Digital Archiving of Traditional Songket Motifs using Image Processing Tool

NURSURIATI JAMIL[1], TENGKU MOHD TENGKU SEMBOK[2], ZAINAB ABU BAKAR[1]
[1]Faculty of Computer and Mathematical Sciences
Universiti Teknologi MARA, Shah Alam, 40450 Selangor
[2]Kuliyyah of Information & Communication Technology
International Islamic University, 50728 Kuala Lumpur
MALAYSIA
liza@tmsk.uitm.edu.my, tmts@gmail.com, zainabcs@salam.uitm.edu.my

Abstract: - This paper presents an image processing tool, part of an image retrieval system, that provides digitization of songket motifs extracted from songket patterns. Songket motifs are acquired from their original songket fabrics and digitized into binary form by using several image processing techniques. This paper describes the digitization process and experiments conducted on fifty textile motifs using image processing techniques: contrast enhancement, noise reduction, binarization and morphological operations.

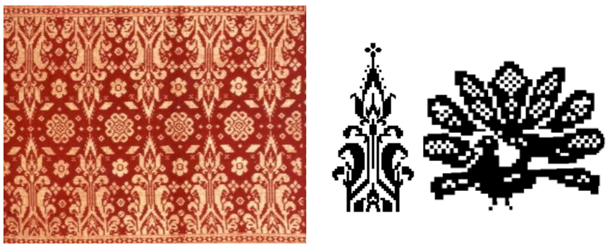
Key-Words: - Heritage preservation, songket motifs, image processing, digital archive

1 Introduction

Malaysia is a country well known for its rich cultural heritage and these aesthetic values of the Malay heritage are reflected in the design of most of its handicraft products. The beauty of textile, which is one of the most popular handicrafts in Malaysia, lies in its beautiful design and motifs that was passed down from traditional weavers to their descendants and subsequently adopted and modified by modern designers. The environment surrounding the weaver and the aspects of the weaver's everyday life largely influenced the motifs and patterns used on the textile products. Songket weavers usually memorize these patterns and motifs or copy them from older examples at hand or from those drawn on tracing paper. As the interest of inheriting weaving skills among younger generations are depleting, these patterns and motifs must be preserved to be appreciated by the public especially the future generations.

1.1 Songket motifs

Motif is the main element of designing songket patterns. When several motifs are arranged within parts of the songket, patterns are created on the songket fabric. The arrangement of motifs in Malay art pieces always deals with the appreciation of the Malay people of God's creation. The way to appreciate God's creation is by looking at and into nature to find answers to human existence [1]. In the past, songket motifs are very much influenced to the cultures and beliefs of Hindu-Buddhist. The motifs are later stylized to incorporate with Islamic religious restrictions where realistic portrayal of animals and human figures are discouraged. Moreover, the nature of the weaving techniques has the tendency to cause the motifs to become geometrical design. Thus, this helps diffuse the exact depiction of the real figures. Fig. 1(a) illustrates a songket pattern and Fig. 1(b) shows a flora (i.e. bamboo shoots) and fauna (i.e. peacock) motif typically used in a songket pattern.



(a) (b)

Fig. 1 (a) Songket pattern. (b) Songket motifs

1.2 Importance of the research

Creating a digital copy of an item provides a surrogate which can be accessed and used instead of the original, thereby assisting in the preservation of the original [2]. Songket pattern is originally designed on graph paper and given to the weavers for production. Currently, Malaysian Handicraft Development Corporation (MHDC) preserved these designs on slides, microfiches, photographs and stored them physically in manual catalouging system. Other than the problem of finding physical space for storage, the task of finding certain motifs or

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designs for references is incredibly tedious. A lot of the motifs and designs were also physically destroyed or misplaced as MHDC moved from one office to another. As the collection of new motifs and design grow over the years, MHDC realized the need of using technology to overcome the problem of storing and retrieving these images for future references. Therefore, the motivation of this study is to utilize image processing techniques to automate the digitization of the songket motifs to be stored in an image archives. As [3] stressed, archives are increasingly important to creative industries, especially the fashion sector, which often relies on historical collections for design inspiration, product-development, and market strategizing.

Some related work is described in Section 2. The image processing operations applied to digitize the songket motifs are described in Section 3. Section 4 elaborates the evaluation methods and Section V reports the findings obtained. Finally, Section 5 draws some conclusions and mentions some plans for future work

2 Related Work

Image processing has been utilized in many applications since it was introduced in 1970s. In textile industry, image processing methods are employed for applications such as automated fabric inspections [4] [5], patterns segmentation [6] [7], and patterns design [8] [9]. Image digitization work can be traced back as early as 1974 [10], a system that created digitized map files in several standard formats from a driver tape. Nowadays, numerous image digitization works for the purpose of archiving and retrieving images have been adopted by many such as photography archives [11], art museum image gallery [12], historical pictures and events [13], rare books and manuscripts [14] [15]. Image processing operations are usually essential in most image digitization work as shown in Gamera [16], a system that allows an expert user to combine image processing and recognition components in archiving ultural heritage materials. Hiary and Ng [17] combined a back-lighting scanning technique with image processing operations to automatically convert paper-based watermark designs into graphical representations at a cheaper and faster rate. National Digital Library [18] in Portugal employed image processing actions such as resampling, scaling, cropping and binary trimming in creating half a million of digitized images. Maino [19] combined image restoration algorithms and multispectral analysis in archiving historical books and documents. Kitamoto *et al.* [20] utilized binarization, edge detection and segmentation in the preprocessing phase of archiving Toyo Bunko Rare Books in the web. In an effort to protect its assets, Time Warner Entertainment Company owned a United States Patent [21] for method and apparatus for archiving and retrieving images from a digital image library.

Despite numerous archiving works in other areas, few attempts are done to utilize image processing techniques in archiving and retrieving textile patterns. Even though a number of textile image databases are in existence [2][22][23], majority used textual annotation to identify, describe and retrieve the images. Text annotation are done manually, thus it is a very time-consuming and subjective procedure. As for image digitization, image processing has increasingly been employed in several textile pattern extractions in recent years [6][7][8][9][24][25]. In 2003, Valor *et al*. [8] employed segmentation and labeling operators to detect pattern objects in 93 synthetic textile and tile design. A more recent work was proposed by [6] whereby printed designs and woven patterns are extracted from textile images using Markov random field pixel labeling. In 2010, Jia and McKenna [25] then extended the research in classifying the woven textile patterns using Fourier descriptors to describe the pattern shapes. Earlier in 2009, Smoaca and friends[25] also used image processing operations such as filtering and thresholding to segment 30 images of jacquards.

2.1 The role of image processing in preservation of songket motifs

As mentioned previously, image processing operations are essential in most image digitization work. In our study, image processing is used to enhance and convert the songket motifs into binary form. The functions of image processing in the preservation of songket motifs are as follows:

1) Extraction and preprocessing of the songket motifs from the fabric are done by image cropping, resizing, morphological reconstructions and grayscale conversion.
2) Contrast enhancement is performed using histogram stretching and equalization to improve the appearance of the extracted songket motif.
3) Noise signal acquired during image acquisition is reduced using noise removal filters.
4) The cleaned songket motifs are then converted to binary form using thresholding technique.

Finally, several morphological operations are applied on the black and white songket motifs to acquire the true representations of the motifs as much as possible.

3 Methodology

The digitization of the songket motifs are facilitated by using an image processing tool developed using MATLAB programming. The songket patterns are collected from various places and several songket entrepreneurs in the state of Terengganu. The old songket photographs from the museum are scanned, while images from the songket entrepreneurs are captured directly from the songket fabrics using a digital camera. Other than that, songket patterns are also scanned directly from old books and manuscripts. A total of more than 200 songket patterns images are acquired and used in this study. Image processing operations are then applied to the songket patterns to produce the best possible digital representation of the songket motifs in binary (black & white) form. At the time of writing, there are approximately 300 songket motifs collected. Traditionally, songket fabrics are woven in either gold or silver thread. Therefore, colors of the motifs are not of upmost importance in designing patterns. Rather, the motifs type is the key factor as songket is design according to a theme. The flowchart of the image digitization is illustrated in Fig. 2. The operations involved are motif extraction, contrast enhancement, noise reduction, image binarization and morphological processing. For each step, the processes are performed repeatedly until the desired results are achieved.

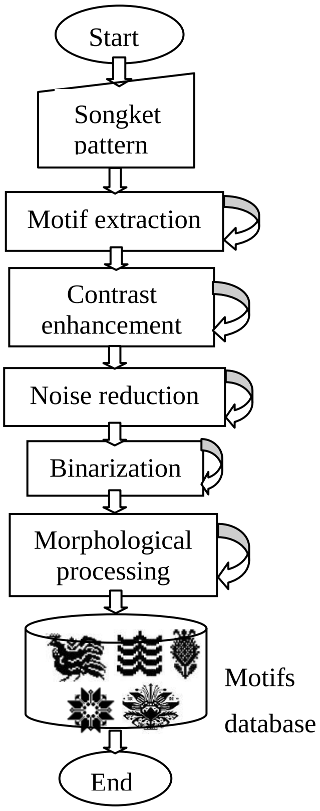

Fig. 2 Flowchart of digitization process

3.1 Motif extraction

The first step is to allow extraction of motifs from the pattern by image cropping. During the cropping process, unwanted objects or partial objects may be cropped together with the intended motif. Thus, removal of these extraneous details needs to be done by filling in the unwanted region of interest with the gray level values on the boundary of the region. As the motif's color is insignificant, the motif is also converted to grayscale image for contrast enhancement.

3.2 Contrast enhancement

Contrast enhancement is important because cleaning and removing unnecessary details during motif extraction may deteriorate contrast level of the image. The deteriorated image may be subjected to histogram stretching or equalization depending on the image's intensity level. Histogram equalization may be chosen automatically and it produced a flat image histogram of 64 bins. Histogram stretching on the other hand, is based on intensity of the input image entered by the user. The objective of contrast enhancement is to highlight the motif by changing the contrast between the motif and its background. Prior to contrast enhancement, the histogram of this image is viewed. An example of histogram equalization operation is illustrated in Fig. 3.

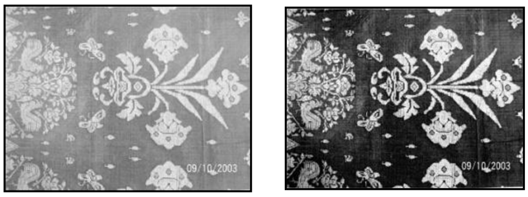

Fig. 3 Histogram equalization

3.3 Contrast enhancement

Since the songket patterns collected are acquired using scanner and digital camera, noises are inevitable. It is imperative that noise is reduced to a certain acceptable level so that true representations of the songket motifs are correctly archived [26]. Two most common types of noises are Gaussian and salt-and-pepper noise. Gaussian noise normally occurs due to electronic noise in the scanner or digital camera; while malfunctioning pixel elements in the camera sensors, faulty memory locations or timing errors in the digitization process may cause salt-and-pepper noise. The image processing tool provides noise removal using three different filters: mean, median and adaptive filter. In this study, we experimented on these three filters with different sizes kernel.

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3.4 Image binarization

Songket motifs are designed on graph paper and thus the shapes are geometrically inclined and only two values (0 and 1) are necessary to store the shape information in digital form. Therefore, after noise filtering, the grayscale image is converted to binary image by thresholding. The image processing tool accepts a threshold value between 0.0 and 1.0 and all pixels with intensity less than this value is converted to 0 (black) while others will be set to 1 (white). In performing binarization, choosing the appropriate threshold level is very important. An automatic thresholding is also provided in the system as an option. It is done by computing a global threshold using Otsu's method.

3.5 Morphological processing

Morphological operations in this paper are used for noise removal and enhancement to produce the best possible representation of the actual songket motif before they are stored in the motifs database. Morphological techniques for digital images rely only on the relative ordering of pixel values thus they are most suitable for binary or grayscale images [27]. Unlike all previous operations of image processing, morphological operations in this study are applied on binary images instead of grayscale or color images. In our study, six simple morphological operations are experimented to enhance and remove noise from binary images. The operations are dilation, erosion, opening, closing, fill and majority.

4 Performance Evaluation

Performance of the image processing operations can be evaluated either subjectively or objectively in an experimental framework. Wirth *et al.* [28] stated that very few literature on evaluation of image processing algorithms existed even though the concepts have been around for decades. There is no single quantitative metric which correlates well with image quality as perceived by the human visual system. In this study, both subjective and objective evaluations using visual assessments are conducted to measure the performance of the four image processing operations. For each operation, the processed images are compared to the original ones and performance is objectively ascertained by defining certain success or failure criteria.

4.1 Contrast enhancement

The objective of contrast enhancement is to highlight the important region of interest (i.e. motifs) by changing the contrast of the images. Success of contrast enhancement is subjectively established by a human based on the objective criteria listed as follows:

1) High contrast between the region of interest (i.e. motifs) and its surrounding background.
2) Minimum existence of false regions (i.e. noise or irrelevant regions).

4.2 Noise removal

The purpose of noise removal in this study is to enhance image quality, thus the filters performances are evaluated based on visual quality. They are divided into three groups:

Group 1 (Best): Noise is substantially suppressed and fine details of the image are preserved.

Group 2 (Moderate): Noise is substantially suppressed but certain image details are blurred.

Group 3 (Bad): No significant noise reduction or lost of image details.

4.3 Image binarization

Performance evaluations of binarization are adapted from [29] using visual inspection based on the following categories:

Group 1 (Good): Image has a small number of disconnected regions and large number of foreground pixels is converted to 1 (i.e. motifs).

Group 2 (Bad): Too many background noise area are converted to 1 (i.e. motifs) and too many foreground pixels are converted to 0 (i.e. background.

4.4 Morphological operations

The purpose of morphological operations is to remove noise and simultaneously construct as much as possible the exact replica of the songket motifs. Dilation, erosion, opening, closing, fill and majority operations are applied on binary motif images and subjectively evaluated based on perceived quality of the enhanced images.

5 Results and Discussions

For the experiments, we selected fifty songket motifs from our collections as the test images. Experiment results are presented in the this section according to the image processing operations.

5.1 Contrast enhancement

The objective of contrast enhancement is to highlight the important portion of the image (i.e. the motifs) by changing the contrast between the motif and its background. Prior to contrast enhancement on each image, the histograms of these images are viewed.

Based on the original gray level value, the motif images can be divided into three categories. Forty-eight percent of the motif images have gray level values ranging from 0–255, twenty-eight percent from 25-255, and twenty-four percent from 0-150. This indicated that seventy-six percent of the original motifs gray values are dispersedly distributed and the others are dark images. For each image then, a number of different ranges of gray values are tested on them to achieve the objective criteria of evaluation. The results showed that fifty-six percent best gray values lies in the range 25.5-255, twenty eight percent in the range 0-200, and sixteen percent in the range 0-100.

Even though the image can be clustered into three groups, contrast enhancement has to be done individually on each motif. As shown in the result of the experiment, there is no specific range of gray scale values that can be generally applied on all motif images. Even for images in the same category of estimated gray-level range, the best gray values vary significantly. The low (minimum) and high (maximum) brightness value has to be determined by looking at the histogram and this range of values are to be used as guideline for the input and mapped to the output range of 0 to 255. The histogram stretching process will lighten the light toned areas and darken the dark toned areas. However, choosing the appropriate brightness value is vital to produce the highest contrast between the motifs and the background, while minimizing false regions. For example, Fig. 4 shows a low-contrast and high-contrast images produced during contrast enhancement. Even though the high contrast image appears superior, it also generated false regions or accentuates erroneous details in the image.

Fig. 4 False regions seen in the image on the right

5.2 Noise removal

The primary objective of noise filtering in this paper is to reduce noise as much as possible without altering the shape of the original songket motif. Results showed that sixty-one percent of the motifs are best filtered using average filter, followed by twenty-five percent using adaptive filter and fourteen percent using median filter. The type of filter chosen to remove the noise depends on the type of noise that exists in the motifs. For example, Fig. 5 demonstrates a motif with grain (Gaussian) noise filtered using a 7x7 averaging filter. Each pixel in the image is set to the average value of its neighborhood thus reducing local discrepancies caused by the grain noise. However, this method causes blurring of the motif's edges.

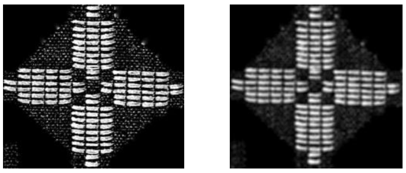

Fig. 5 Gaussian noise filtered using average filter

Motifs with irregular distinct intensities are best filtered using adaptive filter as the filter alters its behaviors based on the local image variance. When the noise variance is fairly equal to the local variance, the filter acts as mean filter and performs more smoothing. In areas where the local variance is much greater than the noise variance, it performs less smoothing and preserves edges or local details

For motifs with a lot of intricate details, median filtering works better to maintain its unique shape. Noise is suppressed by eliminating pixels with dissimilar intensity to be similar to its surrounding pixels. Although median filter does not minimize noises as efficiently as average filter but it preserves edges better.

5.3 Image binarization

Thresholding experiment showed that fifty-six percent of the images use threshold value in the range of 0.3-0.5, followed by twenty-four percent in the range of 0-0.25 and twenty percent in the range of 0.55-0.75. From observation, the images that used low threshold values are dark images, while bright images used high threshold values. All fifty motif images are also subjected to a global threshold value calculated using Otsu's method. However, this method does not produce the desired result due to the existence of noise and non-uniform illumination in the images.

5.4 Morphological operations

Out of the six morphological operations applied on the motif images, close is the most used operation followed by dilate, majority, erode, fill and open. Different operations have to be applied to the motif image to achieve the best-desired results. Dilation operation enlarges an image unnessarily. This operation is more appropriate to connect disjoint pixels of an image. Another drawback of dilation is it could enhance noise if used incorrectly. Closing, on the other hand is more accurate to fill tiny holes in an image and merge narrow breaks. Similar to closing, fill may also be used to significantly improve an image with isolated interior pixels.

Even though each of the operation can be applied individually, combinations of two or more operations applied in sequence can substantially enhanced the motif image. For example, combinations of majority and close done in sequence will smooth edges and fill tiny holes in the image. Another notable combinations of operations are erode and dilate. An image that has a lot of diminutive noise speckles can be greatly enhance if erosions are done repeatedly on it, then followed by dilations to reinstate the motif shape again.

6 Conclusion

Based on the results discussed earlier, there are no conclusive image processing techniques for digitizing the songket motif images. Instead, guidelines and recommendations for each contrast enhancement, noise reduction, binarization and morphological operations are presented. For contrast enhancement, the image histogram has to be viewed beforehand to determine the low and high brightness value. These values are then used to uniformly expand or stretch the image histogram to cover the full range of values from 0 to 255. Choosing the brightness range of values is very crucial and the appropriate range can only be identified through experimentation on each image. The primary objective of noise filtering is to reduce noise as much as possible without altering the shape of the original motif. Results of noise filtering showed that the best filter for songket motif is average filter as majority of the images contain Gaussian or grainy noise. Filtering can also be improved by using the correct filter size. However, motifs that have a lot of intricate details are better filtered using median filter to maintain its unique shape. Meanwhile, motifs with erratic dissimilar intensities are best filtered using adaptive filter. Binarization is done manually by supplying a threshold value to convert the image into binary. For dark images, the recommended choice of threshold value is between the ranges of 0.15 to 0.25, while for bright images the suitable value is within 0.55 to 0.70. On the other hand, a proper value for high contrast images is between the ranges of 0.30 to 0.40. The single most used morphological operations in this study are close, dilate, majority and erode. Even though on their own these operations can contribute in enhancing the motif images, combination of majority-close and erode-dilate are able to significantly improve their appearance.

The suggestions and guidelines given here are based on the experimental results. It can be concluded that there is not a single optimally suited method for all motifs images. It is often best to experiment with the images differently to achieve the best representation of the final binary image that resembles the actual motif. However, the guidelines and suggestion presented in this paper on using image processing techniques may be utilized to digitize motif images.

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