Integration of Artificial Intelligence Models into a Flask-Based Web Application for Classification and Generation of Batik Cual Motifs from Bangka Belitung

Syifa Nandini Girfita[1], Muhammad Ressi Rabsanjani[2], Zikri Wahyuzi[3], Rike Pradila[4]
[1234] Department of Computer Science, Universitas Muhammadiyah Bangka Belitung, Indonesia

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Corresponding Author:

Syifa Nandini Girfita,
Department of Computer Science,
Universitas Muhammadiyah
Bangka Belitung,
Jl KH Ahmad Dahlan KM 4,
Kelurahan Keramat, Rangkui,
Pangkalpinang, Kepulauan
Bangka Belitung 33134,
Indonesia
Email:
syifanandinigirfita@gmail.com

ABSTRACT

Artificial Intelligence (AI) is increasingly used for digital preservation and creative exploration of cultural heritage, yet many studies focus more on model development than on real-world system integration. This study presents the implementation of AI models within a Flask-based web application for Batik Cual motif classification and generation. The system enables users to access AI features through a browser interface, supporting automatic motif classification from uploaded images and motif generation based on textual input and reference motifs. A RESTful backend architecture manages request handling, preprocessing, AI inference, postprocessing, database storage, and result visualization. Evaluation results show that the YOLOv11 classification model achieved a mean Precision of 0.9009, mean Recall of 0.9716, mAP50 of 0.9463, and mAP50–95 of 0.8172, indicating reliable recognition performance. The generative module using StyleGAN2-Ada trained up to 1,000 kimg can produce visually consistent Batik Cual motifs, further enhanced by a Diffusion Model for improved texture realism. Functional testing indicates response times of 1–2 seconds for classification and approximately one minute for motif generation. These results demonstrate that Flask is an effective framework for deploying AI-driven web applications, particularly for prototype-scale systems supporting digital preservation and creative dissemination of cultural motifs.

Keywords: Artificial Intelligence, Flask, Web Application, Batik Cual, Model Integration

1. INTRODUCTION

Batik is an Indonesian intangible cultural heritage recognized by UNESCO as part of the Representative List of the Intangible Cultural Heritage of Humanity since 2009. Each region in Indonesia possesses distinctive batik motifs that reflect local values, philosophies, and cultural identities (Afifah & Lusiana, 2025). One of these regional traditions is Batik Cual from the Bangka Belitung Islands Province, characterized by motifs inspired by flora, fauna, geometric forms, and celestial objects such as stars (Harikiswanto, 2022). Beyond its aesthetic value, Batik Cual represents a cultural identity that must be continuously preserved and transmitted across generations.

However, the documentation and preservation of Batik Cual motifs are still largely conducted through manual approaches, including physical archives and limited digital records. Such practices restrict accessibility, hinder systematic classification, and increase the risk of cultural value loss due to material degradation or inadequate documentation (Putra et al., 2023). Consequently, the sustainability of Batik Cual preservation increasingly depends on the adoption of digital approaches capable of improving accessibility, organization, and long-term safeguarding of cultural assets. Digital transformation is therefore essential to ensure sustainable preservation and broader dissemination of Batik Cual motifs (Purnawibawa et al., 2021).

In response to these challenges, Artificial Intelligence (AI) has emerged as a promising technological approach for cultural heritage preservation (Legya Frannita et al., 2023). AI has been widely applied in cultural heritage studies to support pattern recognition, classification, and content generation tasks (Sinaga et al., 2024). Through AI-based methods, motif classification, documentation, and generation can be performed more efficiently and consistently.

Specifically in batik studies, AI techniques enable automated motif classification and the creation of new design variations inspired by traditional patterns (Dani & Handayani, 2024).

Deep learning methods have shown strong capability in recognizing complex visual patterns. Convolutional Neural Networks (CNN) have demonstrated effectiveness in batik pattern classification, achieving accuracies ranging from 75% to 99% across various motif types (Meranggi et al., 2022; Sinaga et al., 2024). Moreover, AI-based image processing techniques can identify distinctive visual characteristics while producing creative outputs that remain culturally relevant (Wang & Chen, 2025). These findings indicate that AI not only supports analytical recognition tasks but also contributes to cultural preservation and innovation.

As an advancement over conventional CNN approaches, the You Only Look Once (YOLO) architecture offers faster and more efficient detection and classification. The latest version, YOLOv11, introduces improved backbone structures and modules such as C3K2, SPPF, and C2PSA, enhancing feature extraction and overall model performance (L. He et al., 2025). These improvements make YOLOv11 suitable for real-time and high-accuracy classification tasks. Therefore, this research employs YOLOv11 as the primary model for automatically recognizing Batik Cual motifs, offering superior speed and accuracy compared to traditional CNN-based approaches.

Beyond classification, AI also plays a vital role in creative motif generation. Generative models such as StyleGAN2-ADA and Diffusion Models can produce high-quality synthetic images with realistic textures and structural consistency. StyleGAN2-ADA enables the separation of style and structural features, resulting in highly realistic batik patterns (Z. He et al., 2025), while Diffusion Models enhance training stability and texture sharpness (Octadion et al., 2025). Other generative approaches, including DCGAN and SP-BatikGAN, have also proven effective in generating diverse batik motif variations (Chrystian & Wahyono, 2023; Widodo et al., 2023). These capabilities position generative AI as a solution not only for digital archiving but also for creative innovation inspired by traditional Batik Cual patterns. To make these AI capabilities accessible, integration into web-based applications becomes crucial. AI models for classification and generation can be accessed through standard web browsers, allowing users from diverse backgrounds to interact with cultural content without requiring specialized software. Web platforms therefore provide an effective medium for deploying AI solutions that support cultural digitalization initiatives (Duvvur, 2024).

Despite rapid advancements in AI models, many existing studies primarily emphasize model accuracy and algorithmic performance (MAJJATE et al., 2025). Limited attention has been given to the practical integration of AI models into real-world systems, particularly web-based applications. Challenges such as model deployment, request handling, system scalability, and response time significantly influence usability and user adoption but are often overlooked (Kothapalli, 2024). In practice, AI models can only be effectively utilized when embedded in applications that reliably manage data input, inference processes, and output visualization (Campos Zabala, 2023). This indicates a research gap between AI model development and practical deployment.

To address these integration challenges, Flask has emerged as a lightweight Python-based web framework widely used for developing web applications and RESTful APIs (Patkar et al., 2022). Its microframework design provides essential components while allowing flexible integration of additional libraries, making it suitable for AI-driven applications requiring modularity and customization (Dani, 2022). Flask's compatibility with the Python ecosystem ensures seamless integration with AI libraries such as TensorFlow and PyTorch for model inference and deployment (Khandare et al., 2023).

Flask also supports modular architectures with a clear separation of concerns, enabling applications to be structured into routing, business logic, and AI inference modules (Zanevych, 2024). This modularity enhances maintainability and scalability, allowing AI models to be updated or replaced independently (Mishra, 2024). Furthermore, Flask efficiently handles HTTP request–response processes, enabling real-time AI inference services via RESTful APIs (Perih, 2025). Its lightweight nature results in lower computational overhead, making it suitable for research prototypes and small-to-medium-scale deployments (R et al., 2023). Flask's simplicity also shortens development cycles and supports rapid prototyping, which is advantageous in applied research contexts (Walingkas & Saian, 2023). Consequently, Flask has been widely adopted as a practical framework for integrating AI models into accessible web-based systems (Chen, 2023).

Based on these considerations, this study presents the integration of AI models into a Flask-based web application for the classification and generation of Batik Cual motifs. The main contribution lies in describing the system architecture, AI integration workflow, and functional testing of the developed application. Rather than focusing on model development, this research emphasizes the engineering aspects of deploying AI models in a web environment. By bridging the gap between AI capability and practical implementation, the proposed system demonstrates how AI can be effectively operationalized to support the digital preservation and dissemination of Batik Cual cultural heritage from Bangka Belitung.

2. RESEARCH METHOD

This research consists of several stages in developing an integrated deep learning-based system for the classification and generation of Batik Cual motifs. The process begins with dataset collection, followed by data preprocessing, model training, performance evaluation, and finally integration into a web-based system. Each stage is carefully designed to ensure the accuracy, stability, and reliability of the models before full implementation. The overall workflow of the proposed system is illustrated in Figure 1.

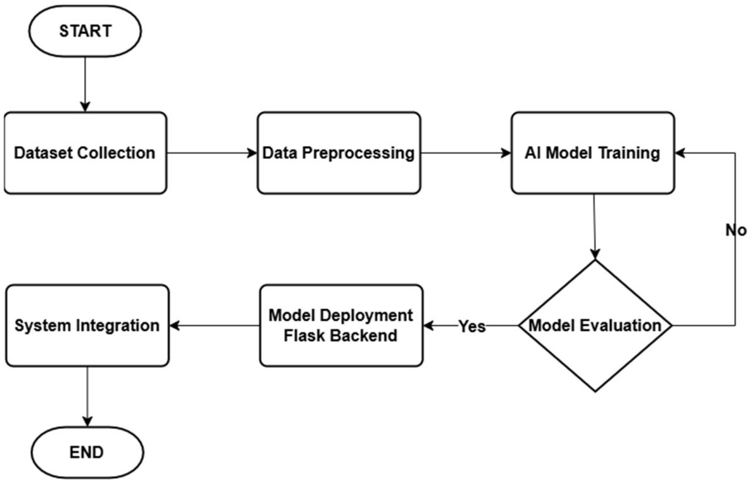

Figure 1. Research Methodology and System Development Workflow

2.1. DATASET COLLECTION

The initial stage of this research began with the collection of Batik Cual motif images through direct observation at three batik galleries in the Bangka Belitung Islands Province: Ishadi Cual Gallery, which provided nine motifs; Santhi Cual Gallery, with three motifs; and Destiani Gallery, with two motifs. From these sources, a total of fourteen Batik Cual motifs were obtained, each featuring diverse variations in pattern, color, and design composition.

In addition, supplementary data were collected from online sources, including digital platforms and public archives containing documentation of Batik Cual motifs. It is important to note that a specific Batik Cual dataset is not yet available in public repositories such as Kaggle. Therefore, data collection was conducted independently and systematically to ensure adequate visual representation of the motifs.

Figure 2. Representative Samples of the Batik Cual Motif Dataset

2.2. DATA PREPROCESSING

The data preprocessing stage was conducted to standardize formats and enhance image quality prior to model training. All images were resized to 512×512 pixels to maintain a consistent resolution. Data augmentation was applied to expand image variations through rotation, flipping, and contrast adjustment. From a total of 248 original images, 621 images were obtained after augmentation. The dataset was then divided into three subsets: 90% for training (560 images), 7% for validation (41 images), and 3% for testing (20 images). Each image was labeled according to its motif category to support the training and evaluation process of the YOLOv11-based classification model.

For the generative models (StyleGAN2-Ada and Diffusion Model), additional augmentation was applied, resulting in 1,053 images used to train the models in generating new synthetic batik patterns with broader visual diversity.

2.3. AI MODEL TRAINING

The model training stage was conducted to develop an integrated deep learning system capable of performing both classification and generation of Batik Cual motifs. Two main models were employed: YOLOv11 for classification and StyleGAN2-Ada combined with a Diffusion Model for motif generation.

In the classification stage, YOLOv11 was selected due to its fast and efficient CNN-based detection and classification capability. The training process was carried out for 163 out of 200 epochs using an NVIDIA Tesla T4 GPU to accelerate computation and optimize model parameters. The model performance was evaluated using accuracy, precision, and recall metrics, assessing its ability to recognize distinctive Batik Cual patterns, textures, and structural elements.

In the generative stage, StyleGAN2-Ada was utilized as the primary generative architecture to produce high-quality synthetic batik images. The Adaptive Discriminator Augmentation (ADA) technique was applied to address the limited dataset size and maintain training stability. Training was conducted for up to 1,000 kimg (kilo-image iterations), allowing the generator to progressively learn the underlying distribution of motif structures, color compositions, and ornamental characteristics of Batik Cual patterns. Throughout training, model checkpoints were periodically evaluated through visual inspection to assess realism, motif authenticity, and aesthetic consistency.

To further enhance visual fidelity, a Diffusion Model was applied as a refinement stage. This model improves texture realism and detail continuity through a gradual process of noise addition and removal (denoising), resulting in synthetic motifs that more closely resemble the original data distribution. The integration of these two models enables the system to generate authentic, diverse, and aesthetically consistent Batik Cual motifs, producing two main outputs: the YOLOv11 model for accurate classification and the StyleGAN2-Ada-Diffusion model for motif generation ready to be integrated into the system prototype.

2.4. MODEL DEPLOYMENT IN FLASK BACKEND

After the AI models were trained and evaluated, the selected models were deployed into the Flask backend to enable real-time inference within the web application.

The classification model was implemented using YOLOv11 and stored in PyTorch format (.pt). The model weights (best.pt) were loaded in the Flask server using the Ultralytics YOLO API, which internally utilizes the PyTorch framework for inference.

The generative model was based on StyleGAN2-ADA, stored in Pickle format (.pkl). The model was loaded using the StyleGAN2-ADA PyTorch implementation through legacy.load_network_pkl() and executed on the server using PyTorch with CUDA support.

During runtime, both models were initialized when the Flask application started, ensuring that inference could be executed without reloading model weights for each request. The system automatically detected hardware acceleration using: torch.device("cuda" if torch.cuda.is_available() else "cpu") allowing inference to run on GPU when available, or CPU as fallback.

2.5. SYSTEM INTEGRATION

The developed system adopts a client–server architecture that integrates a web-based frontend, a Flask-based backend, Artificial Intelligence inference modules, and a MySQL database into a unified platform. This integration enables users to interact with AI models for Batik Cual motif classification and generation through a standard web browser.

The frontend layer is implemented using HTML, CSS, and JavaScript to provide a responsive and user-friendly interface. HTML structures the web pages, CSS manages visual styling, and JavaScript enables interactive elements such as form validation and dynamic content display. Through this interface, users can upload Batik Cual motif images for classification, input textual prompts and/or reference images for motif generation, view inference results, and access a gallery of stored motifs. The design emphasizes accessibility so that users without technical expertise can operate the system easily.

The backend layer is developed using the Flask framework in Python, which manages the complete request–response workflow between users and AI models. Flask routing is used to organize system functionality into multiple endpoints. The home route serves the main interface, while dedicated routes handle classification inference, motif generation, user authentication, and administrative functions. When a user submits data, the backend securely receives uploaded files, stores them in designated server directories, and performs preprocessing before forwarding the data to the AI models.

For classification, the backend loads a pre-trained YOLOv11 model to perform motif prediction. For motif generation, a StyleGAN2-ADA model is loaded using PyTorch, enabling the synthesis of new motif images. All inference processes are executed on the server side, utilizing GPU acceleration when available. After inference, the backend performs post-processing to format prediction labels, confidence scores, generated images, and processing time information into structured outputs suitable for web display.

To support data persistence, the system integrates a MySQL relational database. The database stores uploaded image filenames, predicted motif labels, descriptive information, and user-related data. This database integration enables digital archiving, result tracking, and retrieval of previous classification or generation outputs, thereby supporting long-term documentation of Batik Cual motif data.

Overall, this frontend–backend integration ensures that AI functionalities are delivered as web services in a structured, modular, and scalable manner. Flask acts as the co re middleware that connects user interactions, AI inference modules, and database storage, forming a complete AI-driven cultural heritage web application.

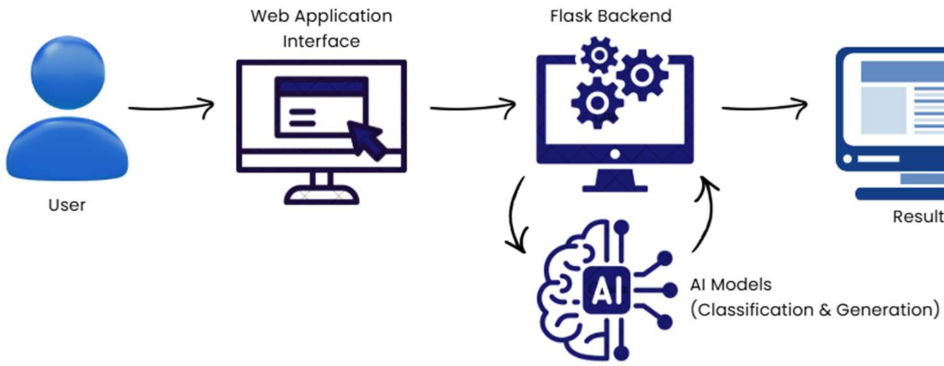

Figure 3. System Overview Diagram

2.6. SERVER AND DEPLOYMENT ENVIRONMENT

The developed web-based AI application was deployed in a local server environment running Ubuntu, which was configured to support deep learning inference and web service execution. This deployment setup ensures compatibility with GPU acceleration and stability for AI model integration within a web system.

Table 1. System Deployment Environment

Component	Specification
Operating System	Ubuntu
Memory (RAM)	32 GB
GPU	NVIDIA GeForce GTX 1650
Backend Framework	Flask (Python)
Database System	MySQL

The Flask server hosts the web application, AI inference modules, and database connection within the same local environment. GPU acceleration is utilized through PyTorch to execute inference for both the YOLOv11 classification model and the StyleGAN2-ADA generative model, enabling faster processing of image data. The deployment process involved installing required dependencies, configuring GPU drivers (CUDA support), setting up Python environments, and integrating the MySQL database to store classification results and generated motif records. This environment allows the system to operate as a prototype-scale AI web platform while maintaining stable performance and responsiveness during user interaction.

3. RESULT AND ANALYSIS

3.1. AI MODEL PERFORMANCE EVALUATION

Before integrating the Artificial Intelligence models into the web-based system, a comprehensive performance evaluation was conducted to ensure that both the classification and generative modules meet the reliability requirements for real-world deployment. This evaluation aims to measure the accuracy of motif recognition, assess the visual quality of generated motifs, and verify that the trained models are sufficiently robust to be used as core inference components within the Cualify platform. The assessment covers quantitative metrics for the classification model and qualitative visual analysis for the generative models, reflecting the dual objectives of motif identification and creative motif synthesis.

3.1.1. CLASSIFICATION MODEL EVALUATION

The performance of the YOLOv11 classification model was evaluated prior to system integration to ensure its reliability for motif identification. The evaluation results demonstrate strong detection and classification capability for Batik Cual motifs.

Table 2. Performance Metrics of the YOLOv11 Classification Model for Batik Cual Motifs

Metric	Value
Mean Precision (mP)	0.9009
Mean Recall (mR)	0.9716
mAP50	0.9463
mAP50–95	0.8172

The high recall value (0.9716) indicates that the model successfully identifies most Batik Cual motif instances, while the precision score (0.9009) reflects a low rate of false predictions. The mAP50 value of 0.9463 demonstrates strong detection performance, confirming that the classification model is sufficiently accurate for deployment within the web-based system. These results support the integration of the model as a reliable inference module for automated motif classification.

3.1.2. GENERATIVE MODEL EVALUATION

The generative module utilizes StyleGAN2-Ada trained on a curated dataset consisting of 14 authentic Batik Cual motifs with a total of 1,053 images. Training was conducted up to 1,000 kimg (kilo-image iterations), allowing the model to learn the visual distribution of geometric and floral Batik Cual patterns.

Figure 4. Real Images

Figure 5. Fake Images

Qualitative evaluation was conducted by comparing real training images (Figure 4) and generated images (Figure 5). The results show that the model is capable of synthesizing motifs that preserve essential visual characteristics of Batik Cual, including floral ornaments, fine woven-like textures, and symmetrical pattern structures. Color harmony and motif continuity are also maintained, indicating that the model successfully captured the stylistic identity of the dataset.

Although the Fréchet Inception Distance (FID) score has not reached optimal levels, visual assessment confirms that the generated motifs demonstrate acceptable aesthetic quality and cultural relevance. To further enhance realism, a Diffusion Model was applied as a refinement stage through progressive denoising. This process improves texture sharpness, detail continuity, and overall visual fidelity of the synthetic motifs.

The integration of StyleGAN2-Ada and Diffusion thus enables the production of diverse and culturally consistent Batik Cual motifs, supporting the creative exploration objective of the system.

3.2. WEB SYSTEM INTERFACE

The Artificial Intelligence models were successfully integrated into a web-based platform named Cualify, which serves as an interactive interface for Batik Cual motif classification and generation. The system was designed to ensure usability, accessibility, and real-time interaction between users and AI inference modules.

The web interface consists of two main functional modules: motif classification and motif generation. These modules are connected to the trained AI models through a backend inference pipeline, enabling automated processing of user input and visualization of results.

3.2.1. HOMEPAGE INTERFACE

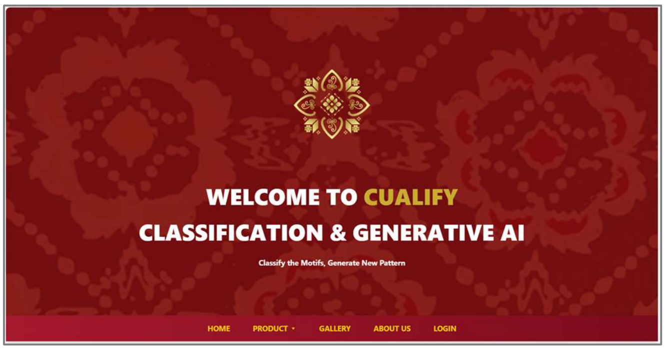

Figure 6. Homepage Interface

Figure 6 shows the homepage of the Cualify web platform. The interface adopts a visual style inspired by Batik Cual, featuring dominant red and gold tones that reflect the cultural identity of Bangka Belitung textiles. This page serves as the main entry point, providing direct access to the platform's AI-based services. The header displays the title "*Cualify Classification & Generative AI*", highlighting the system's dual functionality, while the tagline "*Classify the Motifs, Generate New Pattern*" summarizes its core purpose.

The navigation bar consists of Home, Product, Gallery, About Us, and Login menus, allowing users to access information and AI features efficiently. The structured layout supports intuitive interaction with both classification and generative modules. Overall, the homepage design presents the AI-based cultural platform within a user-friendly digital environment, making advanced AI functionality accessible to general users, designers, and cultural practitioners.

3.2.2. BATIK CUAL HISTORY PAGE INTERFACE

Figure 7. History Page Interface

Figure 7 shows the "Sejarah Batik Cual" (Batik Cual History) page, which provides cultural context as an integral part of the system. This section embeds educational content within the AI-based platform, supporting cultural preservation alongside technological innovation. The page presents structured information describing the historical background of Batik Cual, its cultural significance, and the traditional techniques involved in its creation. It also illustrates the visual characteristics of Batik Cual textiles and explains the transformation of woven fabric traditions into Batik Cual motifs as recognized today.

Images are positioned alongside textual explanations to strengthen visual comprehension and user engagement. The layout follows a clear column structure that enhances readability and ensures that cultural information is conveyed in an organized and accessible manner. The presence of this page demonstrates that the Cualify platform functions not only as a technical AI system but also as a digital cultural information system, effectively bridging artificial intelligence technology with heritage education.

3.2.3. MOTIF CLASSIFICATION FEATURE

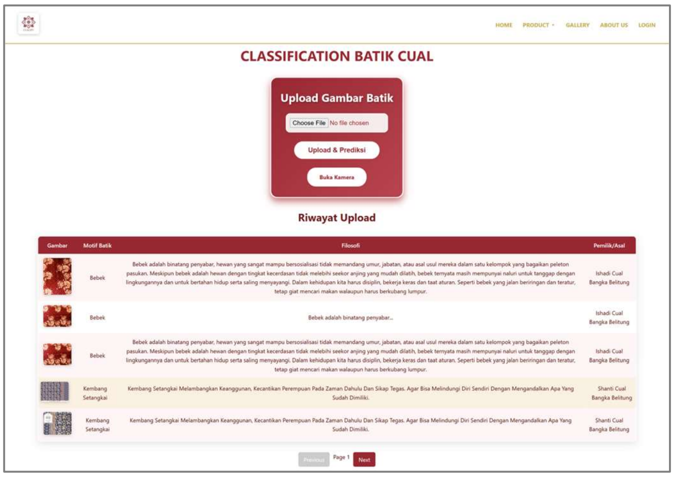

Figure 8. Motif Classification Feature

The Motif Classification feature enables users to upload images of Batik Cual motifs for automated analysis using the YOLOv11 model. Figure 8 illustrates the classification page interface, where users can submit an image through the upload form or capture it directly using the camera feature. Once the image is submitted, it is transmitted to the Flask-based backend server, where preprocessing is performed to prepare the image for model inference. The trained AI model then processes the image to identify the motif class.

Figure 9. Batik Cual motif classification result

After inference is completed, the system presents the classification results through a structured output interface, as shown in Figure 9. The displayed results include the motif label, motif description, and motif ownership information when available. Additional technical information such as confidence score and processing time is also provided, indicating the system's inference performance.

The trial result page demonstrates that the system is capable of automatically recognizing Batik Cual motifs and presenting the outputs in an organized and informative format. This confirms the successful integration of the

YOLOv11 classification model within the web environment and shows that the feature functions effectively as an intelligent motif identification tool within the Cualify platform.

3.2.4. MOTIF GENERATION FEATURE

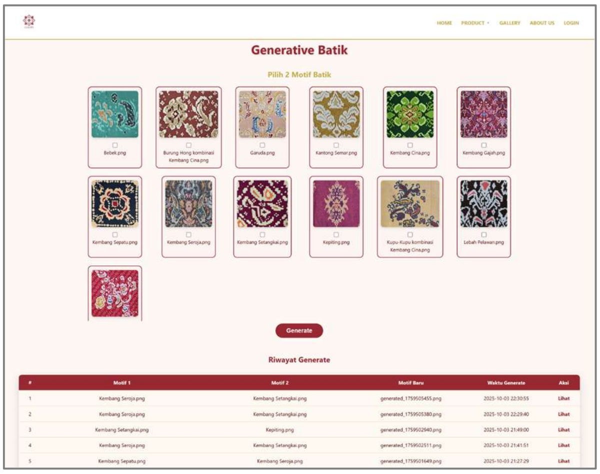

Figure 10. Motif Generation Feature

The Motif Generation feature serves as the creative component of the Cualify platform and is implemented using a combination of the StyleGAN2-Ada model and a Diffusion Model for refinement. Figure 10 illustrates the generative interface, where users can select motif inputs and initiate the generation process through an interactive web-based environment. The interface presents a collection of existing Batik Cual motifs that can be chosen as references, allowing users to explore new motif compositions through AI-driven synthesis.

Figure 11. Batik Cual motif generation results using the generative module in fusion, variation, and prompt modes

The system supports multiple generation modes to accommodate different creative objectives. In the fusion mode, the model combines visual characteristics learned from multiple Batik Cual motif datasets to produce new motifs with complex and diverse pattern compositions. This mode enables the synthesis of novel designs by blending geometric structures, ornamental elements, and color distributions derived from different motif sources.

In the variation mode, the generative model produces new variations based on learned motif patterns while preserving their fundamental structural characteristics. Subtle modifications are introduced in ornament details, color schemes, and texture patterns, allowing the system to generate visually diverse outputs that remain stylistically consistent with traditional Batik Cual motifs.

The prompt-based mode allows users to input textual descriptions as guidance for motif generation. The system interprets the semantic context of the prompt and translates it into visual representations based on the learned distribution of Batik Cual patterns. This mode provides a flexible interaction mechanism, enabling users to influence motif generation through descriptive language while maintaining cultural and stylistic coherence.

Generated motifs are displayed directly on the interface and recorded in the generation history section, which includes information about the input motifs, generated output files, and generation timestamps. The successful operation of this feature demonstrates that the generative AI models are effectively integrated into the web system and capable of supporting creative exploration within a culturally grounded digital platform.

3.3. ANALYSIS

To further evaluate the practicality of the proposed system, response time testing was conducted to measure how efficiently the integrated AI models operate within the Flask-based web environment. The results of the system performance testing are presented in Table 3.

Table 3. System Response Time Measurement

Feature	Average Time
Image Upload	< 2 seconds
Motif Classification	~1–2 seconds
Motif Generation	~45–60 seconds
Result Rendering	< 2 seconds

The measurement results show that lightweight tasks such as image uploading and result rendering require less than two seconds, indicating that the web interface remains responsive. The classification feature demonstrates fast inference performance (~1–2 seconds) due to the efficiency of the YOLOv11 model and GPU acceleration. This response time is considered suitable for real-time user interaction in web-based AI systems.

Motif generation requires a longer processing time (~45–60 seconds) because the StyleGAN2-Ada and Diffusion models involve complex iterative image synthesis and denoising stages. Despite this, the processing duration remains acceptable for creative-generation tasks, where users generally expect longer computation times compared to classification features. From a system integration perspective, these results demonstrate that AI inference can be effectively deployed within a lightweight Flask backend while maintaining acceptable response times. This supports the argument that successful AI application development depends not only on model performance but also on backend optimization and efficient request–response handling. In terms of AI capability, the classification results confirm that the system can accurately identify Batik Cual motifs and assist in digital documentation. Meanwhile, the generative module demonstrates the ability to synthesize culturally consistent motif variations, supporting creative exploration while preserving traditional design characteristics.

However, several limitations remain. The generative evaluation is currently based on qualitative visual assessment rather than standardized quantitative metrics such as FID or IS. In addition, response time measurements were conducted in a prototype-scale local deployment environment, meaning performance may vary under larger workloads or different server configurations. Overall, the analysis confirms that the proposed system successfully integrates AI models into a functional web application, demonstrating both technical feasibility and practical usability for cultural heritage digitalization.

4. CONCLUSION

This study presents the practical integration of Artificial Intelligence models into a Flask-based web application for the classification and generation of Batik Cual motifs. Rather than focusing on algorithmic novelty, the research emphasizes system engineering aspects, including backend deployment, model integration, and web-based accessibility for cultural heritage applications.

The experimental results show that the YOLOv11 classification model achieved strong performance, with high precision, recall, and mAP values, indicating reliable motif recognition capability. The generative module, based on StyleGAN2-Ada and refined using a Diffusion Model, successfully produced synthetic Batik Cual motifs that preserve essential visual characteristics, supporting creative exploration while maintaining cultural identity. From a system perspective, functional testing confirms that the web application operates stably, with fast classification responses and acceptable generation times for a prototype-scale AI service.

The integration of Flask as a lightweight backend framework proved effective for managing request handling, AI inference workflows, database interaction, and result delivery within a client–server architecture. These findings demonstrate that AI models can be operationalized into accessible web systems to support digital preservation, documentation, and dissemination of traditional cultural motifs.

Future work may focus on expanding the training dataset, incorporating quantitative generative evaluation metrics, and optimizing inference performance to improve scalability and visual realism. Overall, this study provides a practical deployment-oriented approach for implementing AI-driven web applications in cultural heritage preservation contexts.

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