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MOTIF DETECTION IN INDONESIAN HAND-WOVEN FABRICS USING MATLAB

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ABSTRACT
The cultural significance of Indonesian woven fabrics intricately patterned by hand is dampened by slow, expensive automatic motif recognition processes. This research aimed to build a system that automatically detects and identifies motifs in textiles using image processing in MATLAB. The steps included collecting and preprocessing images, constructing a dataset, performing image comparison and similarity measurements, and color analysis. A dataset containing images of woven fabrics from different regions of Indonesia was created which included region-specific motifs. Images were enhanced through preprocessing and motif features were extracted through preprocessing. Determining the degree of correlation enabled features to be compared with the dataset, while color analysis tailored color characterization to specific motifs. The algorithm was able to detect motifs accurately using dataset references. The resemblance of motifs was greatly enhanced using color analysis. The approach is efficient and reliable for technology-aided culture preservation compared with manual methods. The analysis confirmed advanced MATLAB automation systems broadened opportunities in motif recognition within traditional textiles beyond automated processes, emphasizing the need for a detailed exploration of textile research projects.
Keywords: Image processing, textile, motif recognition, woven fabric

1. INTRODUCTION

Weaving is one of the many forms of art in Indonesia and handcrafted woven textiles form an inseparable part of the Indonesian cultural heritage. These weaving techniques often showcase intricate designs that capture the essence of various Indonesian traditions and civilizations. Due to their rich symbolic essence and aesthetic value, scientific analysis combined with commercial preserving motives reporting on the investigation of such fabrics becomes indispensable. Furthermore, regions and cultures are recognized by the particular motifs woven into fabrics and textiles including, but not limited to, intricate patterns along with vibrant colors which define uniqueness. Despite the extensive information these motifs entail, the process of motif identification and classification remains tedious, highly subjective, and exposed to human error. Thus, better accuracy and reliability can be provided through technology within automation. Advances in image processing technology have greatly impacted the field of textiles, providing reliable frameworks for evaluating fabric surfaces in regard to their texture, structure, and pattern recognition (Bahera,2004;Himanshi,2013;Semnani,2011).

The proposed techniques utilize algorithms designed for the detection of visual features within images to be captured from the fabric enabling exact determination of textile features. As an example, Behera (2004) discussed the significance of image processing for evaluating the quality of textiles, while Himanshi (2013) focused on the use of this technology for the characterization of a variety of fabrics. Similarly, Merati and Semnani (2011) combined image processing with soft computing techniques to assess textile quality, and Conci and Proença (2000) compared various image-processing approaches for textile inspection, underscoring their potential for automation. Even with these steps taken, there is little research on the use of image processing for the automation of motif detection in woven fabrics, including Indonesian fabrics. Studies done so far have concentrated on more general aspects of textiles such as measuring fiber length or fabric homogeneity (Rust et al, 2001;Putra et al, 2020;Sukendar et al 2019; Putra et al, 2025; Wijayono and Putra,2018). For instance, Putra et al. (2020) and Sukendar et al. (2019) successfully conducted MATLAB-based image processing to analyze fabric homogeneity and drape measurement, respectively, whereas Wijayono and Putra (2018) analyzed

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several parameters of woven fabrics using digital image processing. Also, Putra et al. (2025) merged electromagnetic analysis with response surface methodology to advance the analysis of fabrics, broadening the scope of Putra's earlier work on improving the wetting characteristics of fabrics. These studies in combination verify the achievements of research in image processing in the field of textiles but glaringly fail to solve the problem of motif recognition in culturally important handmade textiles.

This study's objective is to create a trial system for the automated detection and identification of motifs in Indonesian handmade woven fabrics using MATLAB, thus filling the identified gap. The contribution of this work is centered on ethnographic textiles and the application of image-processing algorithms designed for intricate, specific region motifs. The system is expected to extract and classify motif patterns with high accuracy, thus enabling better-automated systems for cultural preservation and applications in the textile industry. The goals are: (1) design an image processing workflow for determining within fabric motifs, (2) assess the efficacy of the system on a dataset of Indonesian woven fabrics, and (3) assess the accuracy of the system against ground truth data. This paper is structured as follows: Section 2 outlines the methodology, including data collection and algorithm development. Section 3 presents the experimental results, followed by a discussion. Finally, Section 4 concludes the study and suggests directions for future research. Combining our experimental findings and existing research, it is clear that the automated detection of motifs improves not just the precision, but also the speed with which textiles are analyzed, enabling further advancements in the preservation of cultural heritage.

2. METHODS

We developed a computer-based method for classifying textile woven motif images using MATLAB® (v.7.12.0 R2011a, MathWorks, Inc., Natick, MA, USA). This research involved capturing images of woven cloth samples, preprocessing them, and comparing them against a reference dataset to identify the best-matching motif based on shape and color characteristics. A digital camera was used to acquire images of three distinct woven fabric samples, which served as the dataset stored in a designated folder alongside a text file containing descriptive labels.

2.1. Image Acquisition and Preprocessing

Images of woven fabrics were captured using a digital camera under consistent lighting conditions to minimize variations in color and texture. Each image was processed to ensure uniformity and resized to a standardized resolution of 600x600 pixels to facilitate pixel-wise comparisons. The resizing operation employed bilinear interpolation, preserving the visual integrity of the textile motifs. For shape-based analysis, each image was converted to grayscale using the standard RGB-to-grayscale transformation as in Eq.(1):

$$I_{gray} = 0.2989 \times R + 0.5870 \times G + 0.1140 \times B, \quad (1)$$

where *R, G*, and *B* represent the red, green, and blue channel intensities, respectively, and I_{gray} is the resulting grayscale intensity for each pixel. This weighted sum reflects human perception of luminance, prioritizing green due to its higher perceptual contribution.

2.2. Dataset Construction

The dataset comprised three woven cloth images stored as PNG files in a folder, accompanied by a labels.txt file mapping each image filename to a descriptive label (e.g., motif type). Each dataset image was preprocessed identically to the input images: resized to 600× 600 pixels and converted to grayscale. The dataset was organized into a structure containing RGB images, their grayscale counterparts, and corresponding labels, ensuring efficient retrieval during comparison.

2.3. Image Comparison and Similarity Measurement

The classification process compared an input image to the dataset to identify the most similar motif based on grayscale pixel intensities. The similarity metric utilized the mean squared error (MSE) to quantify the difference between the input grayscale image I and each dataset grayscale image D. For images of size 600× 600 pixels (N = 600× 600 = 360000 pixels), the MSE was calculated as in Eq.(2):

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$$MSE = \frac{1}{N}\left(\sum_{J=1}^{N}\left(I_j - D_J\right)^2\right), \quad (2)$$

where I_j and D_J denote the intensity of the j-th pixel in the input and dataset image, respectively, with values in [0, 255] for 8-bit grayscale images. To derive this, each image was vectorized into a 1D array of length N, and the squared difference $\left(I_j - D_J\right)^2$ was computed element-wise. The sum of these squared differences was averaged over N as in Eq.(3):

$$MSE = \frac{1}{360000}\left(\sum_{J=1}^{360000}\left(I_j - D_J\right)^2\right) \quad (3)$$

The dataset image with the minimum MSE was identified as the best match. To express similarity as a percentage, the MSE was normalized relative to the maximum possible MSE, which occurs when every pixel differs by the maximum intensity (255) as shown in Eq. (4):

$$MSE_{max} = \frac{1}{N}\left(\sum_{J=1}^{N}(255 - 0)^2\right) \quad (4)$$

The similarity was then computed as in Eq.(5):

$$S = \left(1 - \frac{MSE}{MSE_{max}}\right) \times 10\% = \left(1 - \frac{\sum_{J=1}^{N}\left(I_j - D_J\right)^2}{\sum_{J=1}^{N}(255 - 0)^2}\right) \times 100\% \quad (5)$$

This yields a value between 0% (maximum dissimilarity) and 100% (identical images), reflecting the shape-based similarity of the woven motifs.

2.4. Color Analysis

To complement shape-based classification, the method analyzed the color profiles of the input and matched images by computing the average RGB values. For an RGB image C of size 600x600x3, the pixels were reshaped into a 360000×3 matrix, and the mean intensity for each color channel $k \in \{R, G, B\}$ was calculated as in Eq.(6):

$$\langle RGB\rangle_k = \frac{1}{N}\left(\sum_{J=1}^{360000} C_{j,k}\right) \quad (6)$$

where $C_{j,k}$ is the intensity of channel k for the j-th pixel. This produced a vector $[\langle RGB\rangle_R, \langle RGB\rangle_G, \langle RGB\rangle_B]$ for both the input and matched images, providing a quantitative comparison of their color distributions. ΔE color difference metric can be calculated using Eq.(7)

$$\Delta E = \sqrt{\Delta\langle RGB\rangle_R{}^2 + \Delta\langle RGB\rangle_G{}^2 + \Delta\langle RGB\rangle_B{}^2} \quad (7)$$

where $\Delta\langle RGB\rangle_R$, $\Delta\langle RGB\rangle_G$, and $\Delta\langle RGB\rangle_B$ are the differences in the average red, green, and blue values between the input image and the matched dataset image.

3. RESULTS AND DISCUSSIONS

Our study evaluated the performance of a MATLAB-based system designed for the automated detection and identification of motifs in Indonesian handmade woven fabrics (**Figure 1**). The program was tested across multiple samples, and the results provided valuable insights into its efficacy. **Figure 2** shows the performance of the MATLAB-based automated system for detecting and identifying motifs in Indonesian handmade woven fabrics, presenting comparative analyses across multiple fabric samples.

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The system assessed image similarity using metrics including average RGB values, shape similarity percentages, and ΔE color differences, comparing input images against a pre-constructed dataset. Results demonstrated high accuracy in motif recognition, with perfect matches observed in several cases. For instance, Bali woven fabric exhibited 100% shape similarity with a ΔE of 0.00, indicating an exact correspondence between input and dataset images. Similarly, the NTT woven fabric pattern achieved 100% shape similarity with a ΔE of 0.00, affirming the system's precision in pattern matching. In cases involving more complex motifs, such as floral or abstract designs, the system recorded shape similarities ranging from 80% to 91%, with ΔE values varying from 178.86 to 60.38. These variations highlight the system's ability to handle intricate patterns, though accuracy slightly diminished with greater complexity.

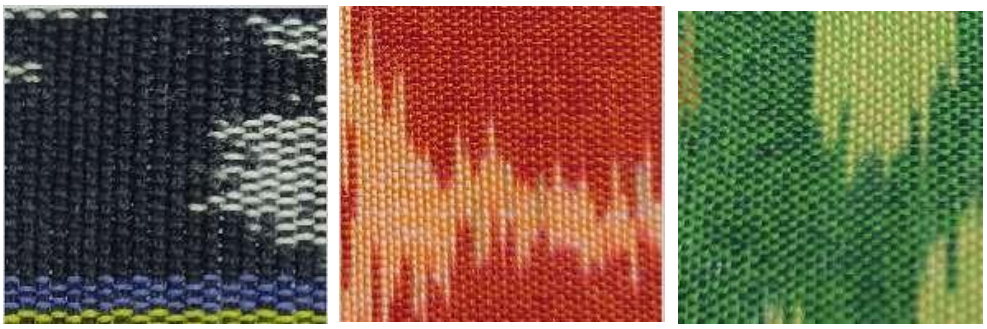


Figure 1. Woven fabric samples: the motif of NTT, NTB, and Bali.

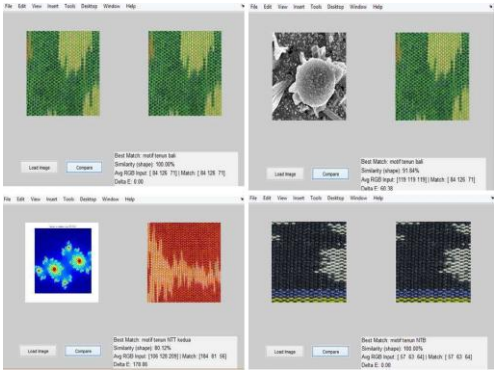


Figure 2. The simulation results.

These findings support prior studies that demonstrated the efficiency of MATLAB in textile image processing (Rust et al, 2001;Putra et al, 2020;Sukendar et al 2019; Putra et al, 2025). Nonetheless, issues remained with extremely intricate motifs and low dataset diversity, indicating potential for future improvements through dataset enlargement and sophisticated algorithmic integration. The method now serves as a dependable tool for conserving culture and textile research, with the potential for broader use in automated pattern identification.

4. CONCLUSIONS

The development and evaluation of an Automated System for Motif Detection in Indonesian Handwoven Fabrics using MATLAB was completed as the fabric pattern recognition algorithm research was developed. The methodological framework went from image capturing and preprocessing to dataset creation, image comparison, similarity measurement, and color analysis. The accuracy in matching the input image to the dataset of specific motifs was commendable; color analysis was shown to be vital in differentiating patterns with similar motifs. The results confirmed that the system was able to deploy the previously programmed commands for a motif's automated identification saving a considerable amount of time and reducing biases from manual methods. The study showed that the image processing capabilities of MATLAB could analyze intricate patterns of textiles, thus, proposing lower-cost solutions for cultural and textile industry preservation frameworks. That constructed dataset

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of Indonesian woven fabrics aids future researchers in documenting and preserving dwindling culture thus, highlighting the importance of applied ethnography. Furthermore, the precision of motif detection substantiates the usefulness of this system for commercial analysis of textiles and adds value to quality and design control. Despite its success, the study faced limitations, including dataset size and motif complexity, which occasionally challenged similarity measurements. Future work could expand the dataset to include a broader range of Indonesian textiles and incorporate advanced machine-learning techniques to further improve accuracy. This study's findings confirm the transformative potential of automated image processing in textile research, paving the way for enhanced preservation and analysis of culturally significant fabrics.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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