Classification of Batik Kain Besurek Image Using Speed Up Robust Features (SURF) and Gray Level Co-occurrence Matrix (GLCM)

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Abstract. Indonesian Batik has been endorsed as world cultural heritages by UNESCO. The batik consists of various motifs each of whom represents characteristics of each Indonesian province. One of the motifs is called as Batik Kain Besurek or shortly Batik Besurek, originally from Bengkulu Province. This motif constitutes a motif family consisting of five main motifs: *Kaligrafi, Rafflesia, Relung Paku, Rembulan, and Burung Kuau.* Currently most Batik Besureks reflect a creation developed from combination of main motifs so that it is not easy to identify its main motif. This research aims to classify Indonesian batik according to its image into either batik besurek or not batik besurek as well as reidentifying its more detailed motif for the identified batik besurek. The classification is approached through six classes: five classes in accordance with classification of Batik Besurek and a class of not Batik Besurek. The preprocessing system converts images to grayscale and followed by resizing. The feature extraction uses GLCM method yielding six features and SURF method yielding 64 descriptors. The extraction results are combined by assigning weight on both methods in which the weighting scheme is tested. Moreover, the image classification uses a method of k-Nearest Neighbor. The system is tested through some scenarios for the feature extraction and some values k in k-NN to classify the main motif of Batik Besurek. So far the result can improve system performance with an accuracy of 95.47% according to weighting 0.1 and 0.9 for GLCM and SURF respectively, and k = 3.

Keywords: Classification · Batik Kain Besurek · SURF · GLCM · k-NN

1 Introduction

Batik is Indonesian cultural heritage which philosophycally posseses visceral meaning and high value. It has also been acknowledged by United Nations Educational, Scientific, and Culture Organization (UNESCO) as one of world cultural heritage. Batik is so various kinds, almost every region in Indonesia has a different batik [1]. One of those is Batik Kain Besurek which is originally from Bengkulu City [2]. The word "Besurek" is Bengkulu language meaning "mail". Therefore Batik Kain Besurek means a batik made from fabric with writing like mail. Batik kain besurek has 5 main motifs,

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those are *Kaligrafi, Rafflesia, Relung Paku, Rembulan, and Burung Kuau* (see Fig. 1). However batik kain besurek is also an art so that a motif of batik kain besurek can sometime be created by craftsmen through combining some motifs. Hence classifying batik kain besurek based on their motifs needs to observe them thoroughly and therefore the way of classifying is a kind of problem to solve. The classification is also beneficial in term of inventorying them in manageable way. On the other hand the so many kind of batik in Indonesia have made many Indonesian people so hard to recognise between batik kain besurek and not batik kain besurek. Identifying and classifying motifs of batik constitute problems related to digital image processing.

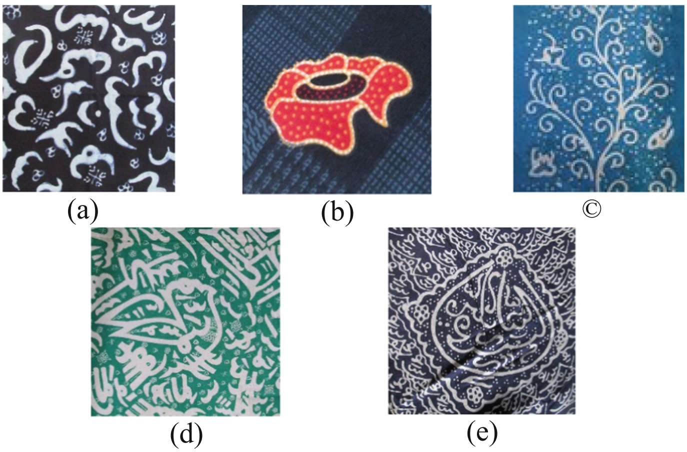

Fig. 1. Motif of batik kain besurek. (a) Kaligrafi, (b) Raflesia, (c) Relung Paku, (d) Burung Kuau, (e) Rembulan

Digital image processing [3] is a process imposed to images for obtaining some certain results as required. By using the digital images processing, the image of batik such as Batik Kain Besurek can also be processed to identify whether the image is right as the image of Batik Kain Besurek and to classify its motif with respect to a certain class of motif. This manner could be one of methods to solve the above-mentioned problem. Research on batik image processing or Content Based Batik Image Retrieval (CBBIR) is a research focused on image processing on the basis of motif characteristic and so many researchers have worked on it. Research on CBBIR that used four extracts of texture features, those are mean, energy, entropy and standard deviation, has resulted in performance 90–92% [4]. The use of treeval and treefit in term of decision tree has been utilized in research [5] to optimize CBBIR, and the result has shown the percentage 80–85%. CBBIR has also been used in research [6] where feature extraction is Gray Level Co-occurrence Matrix (GLCM) and the obtained sensitivity is 82%. This paper proposes development of extraction through other feature for a better result. Combining feature extraction of GLCM and other method has been done such as with wavelet feature [7]. GLCM and wavelet have been combined and the result has shown percentage 94.87%, more accurate performance in compared with its previous methods.

Another feature extraction that has ever been used for classification is Speed Up Robust Features (SURF). This feature extraction has made description based on yielded interest points by using wavelet as having been done in [7].

Based on the term of references above, this paper proposes another way not only to identify a batik as batik kain besurek or not but also to classify the image of the batik according to its motif. The identification of batik in this research uses threshold to differentiate a batik as a member of batik besurek class or not. The feature extraction uses the Gray Level Co-occurrence Matrix (GLCM) method as having been used by previous researchers and is combined with the Speed Up Robust Features (SURF) method. The combination of both methods gives better results [8]. GLCM constitutes one of methods to extract texture features in order to know how often the combination of pixel brightness value for different position happens for an image [9]. SURF constitutes an algorithm which is able to detect keypoint and produce description for every point. Keypoint itself is a point whose value is persistent for the change of scale, rotation, blurring, 3-dimensional transformation, lighting, and shape. Thus, the algorithm works well for images with noise, detection error, as well as geometric and photometric change [10]. In term of classification, we have used k-Nearest Neighbor Method [11] where Euclidean Distance has been used to determine distance of feature extraction result obtained through GLCM and Hausdorff Distance has been used to determine distance of feature extraction result obtained from SURF. Result of distance calculation for the feature extraction method is then combined by using weighting scheme. Afterward we could find the best weight for each of both distance according to proposed testing scenario.

2 Related Work

2.1 Research Materials

Data used in this research are both primary data and secondary data. The primary data are batik kain besurek images consisting of 117 images each of them has been collected three times (actual size, scaled down size, and rotated size) so that all images of batik kain besurek are 351 images. All the images are categorized into two groups, those are the one encompassing 70% of images stored as database for reference of classification (training) and the other one covering 30% of images for testing. The images of batik kain besurek have been taken by using a camera of size 1200 pixels × 1200 pixels. Meanwhile the secondary data comprise 20 images of not batik besurek which have been collected from internet. These latter images have been used for testing.

2.2 System Design

The system design is made to show the work flow of research. This research consists of two main parts, those are training and testing (see Fig. 2). Flow diagram is divided into two, part 1 and part 2. In both parts, the process starts with image acquisition and preprocessing. The next process is the feature extraction process for obtaining the characteristics of each image. In this system, two methods for feature extraction are

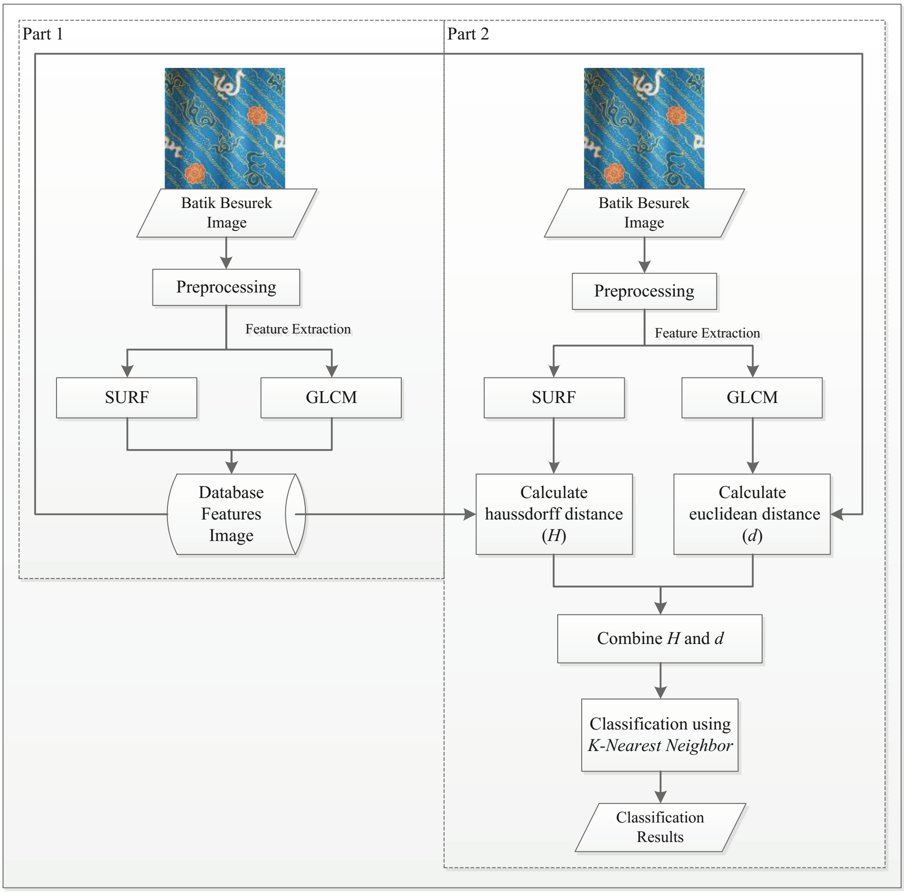

Fig. 2. Flow diagram of classification of batik kain besurek

GLCM [12] and SURF [13, 14]. In Part 1, the feature extraction results of both methods are stored into the system database. While part 2 will be a process of measuring the distance between the feature extraction of the image test and image database to obtain the results of classification.

Preprocessing

The preprocessing of this research comprises the conversion of images to be smaller for its scale and to be greyish for its color. Beside resizing its scale to be smaller, resizing is also to reduce the amount of image pixel so that the duration of system computation can be lessened. Every image input needs to make smaller to the size of about 200 × 200. Subsequently the image inputs need to convert through RGB to grayscale.

Speed Up Robust Features (SURF)

Feature extraction through SURF consists of 5 main steps as shown by Fig. 3. A SURF process is started by shaping integral image [15, 16] through reducing computational

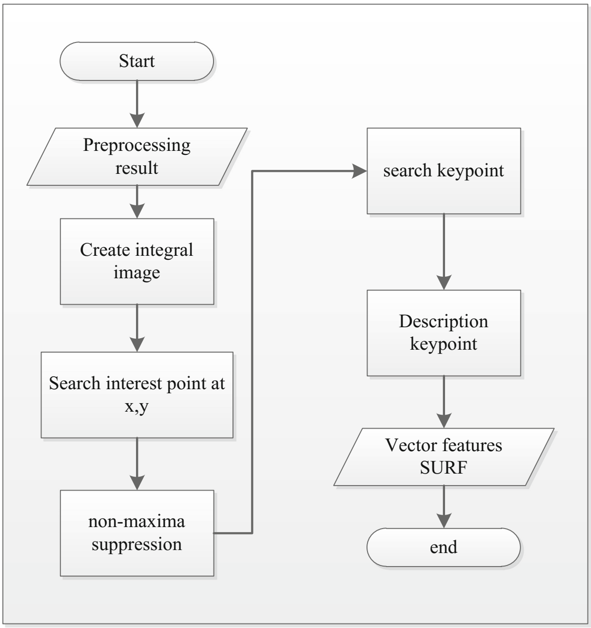

Fig. 3. Feature extraction of SURF

time [14]. Afterward a keypoint as a candidate of image feature needs to search through Fast Hessian [14]. In order to get tenacity of the feature in term of its scale, then the search of feature must be applied to a scale space in order to get image pyramid. The scale space is obtained by iterating convolution to image inputs through filter of discrete Gaussian kernel [17, 18]. In addition, a process of sub-sampling is carried out repeatedly to reduce the image size [14]. By the process, an image pyramid is shaped, meaning that the image size in the scale space decreases continuously.

After finding a feature candidate of the image in the scale space, a keypoint candidate is searched by applying non-maxima suppression method [14]. The keypoint candidate is searched by utilising extreme respons of hessian matrix. Subsequently the obtained keypoint candidate is examined again by determining its deviation. A point can be classified as a keypoint if the extreme value is smaller than the given threshold [19]. The final process is to describe the obtained keypoint. The process is done by searching pixel distribution of neighbor around the keypoint. The description aims to make the keypoint more endure with respect to an angle rotation. The obtained result of processing feature extraction through SURF is a feature vector describing image input.

Gray Level Co-occurrence Matrix (GLCM)

GLCM method of this research is the one with 4 directions (0°, 45°, 90° and 135°) and the neighborhood distance of d = 1 pixel. The direction and distance d use the result of research with best accuration [20]. Figure 4 constitutes steps of GLCM used in this research. The process starts from converting images to become greyish of 8 levels. This conversion is performed to reduce computational time. Then co-occurrence matrices for

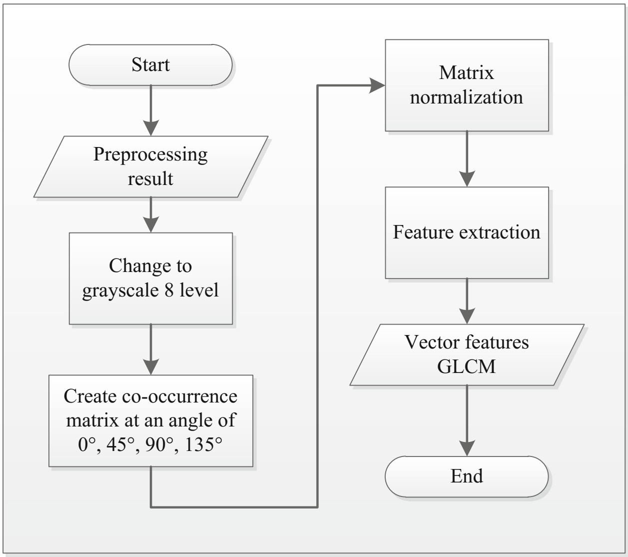

Fig. 4. Feature extraction of GLCM

4 directions are formed. The formations of 4 co-occurrence matrices are done by finding out the frequency of pixel emergence with their neighbors. All the four co-occurrence matrices then are summed up to get one co-occurrence matrix. The result is then d with respect to all matrix elemens. The feature of normalized matrix is then extracted with harlick features [21], those are contrast, correlation, inverse difference moment, angular second moment, entrophy and variance. The six parameters are the most relevant parameters of feature extraction of GLCM [12].

Classification

Features obtained from extraction through GLCM and SURF could be used as references for measuring a closest distance between object and accustomed data. The measurement is applied for different closest distances of feature extraction obtained from GLCM and SURF. In term of applying GLCM, the measurement uses an euclidean distance. Method of Euclidean Distance (ED) is the most often method used to determine distance of 2 vectors. ED can be calculated through the formula as follows

$$d_{ij} = \sqrt{\sum_{k=1}^{n} \left(x_{ik} - x_{jk}\right)^2} \tag{1}$$

Moreover, in term of applying SURF, the measurement uses hausdorff distance. Method of Hausdorff Distance (HD) is introduced by Filix Huasdorff [22]. The method works by determining a maximum distance of closest points of two-point sets. HD can be calculated through the formula as follows

$$H(\mathcal{A}, \mathcal{B}) = \max(h(\mathcal{A}, \mathcal{B}), h(\mathcal{B}, \mathcal{A})) \quad (2)$$

The classification process starts from combining the results of the distance calculation of both feature extraction methods. The combination of both methods is done by two steps, those are (1) multiplying each of the calculated feature extraction distance by the determined weight and (2) then summing up their results. If the result of the two step calculation is greater than the threshold, then the test image has been identified as a non-besurek class and the classification process has been completed. Whereas if the result is smaller than threshold, then the test image is identified to be one class of 5 batik besurek class and the process of classification of k-NN will be processed. The classification using the k-Nearest Neighbors method will involve the nearest neighbor image based on the smallest distance calculation value of k that has been determined. The class with the smallest distance is the result of image classification.

3 Experimental Results

This section explains on testing of research. The test is a weighting method combining feature extraction method, and value of k on k-NN. After having tested in accordance with the given scenario, the results can be compared to find out the best results for each test. The results of this research were compared based on the resulting performance of the confusion matrix on each test that has been done.

Before comparison of system test results for the best feature extraction method (SURF, GLCM or combination of both methods), we search the best weights for combined GLCM and SURF feature extraction. The test results on this weight search are shown in Fig. 5. The weighting results show that the weight of 0.9 for the SURF extraction method and 0.1 for GLCM provide the best system performance of the other

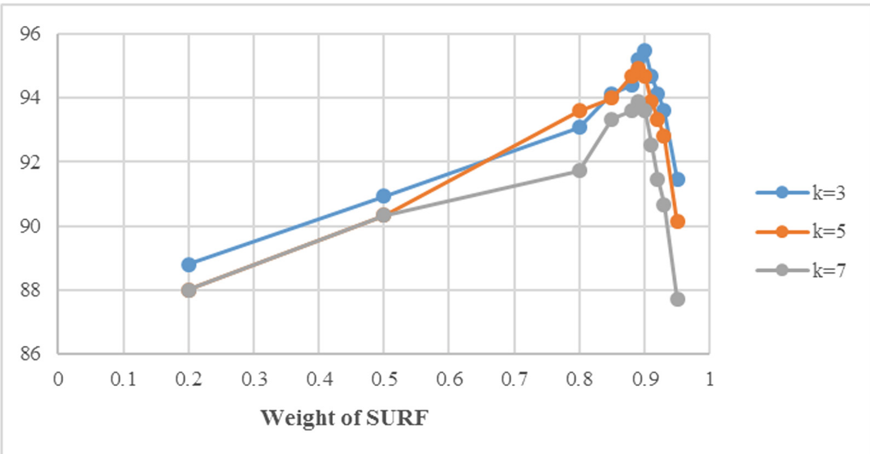

Fig. 5. The performance system to find the best weight for combined of SURF and GLCM

tested weighted ratios. Thus, the weights of 0.9 and 0.1 are weighted for combining the feature extraction methods.

After testing of both weights of extraction method, the next test are for feature extraction method and k value on k-NN. In Fig. 6, comparison graphs of the accuracy of the feature extraction methods and classification methods which are used in this research is presented. In testing of feature extraction method, it shows that the combination of GLCM feature extraction method and SURF is the method with highest accuracy result on every variant of k-NN value. On testing the variation of k, the value k = 3 is the highest accuracy value among all other k value variation. The highest accuracy on the value of k = 3 applies to all the tested featured extraction methods. Thus, the combination of both methods can improve the accuracy of the system. Moreover, the system can identify the image of batik besurek or batik non besurek and batik besurek classification according to the motifs well.

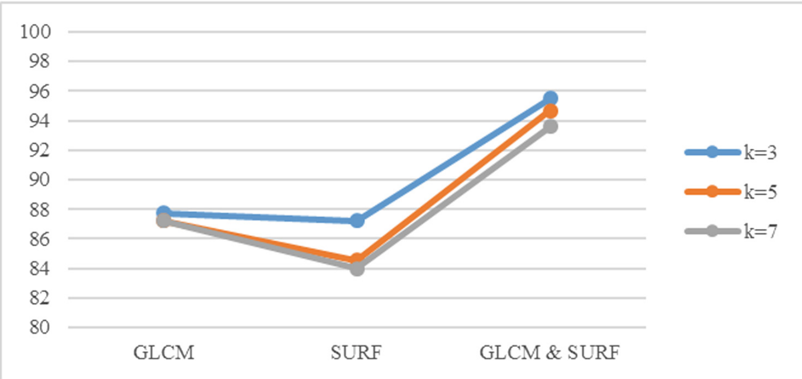

Fig. 6. Comparison of the system using feature extraction GLCM, SURF and combination of both

System performance is shown according to its sensitivity, specificity, precision and accuracy based on the confusion matrix of the system. The four best testing of SURF and GLCM combined for feature extraction and k = 3 for k-NN are shown in Table 1.

The performance according to sensitivity is useful for measuring the proportion of a predefined class according to actual conditions. This system has the highest percentage of sensitivity that is 100% for class of relung paku and rembulan. Thus, all tested images in the class of relung paku and rembulan are well predicted. This is evidenced by 0 in False Negative (FN) column for the class of relung paku and rembulan. The FN column shows the number of incorrect predictably tested images. While the smallest sensitivity for the class of rafflesia is 70.37% with the number of correct (TP column) predictably tested images are 19 images and the number of wrong (FN column) predicted images are 8 images. The average sensitivity of the results of this study is 88.19%.

Table 1. The testing on the combination of SURF and GLCM with 3-NN

No	Class name	TP	FN	FP	TN	Sensitivity (%)	Precision (%)	Specificity (%)	Accuracy (%)
1.	Raflesia	19	8	0	98	70.37	100.00	100.00	93.60
2.	Kaligrafi	27	4	2	92	87.10	93.10	97.87	95.20
3.	Burung Kuau	11	1	2	111	91.67	84.61	98.23	97.60
4.	Relung Paku	20	0	5	100	100.00	80.00	95.24	96,00
5.	Rembulan	15	0	6	104	100.00	71.43	94.54	95.20
6.	Non besurek	16	4	2	103	80.00	88.89	98.09	95.20
Average						88.19	86.34	97.33	95.47

The performance based on specificity is the proportion of incorectly predefined class with respect to the actual conditions. This performance is calculated to measure how well the training image of the class which is independent of other classes. The average specificity performance in the six classes is 97.33% and the specificity performance for each class is greater than 94%. The highest performance of specificity is found in the class of raflesia, 100%. This shows that the class of raflesia does not affect the results of other class classifications.

Predicting data as member of a class does not mean that the data is assured correctly for the class. It is possible that the data are member of other classes. The possibility that we can do is by determining the performance of precision. Precision is a measure of the performance determined by calculating the proportion of a predictable class according to the true condition of all correctly predictable data. The highest precision performance is shown in the class of raflesia with a percentage of 100%. It shows that the test data of the other 5 classes is unpredictable as the raflesia class. While the lowest precision is related to the class of rembulan with a percentage of 71.43%. The average of system precision is 86.34%. Finally the last measure of performance is accuracy. This accuracy is the percentage of correct predictably data of a class. The average percentage of accuracy is 95.47%. The accuracy for each class is above 93%.

4 Conclusion

In this paper, we presented comparison GLCM and SURF as well as the combination of both methods for feature extraction. Based on the results of research, it can be concluded that the combination of GLCM and SURF methods can improve the accuracy of classification of the batik besurek's main motif. It is verified that the combination of both methods has resulted in the highest accuracy performance related to the testing scenario. The highest average accuracy for the combined methods of feature extraction is 95.47%. The accuracy is obtained by combining the GLCM and SURF methods with the weight of 0.1 for GLCM method and the weight of 0.9 for the SURF method, whereas regarding the classification using k-NN, the value k in the test yielding the highest accuracy is k = 3. Testing with the highest accuracy performance is a highest performance test besides other measure of performance such as sensitivity, specificity and precision. It means that the highest performance is the convincing result of testing. Class of relung paku and rembulan have made sure of 100% as the highest sensitivity for the performance testing of the combined feature extraction methods. It suggests that the combination of both GLCM and SURF methods can help to identify the motif of relung paku and rembulan very well.

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