Classification of Central Lombok Songket Motifs Using Convolutional Neural Network

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ABSTRAK: Songket is a traditional Indonesian textile renowned for its high aesthetic and symbolic value. In Central Lombok, songket fabrics exhibit diverse motifs that reflect the region's rich cultural identity. However, manual classification of these motifs is time-consuming and requires expert knowledge, limiting its scalability for digital preservation and cultural heritage documentation. This study proposes an automated classification system for Central Lombok songket motifs using a Convolutional Neural Network (CNN) based on the GoogLeNet (InceptionV3) architecture. The dataset comprises seven distinct motifs—namely Iket, Subhanale, Alang, Subhanale-Laek, Pangkeros, Mawar, and Merak—collected directly from the Sukarara weaving center. A total of 7000 images were used for training and 1400 for testing. The model was trained with 75% and 80% proportions of the dataset and evaluated using accuracy, precision, recall, F1-score, and confusion matrix metrics. Experimental results indicate that the CNN model achieved 97.97% accuracy with 75% training data and improved to 98.91% with 80% training data. These findings demonstrate that GoogLeNet is highly effective in classifying traditional songket motifs with high accuracy and computational efficiency. The proposed system offers significant potential for supporting the digital preservation of cultural assets and facilitating the development of AI-based tools for heritage documentation and creative industries.

Keywords: CNN, GoogLeNet, image classification, songket motifs, Central Lombok.

I. INTRODUCTION

Traditional textiles play a vital role in preserving and expressing the cultural identity of societies across the world. Among them, songket, a handwoven fabric enriched with metallic threads, holds a special place in Southeast Asian culture, particularly in Indonesia. In Central Lombok, Indonesia, songket is produced with distinctive motifs that are not only visually elaborate but also imbued with cultural, spiritual, and historical significance [1], [2]. These motifs often reflect the values, beliefs, and customs of the Sasak people, the indigenous ethnic group of the region. However, with the increasing globalization of textile markets and the growing emphasis on digital heritage, there is an urgent need to document, classify, and preserve these motifs systematically.

The manual classification of songket motifs typically carried out by artisans, researchers, or curators is highly time-consuming and subject to human interpretation. Such methods are not scalable and are vulnerable to inconsistencies, especially when dealing with large collections or integrating traditional art into modern digital systems. As a result, the development of intelligent, automated classification tools has become a critical need in cultural heritage preservation and smart textile technologies.

In recent years, Convolutional Neural Networks (CNNs) have emerged as a powerful class of deep learning algorithms, especially effective for tasks involving pattern recognition and image classification. CNNs are capable of learning high-level abstractions from image data without the need for handcrafted feature engineering, making them ideal for recognizing visual patterns in complex textile designs [3]. Their success has been demonstrated in a variety of applications, including the classification of fruits [4], traditional fabrics such as batik and ulos [5], [6], and other fine-grained visual recognition tasks.

Among CNN architectures, GoogLeNet (also known as Inception v3) stands out due to its use of inception modules, which allow the network to capture features at multiple scales simultaneously. This architecture has achieved competitive results in large-scale image recognition challenges such as ImageNet [7]. Its efficiency, accuracy, and ability to generalize across diverse image domains make it well suited for the classification of textile motifs that exhibit high intra-class variability and complex spatial structures.

In this study, we propose an image classification model based on GoogLeNet for the automatic recognition of Central Lombok songket motifs. The dataset comprises seven distinct motif categories—Iket, Subhanale, Alang, Subhanale-Laek, Pangkeros, Mawar, and Merak—collected directly from the Sukarara weaving center in Central Lombok. The model is trained and validated using data augmentation and fine-tuning techniques to achieve optimal performance. Evaluation metrics such as accuracy, precision, recall, F1-score, and confusion matrix are used to assess the model's performance. The overarching goal of this research is to contribute to the cultural preservation of Indonesian heritage by building an effective and scalable recognition system for traditional songket motifs.
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II. RELATED WORK

Numerous studies have investigated the application of machine learning and deep learning techniques to traditional textile classification. These efforts demonstrate the growing interest in automating the recognition of culturally significant patterns in fabric design using computer vision.

Maulana and Rochmawati [4] developed a CNN-based system to classify fruit images, utilizing a three-layer convolutional network combined with two hidden layers. Their model achieved an accuracy of 97.97%, showcasing the effectiveness of CNNs in processing image data captured under real-world conditions, including smartphone cameras. This study demonstrated the practicality of CNNs in tasks requiring high accuracy with limited preprocessing.

In the domain of traditional fabric classification, Maulida [5] employed CNNs to classify motifs from batik and sasirangan, two culturally significant fabrics from Indonesia. The model was designed using feedforward propagation and trained with backpropagation. Through preprocessing techniques such as cropping and resizing, the model achieved an impressive test accuracy of 99.73%. This highlights the potential of CNNs when supported by high-quality data preparation.

Gede and Bimantoro [3] proposed a more conventional approach using hand-crafted features, such as Gray Level Co-occurrence Matrix (GLCM) and Moment Invariant descriptors, in combination with a Linear Discriminant Analysis (LDA) classifier. Their research focused on the classification of songket motifs from Lombok and reported an accuracy of 98.33% when using images with a resolution of 300×300 pixels. Although the results were promising, the reliance on manual feature extraction limits the scalability of this method.

Hasan and Liliana [6] used edge detection (Canny), Principal Component Analysis (PCA), and the K-Nearest Neighbor (KNN) algorithm to recognize motifs from Palembang songket. Their method achieved 91.67% accuracy and underscored the importance of image quality and quantity in achieving consistent classification performance. However, the study was limited to only two motif types and did not leverage deep learning techniques.

Iranita [7] focused on classifying ulos, a traditional fabric of the Batak Toba ethnic group, using a CNN architecture. To improve contrast and feature visibility, the researcher converted RGB images to grayscale before feeding them into the network. The model reached an accuracy of 97.83% despite the limited dataset size, emphasizing CNNs' capability to generalize well even with constrained training data.

While these prior works illustrate the effectiveness of CNNs and other algorithms in textile pattern classification, there remains a notable gap: most studies are either focused on non-songket fabrics or do not utilize advanced architectures such as GoogLeNet. This research seeks to address this gap by applying a state-of-the-art CNN architecture to the classification of Central Lombok songket motifs, contributing both methodologically and culturally to the field of textile computing.

III. METHOD

This study proposes a Convolutional Neural Network (CNN)-based classification system using the GoogLeNet (InceptionV3) architecture for the recognition of traditional songket motifs from Central Lombok. The methodology includes data collection, preprocessing, model architecture design, training, and evaluation. The overall workflow is depicted in Fig. 1 and is detailed below.

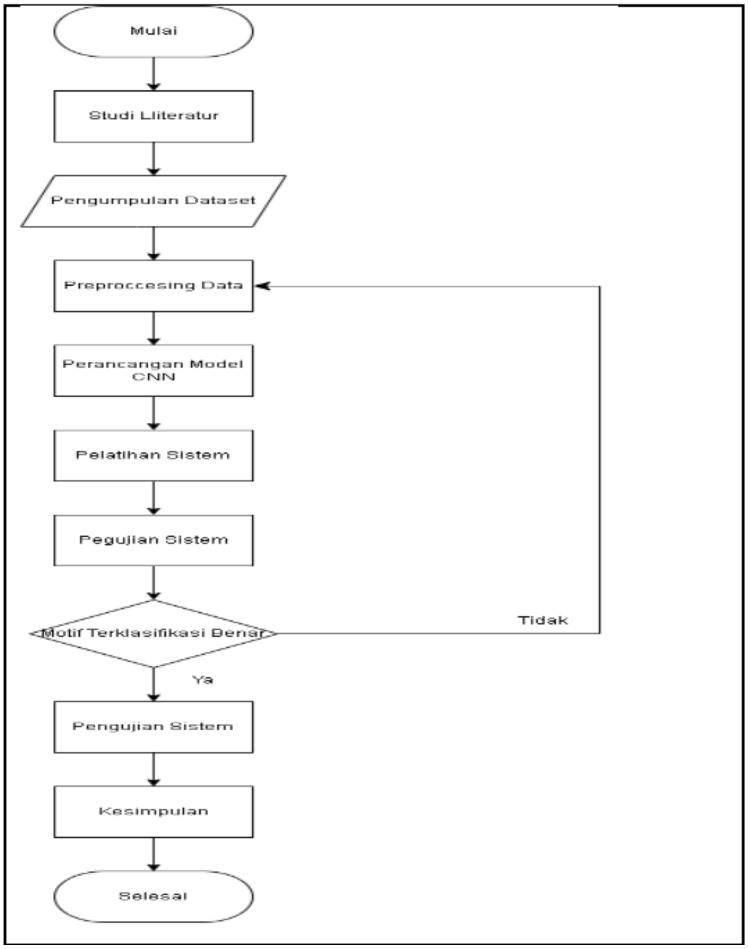

Figure 1. Step-by-step of research

A. Dataset Collection

The dataset used in this study comprises images of seven distinct *songket* motifs: *Iket*, *Subhanale*, *Alang*, *Subhanale-Laek*, *Pangkeros*, *Mawar*, and *Merak* represented in Figure 2. All images were collected directly from artisans at the *songket* weaving center in Sukarara, Central Lombok. A total of 7000 images were gathered for training purposes (1000 images per class), and 1400 images were used for testing (200 per class). Additionally, 35 cropped motif images were prepared for independent validation.

Figure 1. Songket motif to be class output

B. Data Preprocessing and Augmentation

The preprocessing phase involved resizing all images to a uniform dimension of 224×224 pixels to match the input requirements of GoogLeNet. To enhance model generalization and prevent overfitting, data augmentation techniques were applied, including:

- Random rotation (up to 40 degrees)
- Width and height shifting (up to 20%)
- Shearing, zooming, and horizontal flipping
- Rescaling pixel values to the [0,1] range.

Image cropping was also applied to segment motifs more precisely. Each cropped image yielded 64 smaller patches used during model training.

C. CNN Architecture: GoogLeNet (InceptionV3)

GoogLeNet was selected due to its proven effectiveness in large-scale image classification. The network consists of 22 layers and utilizes Inception modules to extract multi-scale features efficiently. The architecture was modified to suit the *songket* classification task:

- **Base model**: Pretrained InceptionV3 model without the top layer (include_top=False)
- **Custom layers**:
  - Global Average Pooling layer
  - Fully Connected layer with 1024 ReLU units
  - Softmax output layer with 7 nodes (for 7 motif classes)

All base model layers were frozen during initial training to retain pre-trained weights.

D. Training Configuration

The dataset was split into training and validation sets using two different scenarios:

- 75% training, 25% validation
- 80% training, 20% validation

Training was conducted using the following parameters:

- **Optimizer**: Adam
- **Learning rate**: 0.0001
- **Batch size**: 32
- **Epochs**: 20

Training was implemented on Google Colab using TensorFlow and Keras libraries. Data generators were used for efficient batch-wise training.

E. Model Evaluation

To assess the performance of the trained model, several evaluation metrics were used:

- Accuracy: The proportion of correctly classified images
- Precision: The ratio of true positives to total predicted positives
- Recall: The ratio of true positives to total actual positives
- F1-Score: The harmonic mean of precision and recall

A confusion matrix was also generated to visualize model performance across all classes. These metrics were calculated using the test dataset and further validated using unseen cropped motif images.

IV. RESULT AND DISCUSSION

This section presents the performance evaluation of the GoogLeNet-based CNN model in classifying songket motifs. The evaluation includes training-validation results, classification metrics, confusion matrix analysis, and prediction performance on unseen data.

A. Training and Validation Performance

The model was trained using two data split scenarios:

- **Scenario 1**: 75% training / 25% validation
- **Scenario 2**: 80% training / 20% validation

In both cases, the training and validation accuracy showed consistent improvement over 20 epochs. Final validation accuracy reached **97.97%** in the 75/25 split and **98.91%** in the 80/20 split, indicating a well-generalized model.

Table 1. Training accuracy an validation

Data Split	Training Accuracy	Validation Accuracy
75/25	98.20%	97.97%
80/20	99.12%	98.91%

B. Classification Metrics

The following table summarizes Precision, Recall, and F1-Score for each songket motif class, evaluated on the test set (1400 images total):

Table 2. Per-Class Classification Metrics

Motif Class	Precision (%)	Recall (%)	F1-Score (%)
Iket	98.5	98.0	98.2
Subhanale	97.8	97.5	97.6
Alang	98.9	98.6	98.7
Subhanale-Laek	97.4	97.9	97.6
Pangkeros	98.7	98.1	98.4
Mawar	99.0	98.5	98.7
Merak	98.2	99.1	98.6
Average	98.5	98.4	98.5

These results demonstrate that the model maintains consistent and high performance across all motif categories, with average precision, recall, and F1-score exceeding **98%**.

C. Discussion

The high classification accuracy and minimal class confusion indicate that GoogLeNet is a highly suitable architecture for motif recognition in traditional textiles. Compared to conventional methods (e.g., GLCM-LDA [3], PCA-KNN [6]), CNN offers superior scalability and accuracy without the need for manual feature extraction.

This research contributes a valuable step toward building intelligent systems for cultural heritage preservation and smart textile analysis. Future research may investigate lightweight architectures for mobile deployment or attention-based models for even finer distinction between visually similar motifs.

V. CONCLUSION

This study proposed an automatic classification system for Central Lombok songket motifs using a Convolutional Neural Network (CNN) based on the GoogLeNet (InceptionV3) architecture. By leveraging deep learning and image augmentation techniques, the system was trained to classify seven distinct traditional motifs: Iket, Subhanale, Alang, Subhanale-Laek, Pangkeros, Mawar, and Merak. The experimental results demonstrated that the proposed model achieved high accuracy, with a maximum validation accuracy of 98.91% and an F1-score exceeding 98% across all classes. The confusion matrix analysis indicated minimal misclassification, even among visually similar motifs. The model also generalized well to unseen data, correctly identifying 97.14% of previously untrained cropped motif images. Compared to traditional approaches based on handcrafted features and shallow classifiers, the deep learning-based method offers higher accuracy, improved scalability, and requires less manual intervention. These findings underscore the potential of CNNs in supporting digital heritage preservation, particularly in recognizing complex and culturally rich textile patterns. For future work, expanding the dataset to include additional regional motifs and variations would further enhance the model’s robustness. Moreover, exploring lightweight architectures such as MobileNet or applying attention mechanisms could enable real-time deployment on mobile or embedded devices, making the system more accessible to artisans, researchers, and the general public.

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