- To handle large-scale embroidery datasets efficiently using optimized indexing techniques.

## IV. LITERATURE REVIEW

Wang, J. et.al. in the paper “Enhancing and Accelerating Image-Text Retrieval with Knowledge Graphs and FAISS” (2024), proposed an advanced image-text retrieval framework that combines Knowledge Graphs with FAISS indexing to improve semantic understanding and retrieval efficiency. The authors highlighted that traditional CLIP-based retrieval systems often struggle with semantic gaps between images and text. To overcome this issue, the proposed system integrates Graph Convolutional Networks (GCNs) with CLIP embeddings and uses FAISS for high-speed similarity search. Experimental results showed significant improvement in retrieval accuracy and reduced query processing time, making the framework suitable for large-scale multimedia retrieval systems. [1]

Liu, L. et.al. in the paper “The Application of Style Transfer Algorithms in the Innovative Design of Miao Ethnic Embroidery Patterns” (2024), explored the use of artificial intelligence and style transfer algorithms for preserving and modernizing traditional embroidery designs. The authors used convolutional neural networks, particularly the VGG-19 model, to transfer artistic styles between embroidery patterns while preserving structural details. The study demonstrated that AI-based style transfer techniques can effectively support cultural preservation and creative textile design innovation by generating visually enhanced embroidery patterns. [2]

Sha, S. et.al. in the paper “Image Classification and Restoration of Ancient Textiles Based on Convolutional Neural Network” (2024), proposed a deep learning framework for classifying and restoring ancient textile images. The authors combined the YOLOv4-ViT network for textile pattern classification with an improved GAN-based restoration model for damaged textile reconstruction. The system achieved high classification accuracy and improved restoration quality, demonstrating the effectiveness of deep learning techniques in textile image analysis, restoration, and retrieval applications. [3]

Danner, M. et.al. in the paper “AI-assisted Pattern Generator for Garment Design” (2024), presented an AI-driven framework for automated garment pattern generation using 3D body scanning and neural network models. The proposed system integrated CAD tools, AI models, and pattern reconstruction techniques to generate accurate 2D garment patterns from 3D body data. Experimental evaluation showed that AI-generated patterns closely matched manually created designs, reducing manual effort and improving efficiency in fashion and garment industries. [4]

Wu, Y. et.al. in the paper “Research on Embroidery Image Recognition Based on Deep Learning” (2023), investigated the application of deep learning techniques for embroidery image recognition. The author proposed a Faster R-CNN-based recognition framework using ResNet50 and VGG16 models for extracting robust embroidery features. Experimental results demonstrated that the ResNet50-based model achieved higher recognition accuracy and reduced misclassification compared to traditional image-processing methods. The study concluded that deep learning significantly improves embroidery pattern recognition and supports intelligent automation in textile industries. [5]

## V. SOFTWARE/HARDWARE REQUIREMENTS

### For End-Users (Designers / Textile Professionals / Students):

The system requires a desktop, laptop, or mobile device running on Windows, Linux, macOS, or Android, with a minimum of 4 GB RAM (8 GB recommended), a modern web browser such as Google Chrome, Mozilla Firefox, or Microsoft Edge, and a stable internet connection for accessing the embroidery design matching web application, uploading embroidery images, performing similarity searches, and viewing AI-generated embroidery patterns.

### For Admin / Developer:

The system requires Windows 10 or higher, Linux, or macOS operating systems with an Intel Core i5 or higher processor, 8 GB to 16 GB RAM, and at least 256 GB SSD storage for handling deep learning models and embroidery datasets efficiently. Development tools such as Visual Studio Code, Python, FastAPI, MongoDB, PyTorch, OpenCV, FAISS, and Transformers are required for backend development, embedding extraction, similarity search, and AI model integration.

### For Server / Deployment Environment:

The system can be deployed on cloud platforms such as AWS, Google Cloud, Render, or DigitalOcean, or on a local server environment. It requires Python runtime support, FastAPI server configuration, REST API support, GPU support (optional for faster AI processing), and stable internet connectivity for handling image uploads, embedding generation, similarity matching, and AI-based embroidery design generation.

**For Database Storage:**

The system requires a NoSQL database such as MongoDB for storing user information, embroidery images, embeddings, search history, generated designs, and system logs. Storage requirements may vary depending on the embroidery dataset size, with a minimum of 500 MB or more recommended for efficient and scalable operation.

**VI.SYSTEM ARCHITECTURE**

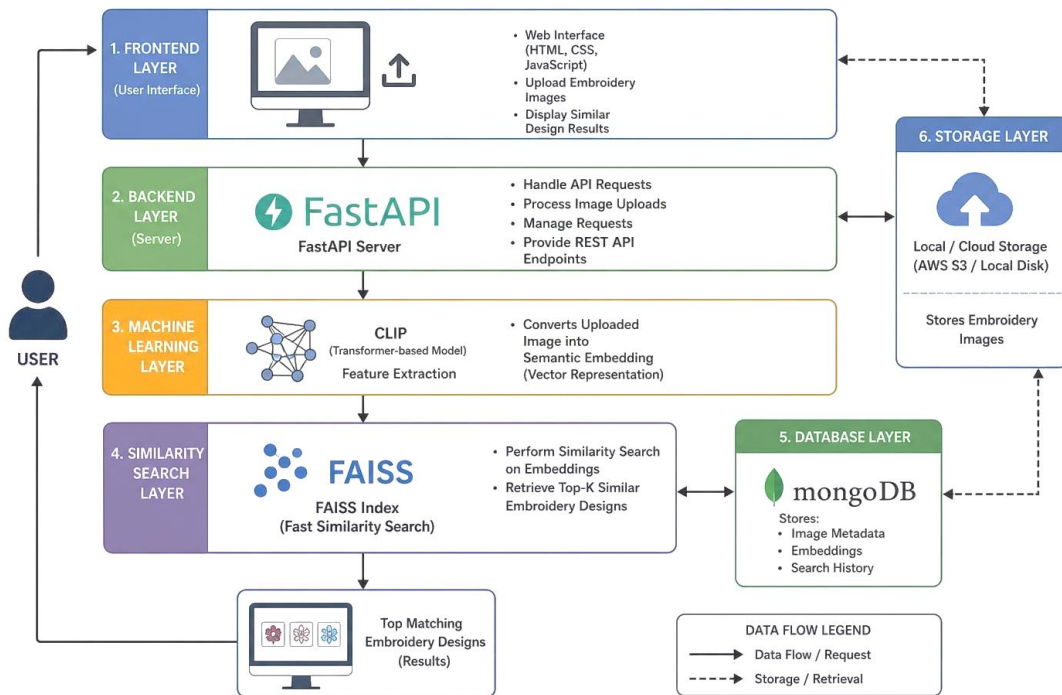


Fig 1: - System Architecture Diagram for Embroidery Design Matcher

The architecture of the Embroidery Design Matcher Using Deep Learning system is designed using a modular and scalable approach consisting of five major components: User Module, Backend Processing Module, AI/ML Model Module, Database Module, and Storage Module. The User Module provides a simple and interactive web interface for designers, textile professionals, and students to securely log in, upload embroidery images, perform similarity searches, and view ranked matching results along with previous search history. The frontend communicates with the backend through REST API calls for efficient request handling. The Backend Processing Module, developed using FastAPI, acts as the central controller that manages image uploads, search requests, image preprocessing, feature extraction coordination, FAISS-based similarity search, and result delivery. The AI/ML Model Module serves as the core intelligence of the system, where the CLIP transformer-based model extracts semantic and visual embeddings from embroidery images and converts them into high-dimensional feature vectors for similarity comparison and ranking. The Database Module uses MongoDB to store user information, embroidery design metadata, search history, and reference indexing data for scalable and efficient data management. Additionally, the Storage Module securely stores uploaded embroidery images, processed images, dataset files, and generated designs for quick retrieval during matching operations. The integration of CLIP and FAISS enables fast and accurate similarity search even for large embroidery datasets, while the modular architecture ensures scalability, efficient resource utilization, secure data handling, and a user-friendly experience for both technical and non-technical users.

**Data Flow Diagram**

The Data Flow Diagram (DFD) of the Embroidery Design Matcher Using Deep Learning system illustrates the overall flow of data between the user, processing modules, and storage components. The process begins when the User (Designer/Customer) uploads an embroidery image through the web interface. The uploaded image is then passed to the Image Upload module, where it is validated and stored in the Image Database. After successful upload, the image is sent to the Image Preprocessing module, which performs operations such as resizing, normalization, and cleaning to prepare the image for analysis. The processed image is forwarded to the Feature Extraction module, where the CLIP deep learning model extracts semantic and visual features and converts them into high-dimensional embeddings. These embeddings are stored in the Embedding Database and simultaneously sent to the Similarity Matching (FAISS Engine) module, which compares the query embeddings with stored embeddings to identify visually similar embroidery patterns. The matching results are ranked based on similarity scores and passed to the Result Display module, where the top matching embroidery designs are presented to the user in a structured and user-friendly format. Finally, the search results and related query information are stored in the Search History Database for future reference and analysis. The diagram represents a clean and efficient workflow that enables fast, scalable, and accurate embroidery pattern retrieval using Deep Learning and vector similarity search techniques.

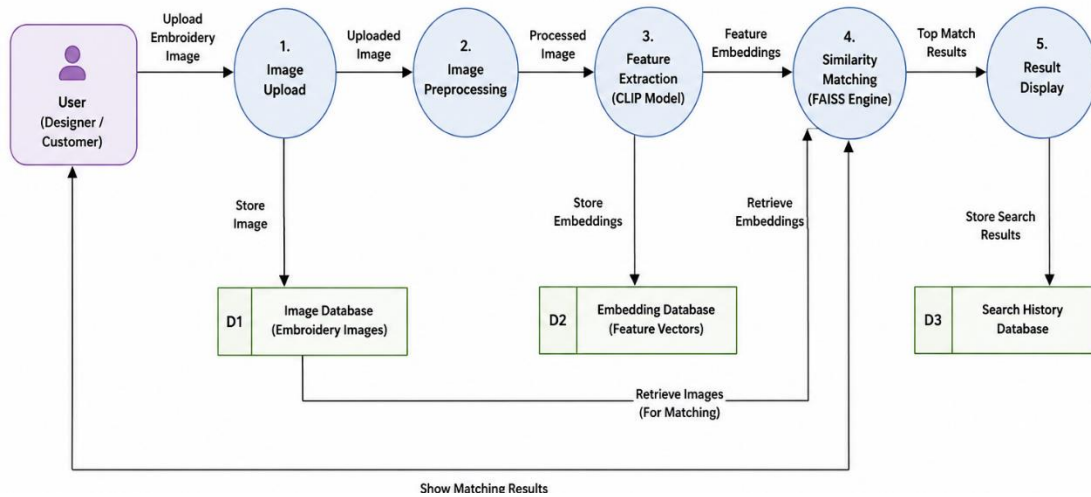


Fig 2: - Data Flow Diagram of Embroidery Design Matcher

### VII. ENTITY RELATIONSHIP DIAGRAM

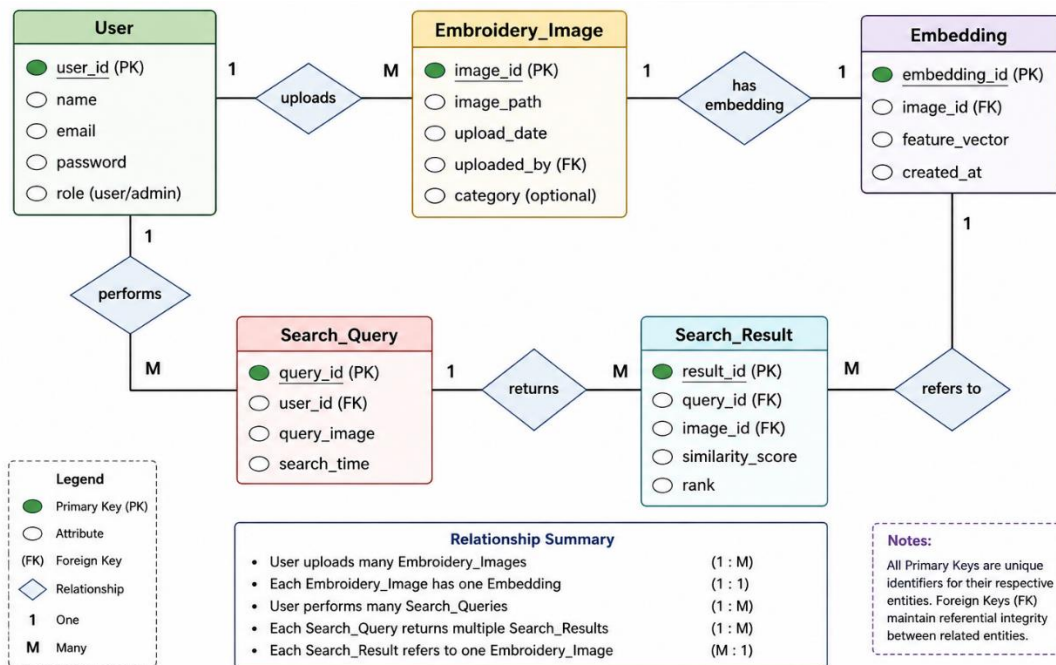


Fig 3: - Entity Relationship Diagram of Embroidery Design Matcher

The Entity Relationship Diagram represents the database structure of the Department Management System. It shows the main entities such as Users (Admin, Faculty, Students), Attendance, Notices, and Reports, along with their attributes and relationships. The diagram explains how different data elements are connected and stored in the system. For example, users are linked with attendance records, and faculty can manage notices and student data. This structure ensures proper organization of data and maintains data integrity. It also helps in efficient data retrieval, updates, and management within the system.

### VIII. USE CASE DIAGRAM

The ER Diagram of the Embroidery Design Matcher Using Deep Learning system represents the relationship between the main entities involved in embroidery pattern retrieval and management. The USER entity stores information about designers, customers, and administrators who interact with the system and perform search operations or upload embroidery images. The EMBROIDERY\_IMAGE entity stores embroidery design images and related metadata, while the EMBEDDING entity stores the numerical feature vectors generated from images using deep learning models. The SEARCH\_QUERY entity maintains records of user search requests, and the SEARCH\_RESULT entity stores the matched embroidery designs along with similarity scores and rankings. These entities are interconnected to support efficient image storage, embedding management, similarity search, and retrieval operations within the system.

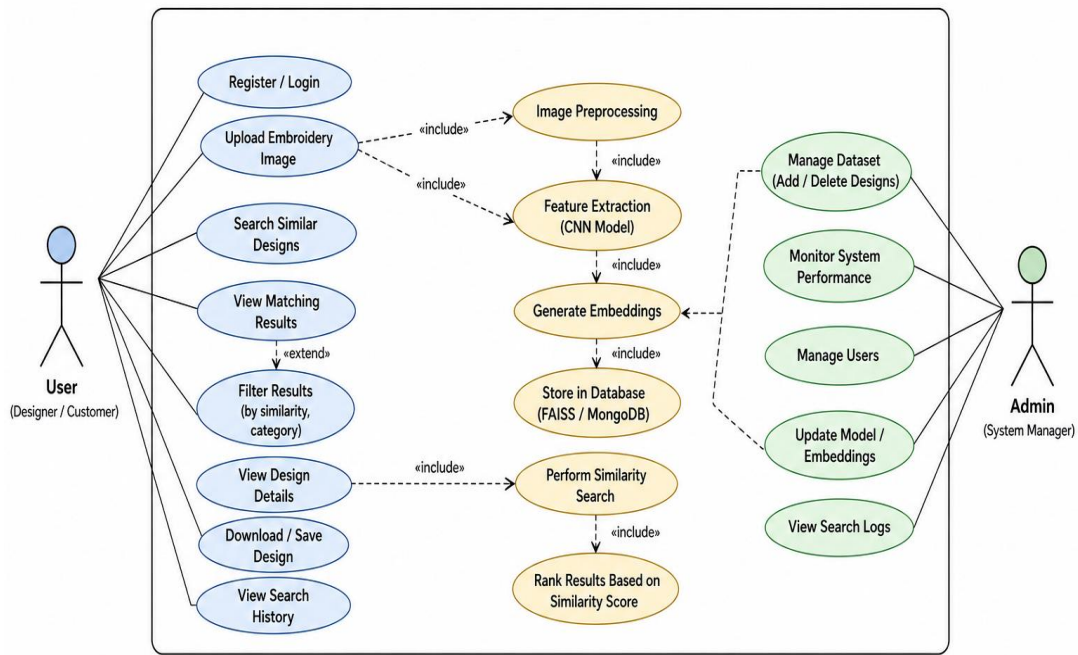


Fig 4: - Use Case Diagram of the System

### IX. RESULTS

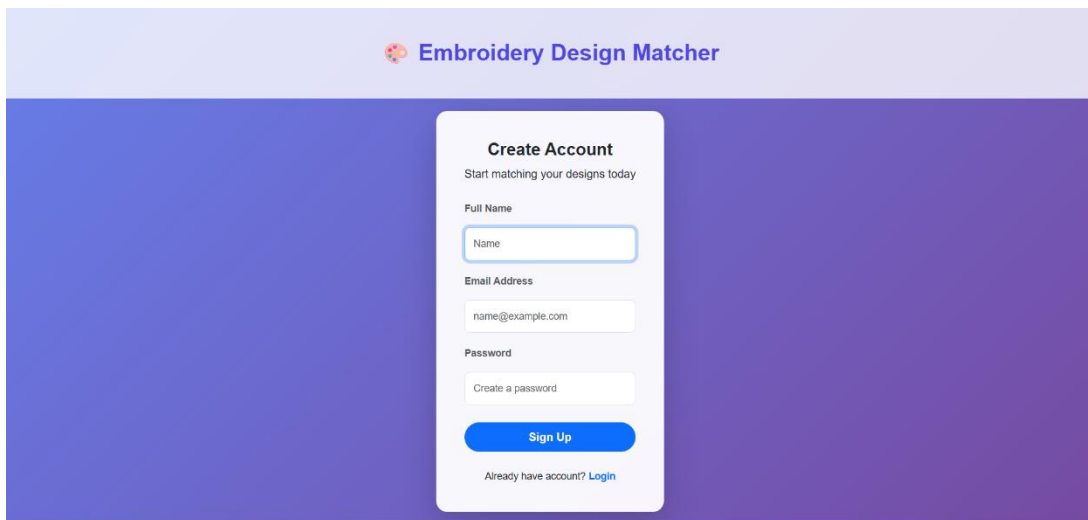


Fig 5: - Sign Up Page of the System

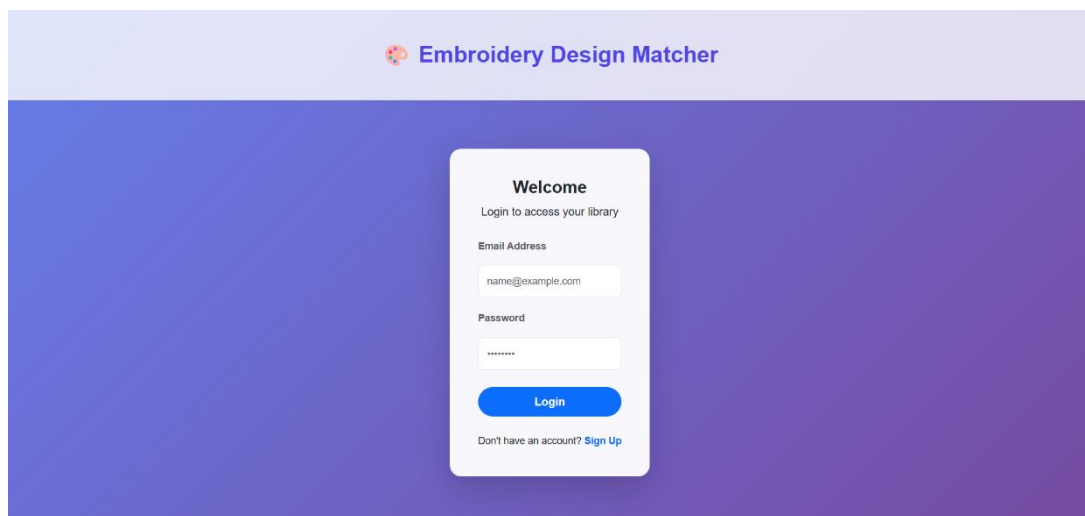


Fig 6: - Login Page of the System

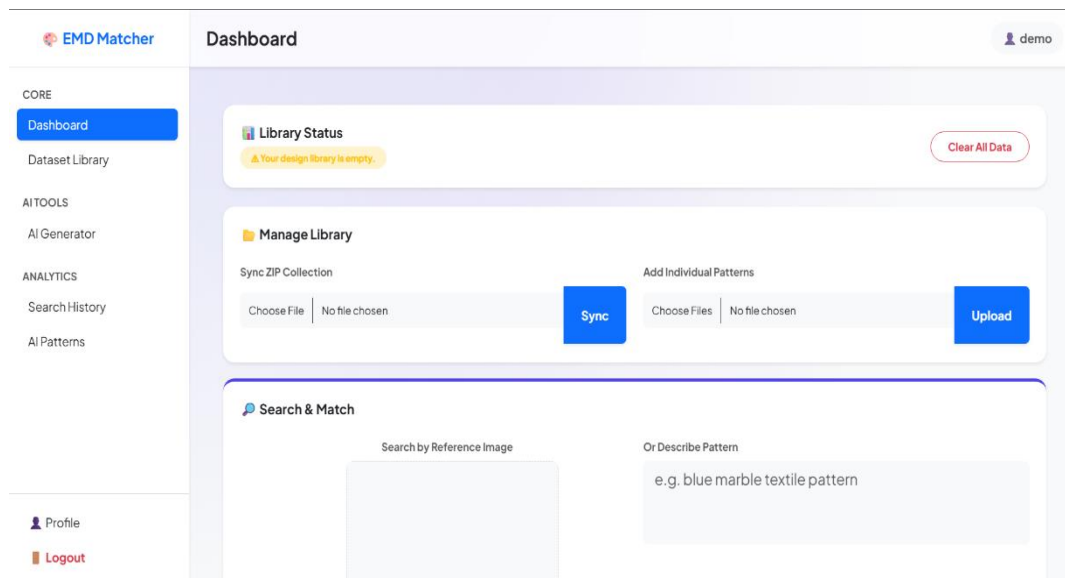


Fig 7: - Embroidery Design Matcher Dashboard

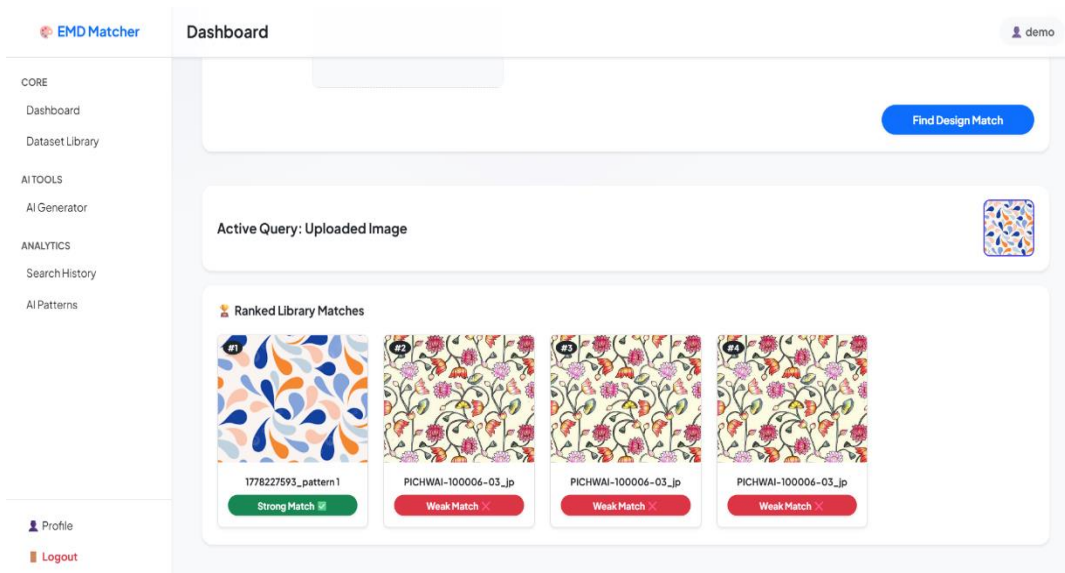


Fig 8: - Search by Image in Dataset

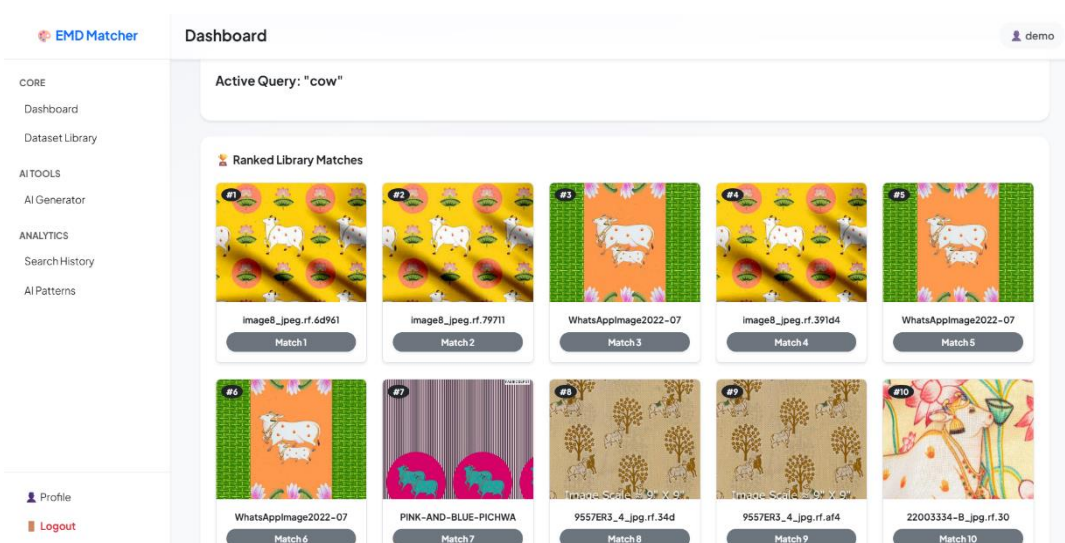


Fig 9: - Search by text in Dataset

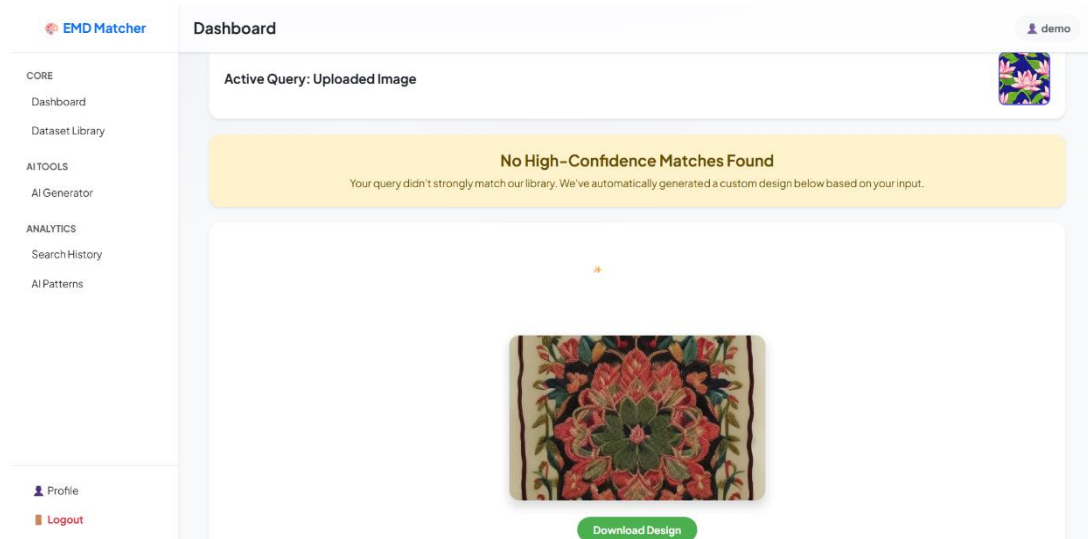


Fig 10: - Auto generate pattern if not found in dataset

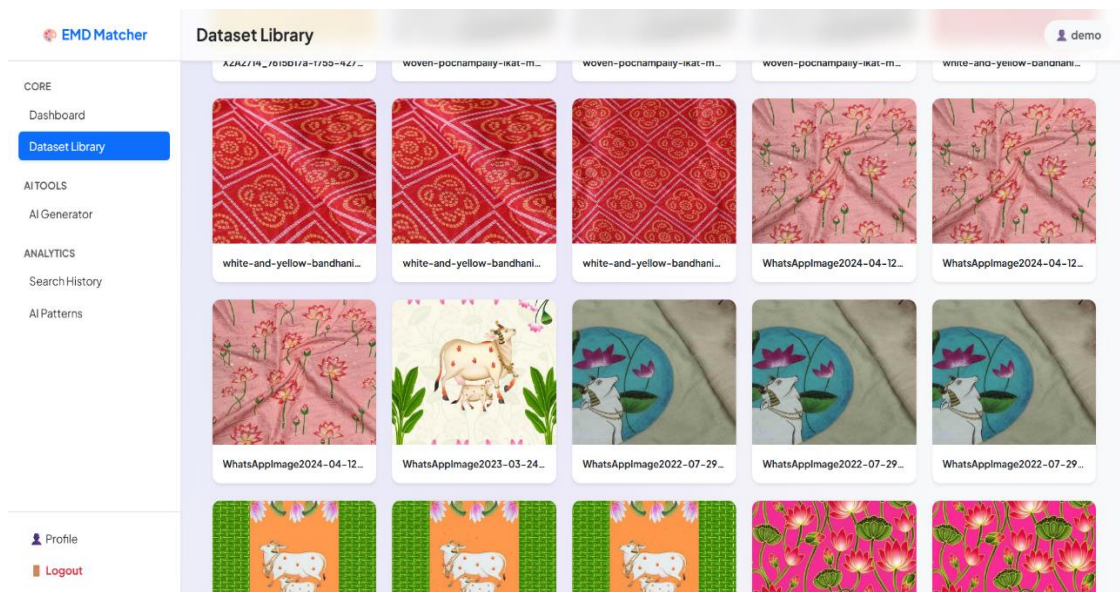


Fig 11: - Dataset Library

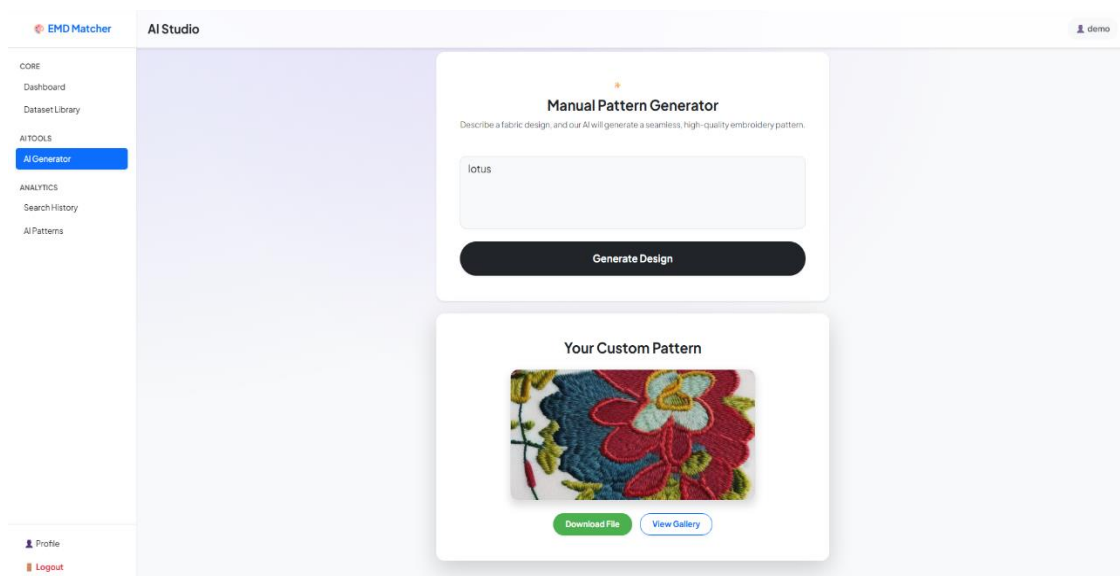


Fig 12: - AI Pattern Generation with text

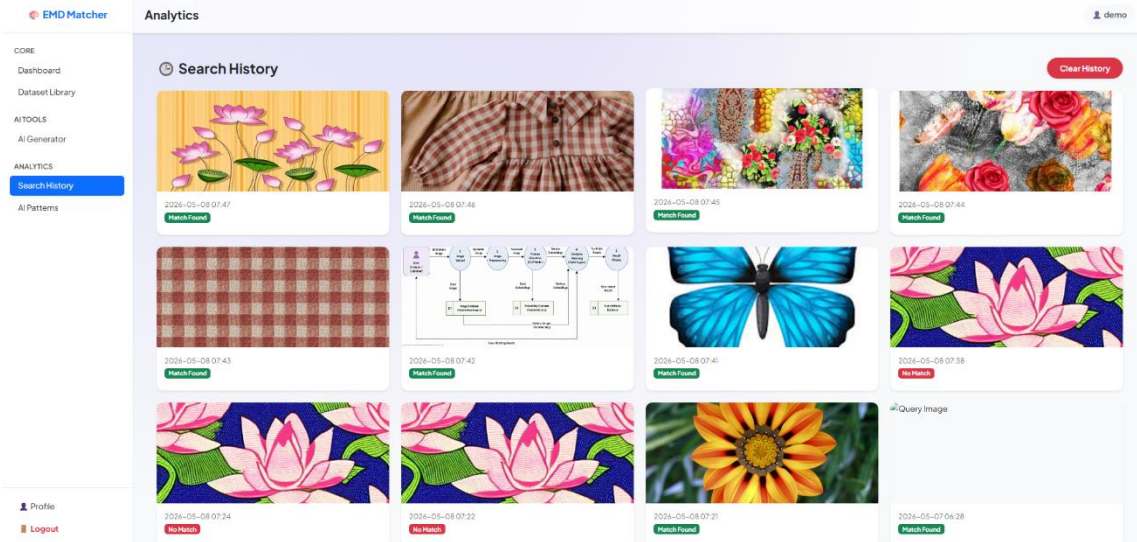


Fig 13: - Search History of User

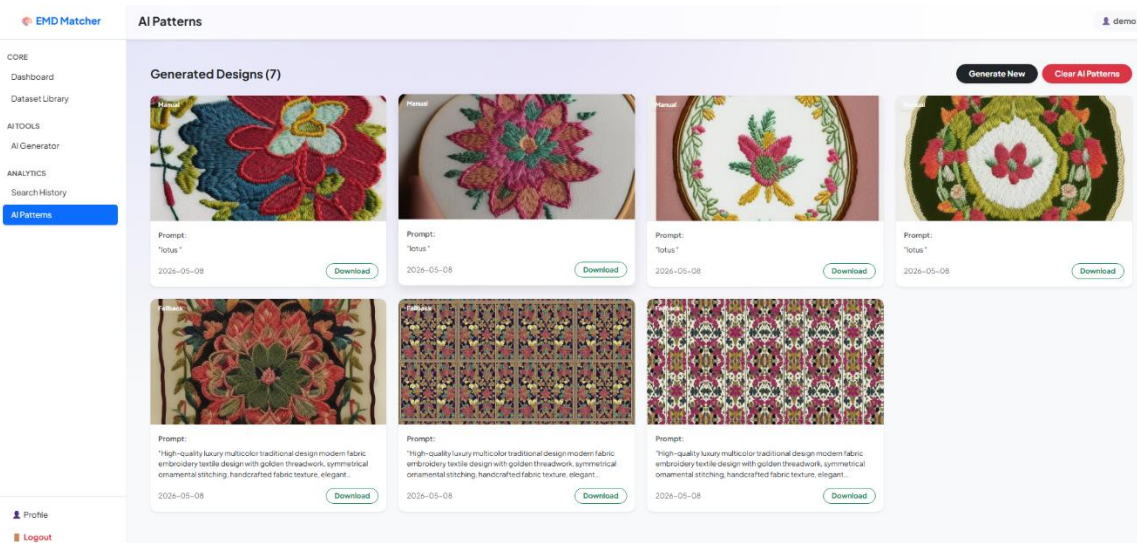


Fig 14: - Total AI patterns generated by user

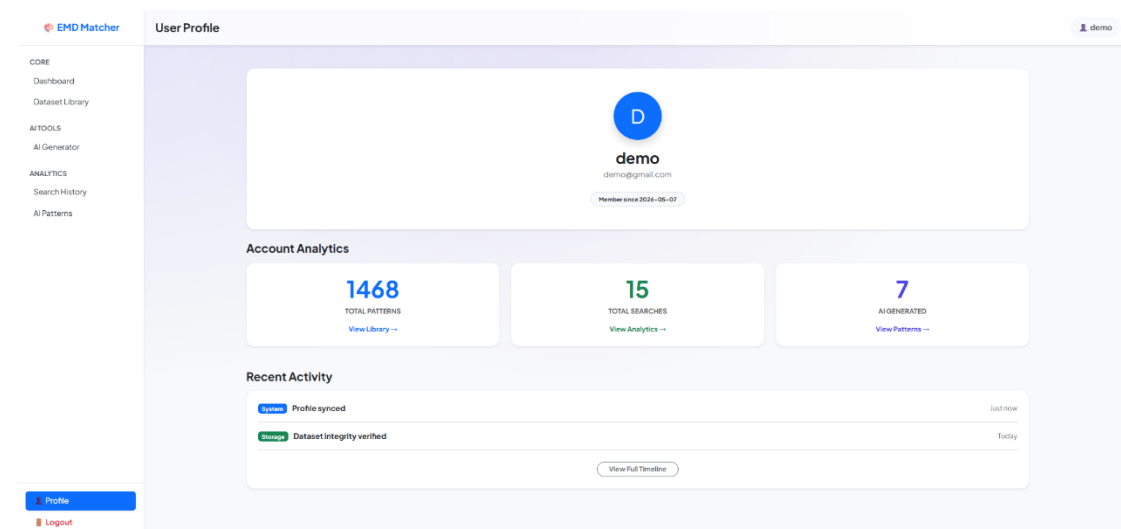


Fig 15: - User Profile

**X. ADVANTAGES**

- Real-Time Search and Results: Provides instant embroidery pattern retrieval for image and text queries.
- High Accuracy Using Deep Learning: Uses CLIP embeddings to improve semantic understanding and matching accuracy.
- Efficient Similarity Search: Uses FAISS for fast and scalable similarity matching on large datasets.

- AI-Based Design Generation: Generates new embroidery patterns automatically using Stable Diffusion.
- User-Friendly Interface: Offers a simple and intuitive interface for easy image upload and result viewing.

### XI. DISADVANTAGES

- High Computational Requirements: Requires powerful hardware and GPU resources for deep learning processing.
- Dependency on Internet Connectivity: Needs stable internet access for smooth search and AI generation operations.
- Limited Accuracy in Complex Patterns: May struggle to distinguish highly similar or detailed embroidery designs.
- Storage Requirements for Large Datasets: Requires significant storage space for images and embeddings.
- Dependence on Pre-trained Models: Pre-trained models may not fully capture domain-specific embroidery features.

### XII. APPLICATIONS

- Textile Industry: Used for fast retrieval and management of embroidery design collections.
- Fashion Design: Helps designers quickly find similar embroidery patterns and generate new creative designs.
- Embroidery Manufacturing: Supports efficient pattern comparison and reduces manual design searching effort.
- E-commerce Platforms: Enables visual search for embroidery-based products using image similarity matching.
- Textile Research and Education: Assists students and researchers in analyzing embroidery patterns and textile designs.

### XIII. LIMITATIONS

- High Computational Cost: Deep learning models require powerful hardware and GPU resources for efficient processing.
- Internet Dependency: The system requires a stable internet connection for image upload and search operations.
- Complex Pattern Recognition Issues: Highly detailed or visually similar embroidery patterns may reduce matching accuracy.
- Large Storage Requirement: Managing large embroidery datasets and embeddings requires significant storage space.
- Dependence on Pre-trained Models: Pre-trained AI models may not fully capture domain-specific embroidery features.

### XIV. CONCLUSION

The Embroidery Design Matcher Using Deep Learning system successfully implements an intelligent and automated solution for identifying and retrieving similar embroidery patterns using image-based and text-based search techniques. By integrating advanced technologies such as deep learning-based embeddings, CLIP feature extraction, FAISS similarity search, and OpenCV-based image analysis, the system significantly improves the accuracy, speed, and efficiency of embroidery pattern matching compared to traditional manual methods. The proposed framework enables users to upload embroidery images or text queries and instantly receive visually and semantically similar designs from large datasets, reducing manual effort and improving productivity for designers and textile industries. Additionally, the integration of Stable Diffusion-based AI design generation enhances creativity by generating new embroidery patterns when suitable matches are unavailable. The modular and scalable architecture of the system ensures efficient data management, fast retrieval performance, and easy integration of future enhancements. Overall, the project demonstrates the effective application of Artificial Intelligence, Deep Learning, and Computer Vision in modernizing embroidery design workflows and transforming traditional textile processes into efficient digital solutions.

### XV. FUTURE SCOPES

The Embroidery Design Matcher Using Deep Learning system can be further enhanced by integrating advanced deep learning models such as fine-tuned CNNs and Vision Transformers to improve matching accuracy for complex embroidery patterns. The system can also be extended into a mobile application with real-time image capture functionality, allowing users to search embroidery designs directly through smartphone cameras. Future improvements may include multi-modal search capabilities combining image and text-based queries for more flexible and intelligent retrieval. Cloud-based deployment can be implemented to provide better scalability, faster processing, and efficient management of large embroidery datasets. Additional features such as duplicate design detection, copyright protection, and ownership tracking can help protect original embroidery work from misuse. An AI-based recommendation system can also be integrated to suggest similar or trending designs based on user preferences and search history. Furthermore, automatic category and style classification of embroidery patterns into groups such as floral, traditional, modern, or abstract can improve dataset organization and simplify the search process for designers and textile industries.

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