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Content-Based Image Retrieval for Songket Motifs using Graph Matching

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Abstract: . Indonesia is a country that has abundant cultural wealth. One of the characteristics of Indonesian culture is Songket. Songket is a typical Malay woven cloth that has many variants of motifs, each of which represents a different meaning and philosophy. Songket is often found in Sumatra Island with different motifs in each region. With so many types of songket motifs, not everyone can recognize and distinguish between one songket motif and another, even Indonesian citizens themselves. With the help of computers, it is easier to find information about a songket motif or to find a similar songket motif. The field that can play a role in solving this problem is Content-Based Image Retrieval (CBIR). This study aims to carry out a content retrieval process on the songket core motif using graph matching-based processing. In this study, the method used is felzenzswalb segmentation, and graph matching through the VF2 isomorphism algorithm and graph edit distance. The number of songket core motif images used as data is 180 data in the form of color images measuring 64 x 64 pixels. Based on the results of the study, it was found that the optimal graph matching algorithm and parameters in this study were the VF2 algorithm for artificial images with an f-1 score of 91.05%, and Graph Edit Distance with GED≤8 parameters for songket motif images with an f1-score. by 53.36%.

Keywords: Classification; Sentiment Analysis; Shopee; SVM; Mining Opinion.

INTRODUCTION

Songket is a typical Malay woven cloth that has many types of motifs that represent different meanings and philosophies (Yusof, Ismail, & Majid, 2019) . With so many types of songket motifs, not everyone can recognize and distinguish between one motif and another. Coupled with the absence of data collection on the type of computer-based songket motifs (Imran & Efendi, 2020) . Supposedly with the current development of artificial intelligence, finding information about songket motifs can be done easily.

A number of studies on the classification of various types of songket motifs have been carried out by various researchers with different methods. By applying the Speeded-Up Robust Feature to the Random Forest algorithm, the classification of the emblematic songket motif was successfully carried out with an accuracy rate of 77.78% (Yohannes, Devella, & Pandrean, 2019) . The test results on 40 types of songket motifs using the Backpropagation Neural Netwrok algorithm reach a precision level of 98% and recall 99% (Yuhandri, Madenda, Wibowo, & Karmilasari, 2017) . Songket type classification using the Principal Component Analysis and K-Nearest Neighbor algorithms produces an accuracy of 91.67% with a note that the quality of the songket image greatly affects the level of accuracy (Hasan & Liliana, 2020) .

Content-Based Image Retrieval (CBIR) is one of the applications of computer vision that is used in the problem of finding digital images in large-scale data. The difference with the traditional method is that CBIR uses the pixel features contained in an image, while the traditional method uses image indexation based on descriptions or text for each image in the database. Traditional pixel-based image processing and classification methods do not produce efficient extraction because they only represent the contents of each pixel.

a graph-based image processing and analysis method is proposed . A graph-based approach can be used to provide a more efficient image description through a collection of vertices with attributes determined by image components, as well as *edges* with a weighted value approach that suits the needs of the image (Sharma et al., 2012) . Graph also requires a very simple process with more efficient methods (Malmberg & Ciesielski, 2020) .

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This study aims to carry out the image retrieval process on the songket core motif using graph-based processing. The algorithm that will be used in this process is Felzenzswalb segmentation, and graph matching using VF2 Isomorphism and Graph Edit Distance. The formulation of the problem in this research is how to implement graph matching in order to provide relevant results for digital image retrieval of songket motifs used in this study and how the results are.

LITERATURE REVIEW

Content-Based Image Retrieval (CBIR) offers a convenient digital image search technique in a large database (Prasetyo, Wiranto, Winarno, Salamah, & Harjito, 2018) . In CBIR, the image is taken based on a comparison of colors, shapes, textures, or other information related to the image itself (Oksaputri, Ernawati, & Andreswari, 2018) . CBIR was created because it is believed that manually inputting words in the form of keywords or metadata by humans is time consuming and does not necessarily lead to the right keywords to describe the image. The accuracy value of the CBIR is determined by the number of clusters and the appropriate vocabulary factors (Baso & Suciati, 2020) .

graph is a set that has a number of points, called vertices (*vertices* or *nodes*), which are connected to each other through lines called *edges* (Sharma et al., 2012) . In general, *graph* G is defined as a pair of sets (*V, E*), written in $G = (V, \varepsilon)$which in this case *V* is a non-empty set of *nodes* and $\varepsilon$is a set of *edges* connecting a pair of vertices (Martey, Lei, Li, & Appiah, 2021) . Graph serves as a representation of information that has long been used since 1970 in recognizing an object (Brun, Foggia, & Vento, 2020) . The advantage of graphs is that they work by looking for relationships between objects, and can be applied to machine learning (Holzinger & Jurisica, 2014) .

Graph has image segmentation methods, one of which is the method proposed by Felzenzswalb. This segmentation method was proposed in the 59th International Journal of Computer Vision (2004) with the title "Efficient Graph-Based Image Segmentation" written by Pedro F. Felzenszwalb. This method uses a graph in the form of a Minimum Spanning Tree (MST) and the Kruskal algorithm approach as a representation for the segmentation process. This algorithm has been tested for real and artificial images. Running time for this algorithm runs linearly with the number of edges (Felzenszwalb & Huttenlocher, 2004) . This method can measure regional boundaries by comparing two quantities: based on the difference in intensity of opposite regional boundaries, and based on the intensity between neighboring pixels in each region. The algorithm in this method contains input in the form of *graphs* $G = (V, E)$, with $n$vertices and $m$sides. The output that will be produced is segmentation Vinto components $S = (C_1, \ldots, C_r)$which are a combination of regional components that have been grouped.

Graph Matching is the process of comparing two graphs to measure a similarity or dissimilarity relationship between the vertices and edges of the two graphs. This refers to the process of mapping F from the vertices of a graph G to the vertices of another graph G' that meet the limits or optimal criteria. One application of graph matching is the Graph Edit Distance. Graph edit distance (GED) is a technique to measure the similarity between two graphs. The initial concept of this technique was first introduced by Alberto Sanfeliu and King-Sun Fu in 1983 (Sanfeliu & Fu, 1983) . Its main application is inexact graph matching or error-tolerant pattern recognition.

GED between two *graphs* $g_1$andg_2 mathematically written as $GED(g_1, g_2)$, and can be defined as follows:

$$GED(g_1, g_2) = \min_{(e_1, \ldots, e_k) \in P(g_1, g_2)} \sum_{i=1}^{k} c(e_i) \quad (1)$$

Where is $P(g_1, g_2)$denoted as a set of *edit paths* which transform $g_1$to isomorphic form of $g_2$and is the cost value of each $c(e) \geq 0$*graph* change operation .

METHOD

This research was conducted to build a graph-based analysis that can be used to recognize digital songket images. The whole process of analysis starting from segmentation, and classification will be done using a graph-based method. The data used is a simple digital image that represents an object. As for the testing process, it will be done by testing each data against the entire dataset. Figure 1 shows the stages of the research to be carried out.

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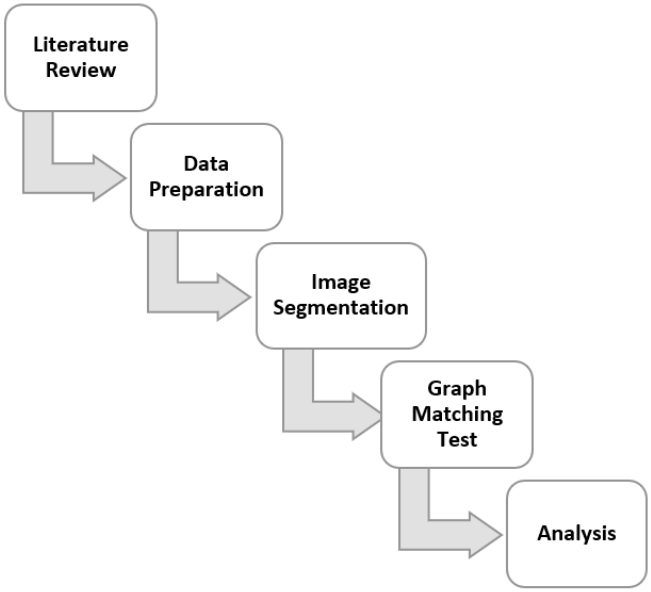

Fig 1. Research Framework

Data Preparation

The data used in this study are 200 synthetic image data with a size of 64 x 64 pixels consisting of 4 different classes, so that each has 50 images. Figure 2 shows a sample of artificial image data.

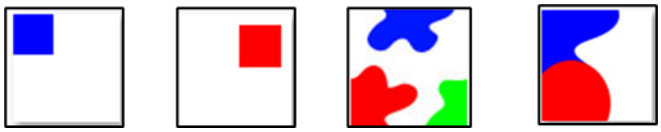

Fig 2. Artificial Image Data Sample

While the songket motif data with a size of 64 x 64 pixels consists of 3 types, namely, Songket with the Tampuk Mangosteen, Bamboo Shoots, and Silver Pucuk motifs which are typical songket motifs from Batubara Regency, North Sumatra. Each type of songket motif consists of 60 images each to be included in the dataset. Then the images must be separated from one another. Separation of motif patterns is done by cropping technique. Each songket motif will be cropped as many as 60 pieces based on the boundaries between patterns. Figure 3 shows the sample from the cropping results with the songket tampuk mangosteen motif.

Fig 3. Songket Core Motive Collection

Image Segmentation

At this stage, the image segmentation process will be carried out into simpler parts. The method used is segmentation through a graph-based approach with the method proposed by Felzenzswalb. This segmentation process is assisted by the library from scikit- image in python through a **segmentation.felzenzswalb function**.

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Then the parameters of the function are adjusted, to get the segmentation results in accordance with the perception of the number of regions that should be. The input at this stage is a 64 x 64 x 3 digital image. After processing, the output is produced in the form of a label with an n-dimensional array data type of size 64 x 64 which shows the region label for each pixel. Figure 4 shows a simple example of segmentation on an 8 x 8 x 3 image, so that a label is obtained in the form of an 8 x 8 array. Then the label will be stored in *.csv format on the storage media.

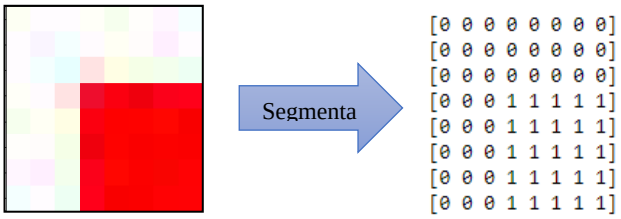

Fig 4. Segmentation Results

Graph Matching Test

In this step, an image will be given as input to obtain data that is similar to the image based on the specified graph matching algorithm. The algorithm used is the VF2 algorithm and Graph Edit Distance. The output of this step is a digital image that is similar to the test image given in each experiment. The image to be tested is taken from the dataset, and will be processed against each dataset. The image will be given the same treatment as in the dataset, namely segmentation, then matched to the entire dataset.

RESULT

The segmentation parameter settings are carried out on 200 artificial images that have been prepared. This test does not use ground truth as a comparison. Because the artificial image used is simple, parameter tests will be carried out to find the unique number of each group of images by tracing around the best value in the reference (min_size = 300). The smaller the value of the uniqueness of the cluster in each image class, the better the segmentation performed. The following are the results of the observation of determining the parameters for the segmentation stage shown in Table 1.

Table 1. Exploratory Data Analysis

min size	**Image Group**				**Unique Cluster Total**
	I	II	III	IV	
200	2	0	27	3	32
210	2	0	25	3	30
220	2	0	23	3	28
230	2	0	23	2	27
240	2	0	22	2	26
250	2	0	22	2	26
260	2	0	23	0	25
270	0	0	21	0	21
280	0	0	21	0	21
290	**0**	**0**	**20**	**0**	**20**
300	0	0	22	0	22
310	0	0	22	0	22
320	0	2	24	0	26
330	0	2	24	0	26
340	0	2	25	0	27

Based on the observations above, the lowest uniqueness value of the cluster is obtained at min_size = 290. As for the parameters after that, the total uniqueness value will be higher. So the value above will be used for this research.

Then evaluate the two types of data against each other, artificial against artificial, and songket motifs against songket motifs. Each data is compared with all data so that in the artificial image, 200 precision, recall, and f1 scores are obtained, while in the songket motif image, 180 precision, recall, and f-score values are obtained.

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Then for each type of data, an average value is taken for each given algorithm/parameter. Table 2 is the evaluation result of the graph matching process that has been tested with various parameters in the CBIR system.

Table 2. Graph Matching Evaluation Results

Data	Precision (%)	Recalls (%)	F1-Score (%
Artificial (VF2)	97.35	85.52	91.05
Artificial (GED 1)	96.01	78.94	86.64
Artificial (GED 2)	98.19	78.94	87.52
Artificial (GED 3)	45.61	81,12	58.39
Artificial (GED 4)	39.76	82.40	53.64
Artificial (GED 5)	30.38	87.56	45.11
Songket (VF2)	90.79	21.94	35.34
Songket (GED≤ 1)	92.36	5.59	10.54
Songket (GED≤ 5)	76.79	24.91	37.62
Songket (GED≤ 7)	69.29	41.54	51.94
Songket (GED≤ 8)	50,11	57.07	53.36
Songket (GED≤ 9)	40,40	64.37	49.64

DISCUSSIONS

Based on the test data, the best results are found in artificial data with the VF2 algorithm. Which this algorithm is part of exact matching. This can happen because the artificial image has a simple number of clusters, so that the predicted clusters from the segmentation results are almost completely correct. As for the second data (songket), the best results were obtained using GED≤8. GED is a category of inexact matching or error-tolerant matching. In this case, the image of the songket motif has a fairly complex number of clusters so that the results of the segmentation process also give different values for each data class. So the number of vertices and edges that are formed varies.

From this it can be found that the results are very dependent on the segmentation process. Especially on the number of graph nodes whose value will be equal to the number of clusters created from the segmentation process. Then in the isomorphism graph, if the two graphs compared do not have the same number of vertices and edges. The result will definitely be false. Therefore, GED plays a better role in images with a number of clusters that are difficult to define with the naked eye (eg in songket images). So that error-tolerant matching will work better on this type of image.

CONCLUSION

After testing graph matching and analyzing the data, it is concluded that to get relevant results in digital image retrieval of songket motifs, the dataset used must be an artificial image with segmentation parameter min_size = 290 and the algorithm used is VF2. The best results obtained are artificial images with an f1-score of 91 0.05%, and Graph Edit Distance with parameters $GED \leq 8$for the songket motif image with an f1-score of 53.36%.

Based on these results, it is possible to conduct research such as using data that has more complex image cluster information and contrasting color differences. In addition, it is also better to carry out further evaluation at the segmentation stage to produce a better segmented image. As for research related to other fields, the graph matching method can be replaced using machine learning or deep learning-based methods to get more optimal results.

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