Copy-move Image Forgery Detection using Autocolor Correlogram

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***Abstract*—Digital images are one of those digital objects that are vulnerable to counterfeiting, so it takes a technique that can detect the authenticity of digital images. One of the techniques used to detect the authenticity of digital images is by using auto color correlogram algorithm to compare the image blocks. The use of autocolor corelogram in image forgery detection process has been done by some researchers. There are several other algorithms that can be used to improve the performance of autocolor correlogram algorithm, one of which is the relevance feedback algorithm. Relevance feedback algorithm is an algorithm that receives user feedback, this algorithm is used in image search process using autocolor correlogram to update the parameters of similarity to improve search accuracy. In this research, a combination of relevance feedback algorithm and autocolor correlogram is used in image forgery detection. The results of the tests that have been done show thet the use of relevance feedback algorithm provides an accurate increase of about 10% if it receives user feedback and has an accuracy reduction of about 9% if it receives feedback from the affine block.**

keywords— block images, feedback, pixels, affine blocks

I. INTRODUCTION

Images or digital imagery holds an important role in everyday life. Digital imagery is generally used as a medium for conveying information. For example, in the advertising world, digital imagery is used as a medium to introduce products owned by a company. In the world of entertainment, digital images are inserted with content that contains drama or joke. In addition, digital images are also used in the legal world as evidence of an event.

Along with the development of technology and information, began to emerge various kakas that allows us to manipulate digital images easily as Photoshop, CorelDraw, and others. Image manipulation can aim to change the features in the image so that the image becomes more interesting and informative. But the manipulation of images can also aim to change the information contained in the image. For that, it takes a method to ensure a digital image is an authentic digital image.

Manipulation of digital images is divided into three types: copy-move, image splicing, and image retouching [6]. Copy-move is an image manipulation process used to duplicate or eliminate information in digital images. Copy-move is done by taking a certain part of the digital image, then moving that part to another part of the same digital image. Image splicing is a manipulation process by combining objects that exist in an image to another image. This process is done by taking a particular object from two or more images, then the objects are combined to produce a new image. Retouching is the process of image manipulation by changing color and lighting on the image.

The method of detection of image forgery is divided into two approaches of methods, active approach and passsive approach [6]. The most commonly used active approach is digital watermarking. Digital watermarking is done by adding a watermark to the image. If the image is manipulated, it will cause changes to the watermark that has been inserted in the image. The disadvantage of this method is that not all images are watermarked when the image is taken, so this method is not always usable. In the detection of changes in images using a passive approach does not require a watermark to detect changes. Passive approach method is generally done by checking features such as lighting, color borders, and the relationship of one pixel with other pixels in the image. This causes the passive approach does not require information when the image has not been changed.

Some of the passive approaches that have been developed are using extracted features such as lighting), Hidden Markov Model, SIFT and others. In addition, image forgery detection techniques can also be done by comparing image blocks using image retrieval algorithms. Image retrieval is a technique used to search images from a set of images. This technique is done by dividing the image into blocks of images, then comparing one block with another block.

One of the image retrieval algorithms used for image block comparison is autocolor correlogram algorithm [1]. Detection of image forgery with autocolor correlogram algorithm is done by dividing the image into several blocks of the image of the same size. The blocks of images are rotated eight times. Each block that has been rotated will be calculated the value of the color correlation. Each image block correlation value is compared with the other image block correlation value. Differences in each image block will be measured. If the measurement results show that two blocks are equal, it can be concluded that the block is a forged block

The autocolor correlogram algorithm can be combined with several techniques for better image search results. Some of the techniques used are relevance feedback [8]. Relevance feedback aims to improve the accuracy of image search results by updating the comparison parameters based on user feedback. It is hoped that applying the correlogram and relevance feedback algorithms can improve accuracy in the image forgery detection process.

II. Fundamental Concept

A. Digital Images

Digital images or digital images are digital data on a computer that represents an image. Digital imagery consists of a collection of image pixels with the number of pixels in each digital image depending on the size of the digital image. The number of pixels on a digital image of size $n \times m$ will have $n \times m$ pixels. In addition, digital imagery can also be described as a collection of pixels represented by functions $f(x, y)$ with x and y being the coordinates on a plane (Rafael & Richard, 2008). Each function $f(x, y)$ will have a value indicating the color value at x and y coordinates. The value of each pixel in a digital image is represented by using color models in the form of numbers. In general, a color model is a combination of several primary colors. Each uses a different primary way and color to represent a color. Commonly used color models are RGB, CMYK, YCbCr, HSB, and CIE - XYZ.

In the RGB color model, the primary colors used are red, green, and blue. The red color mixed with the green will produce a yellow color; green and blue will produce cyan colors; while blue and red will produce magenta colors. The combination of blue, red, and green in full intensity will produce white. This model fits perfectly with the psychology of the human eye that has receptors for these three primary colors.

B. Image Forgery Technique

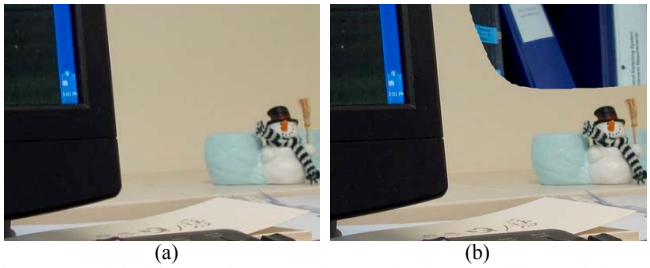
Image forgery is an attempt to change the authenticity of the image. Image forgery is generally done by removing or adding certain information to the image. The techniques used in the process of image forgery are divided into three types: copy-move, image splicing, and image retouching.

1) *Copy-move*, the most popular technique used to do image forgery. This technique aims to add and remove the information contained in the image. This technique is done by taking a certain part of the image, then the part is placed on the other part of the picture (see an example in Fig. 1). The technique is generally ideal on images that have features like grass, leaves, and other features that have repeating patterns. This causes the human eye is difficult to detect changes that occur. In addition, this technique is also ideal used to duplicate a particular object in the image.

(a) (b)

Fig. 1 (a) Original image, (b) Forgery image after copy-move technique [10]

2) *Image splicing*, image forgery techniques are done by taking a certain part of the image, then placed on another image. The image part can come from two or more images. By combining several parts of the image, it is expected to produce a new image (see an example in Fig. 2). Because of the merging process involves more than two images, thus causing anomalies in image features such as lighting, geometry, and more. To overcome the anomaly of the merged features, adjustments such as smoothing image boundaries, and rearrange the illumination of the image.



(a) (b)

Fig. 2 (a) Original image, (b) Forgery image after image splicing technique [10]

3) *Image retouching*, image fraud techniques performed by altering lighting, geometry, and color. Image retouching generally aims to embellish the image without changing the information from the image (see an example in Fig. 3). This technique can be found in various applications either on mobile devices or applications used by photographer.

(a) (b)

Fig. 3 (a) Original image, (b) Forgery image after image retouching [10]

C. Copy-move Image Forgery Detection

Detection of image fraud caused by copy-move technique is done by using two approaches: block-based approach and keypoint-based approach.

An image fraud detection process that uses a block-based approach performs a sequence by dividing the image into multiple image blocks in the pre-process stage. Then from each image block performed feature extraction. Each feature gained from each image block is then compared with features obtained from other image blocks. Comparison of image blocks aims to obtain the similarity between blocks of images.

Keypoint-based is a copy-move detection technique by extracting local features on images such as angles and areas that have certain color brightness. Keypoint-based has resistance to local and global changes in images. This technique is commonly used in image recognition, image comparison, and motion detection

D. Autocolor Correlogram

Autocolor Corelogram is a technique used to compare two images. This technique uses the color correlation in the image. This technique is quite effective and requires less resources. Autocolor correlogram is able to detect image changes at large

tolerance limits. Based on experiments conducted by Jing Huang et al (1997), this technique gives better results than histograms.

The autocolor correlogram technique uses each pixel in the image to generate an $i \times j$ matrix that maps the color pair values. The value of the color pair is the probability value of a pixel having a color i will have a pixel neighbor that has a color j at a distance k. This matrix tends to be stronger against substantial changes in images such as changes in viewpoints, background changes, enlargements, and more.

Notation. Assume I is an image that has a dimension $n \times n$ (for convenience, the image used is a square image). The value of one correlogram matrix cell is formed by using p_1 and p_2 where $p_1 \in I$ and $p_2 \in I$. To determine the value of the distance between pixels using $L_\infty - norm$, so that for each $p_1 = (x_1, y_1)$ and pixel $p_2 = (x_2, y_2)$ defined $|p_1 - p_2| \triangleq \max\{|x_1 - x_2|, |y_1 - y_2|\}$, Then defined $[n]$ where $[n]$ is $\{1, 2, 3, \dots, n\}$.

By using as distance, and, the correlogram value can be defined as follows:

By using $d \in [n]$ as distance where $i, j \in [m]$ and $k \in [d]$, correlogram value can be defined as follows:

$$\gamma_{c_1,c_2}^{(k)}(I) \triangleq \Pr_{p_1 \in I_{c_i}, p_2 \in I}[p_2 \in I_{c_j} | \, |p_1 - p_2| = k]$$

Each pixel with color c_1 in the image, define $\gamma_{c_1,c_2}^{(k)}$ is the probability that a pixel at a distance k of pixels is pixel with color c_j. Each correlogram value for each i, j, and will be stored so that the correlogram size will be obtained $O(m^2 d)$.

Autocolor correlogram is the development of color correlogram. Autocolor correlogram uses only identical color correlation. The autocolor correlogram is defined as follows:

$$\gamma_c^{(k)}(I) \triangleq \gamma_{c,c}^{(k)}(I)$$

Using this technique, the required correlogram size is equal $O(md)$. This will reduce the size of the correlogram matrix that needs to be stored. In addition, because the resulting matrix is smaller, the required computation will become smaller, so the time required will be less.

III. Related Works

A. The Use of Autocolor Correlogram Algorithm on Digital Image Count Fading Detection Process

Detection of digital image counterfeiting using an autocolor correlogram performed by Ashwini and Siddharth (2016). The image forgery detection process is done by following steps:

- Pre-process, filter noise and divide the image into multiple blocks of images
- Each image block is then performed 8Z affine transformation. 8Z affine transformation is the process of transforming the image blocks into blocks of rotation and feedback from the initial blocks
- Extracts the correlogram feature for each image block
- Compares one block of drawing with another image block using the obtained correlogram matrix.

The detection of image fraud using this technique has a higher accuracy than other techniques such as DCT, PCA, and SURF.

B. Use of Relevance Feedback Algorithm in Image Search Process

The research conducted by Ramadass and Santhosh (2013) aims to improve the accuracy of image search by updating the value of the comparison coefficients by using the relevance feedback technique. Relevance feedback is a technique that receives feedback from users whose purpose is to know whether the output is obtained according to the user with the expected output. Relevance feedback technique used in this research is query movement point. Query movement point is one of the relevance feedback relevance feedback techniques that evaluate the system by updating the query limit used for the comparison process.

The application of feedback relevance technique on image fraud detection process is done on the test data. Test data in the form of a collection of images that have been known whether the image is genuine or not. The comparison parameters will be matched with a certain value. The process of parameter change is done by receiving input from the user stating whether the forgery detection result is accurate or not. Each user input will change the value of the comparison parameter. The process of changing parameters using the Rocchio algorithm.

IV. Proposed Method

A. Use of the Correlogram Autocolor on Image Fraud Detection

Autocolor Correlogram is an image retrieval algorithm that utilizes correlation between colors. any correlation between colors will be mapped into a correlogram matrix. To determine an image is the same image with another image by comparing the correlogram matrix resulting from the image. In the image fraud detection process, this algorithm is used in the image block comparison process using a block-based approach. The correlogram autocolor algorithm is an algorithm that is resistant to various manipulation pretypes such as rotation and scaling.

There are several that affect the accuracy of image fraud detection, one of which is the image block size. The image block size that is too large can cause the resemblance between blocks to be lower. But if the image blocks used are too small, it can cause too many blocks that have a high resemblance. This is because the smaller the block image will be used, then the number of pixels that will be used to produce the correlogram matrix will be less. So that more correlogram matrices will have a high resemblance even though the block is not the resultant block of manipulation.

In addition to the preprocessor and image block size factors, another factor that may cause deterioration of detection accuracy is the inappropriateness of the image block drawings. so the similarity value obtained is quite low even though the block is the resultant block manipulation. To solve the problem, can do with the use of affine block which is the result of the initial block transformation with value and value.

B. *Use of Relevance Feedback and Autocolor Correlogram on Image Detection Process of Authenticity*

In the process of comparison the two image blocks required coefficients which become parameters to express the similarity between the two image blocks. The coefficients can be determined by experimenting so as to obtain the most effective limits. A boundary value will be considered more effective when the amount of true positive is high and false positive is low. True positive is the true system condition in detecting the block of manipulation while false positive is the block considered to be manipulated result but the block is not the result of manipulation. The determination of this similarity parameters can be done by using relevance feedback algorithm. The use of relevance feedback algorithm is done by accepting and evaluating user input. Then the evaluation result will be used as the value of similarity parameters. One method that can be used to evaluate similarity parameters is to use the Rocchio algorithm.

The evaluation that will be given by the user is a value stating whether there is a positive and false positive. Other parameters that can be used as user input evaluation parameters are true and false. Since the objective of the evaluation is to increase the positive true value and subtract the positive false value, then the user input to be used is the parameter stating whether there is true positive and false positive. The formula of Rocchio algorithm that will be used is as follows:

$$q' = q + \frac{\alpha}{n}\sum_{i=0}^{n} X_i - \frac{\beta}{n}\sum_{i=0}^{n} Y_i$$

The value of q' is the value of the evaluation result obtained from the user feedback. X is a value between 0 and 1 indicating whether there is a positive true or not, Y is a value between 0 and 1 indicating there is false positive or not and n is the number of user feedback. The coefficient α is the weight parameter of value X and the coefficient β is the weight parameter of value Y.

V. Experimental Results

Experiment is done by using 40 pieces of test images. The tested images consist of un manipulated images and manipulated images with copy-move techniques coupled with rotation and scaling.

The accuracy of a test result image will have the values grouped into three values of 0, 0.5, and 1. The value 0 is the condition where there is asn error in the detection result and there is no correct detection result. Value 0.5 is the value where there is an error in the detection result but also the correct detection result, while value 1 is a condition where there is a correct detection results and no error results detection.

Fig. 4, 5, and 6 show some experiment results. Fig. 4(a) shows image of copy-move manipulation and Fig. 4(b) shows image of detection result. Green lines in Fig. 4(b) indicate two objects as result of copy-move manipulation.

Fig. 5(a) shows image of copy-move manipulation with scaling. The copied object was scaled before it was moved to other area in the image. Fig. 5(b) shows image of detection result.

Fig. 5(a) shows image of copy-move manipulation with rotation. The copied object was rotated before it was moved to other area in the image. Fig. 5(b) shows image of detection result.

Fig. 4 (a) Image of copy-move manipulation results. (b) Image of detection result

Fig. 5 (a) Image of copy-move and scaling manipulation results. (b) Image of detection results

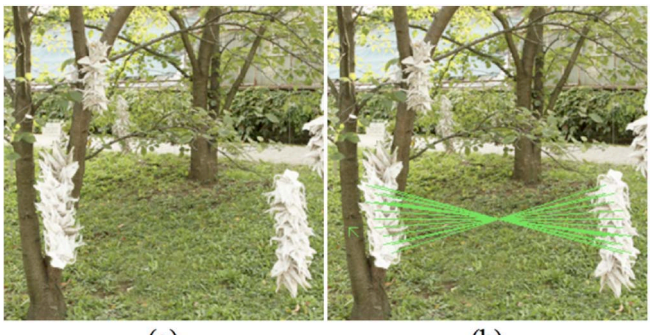


Fig. 6 (a) Image of copy-move and rotation manipulation. (b) Image of detection results

The test of the effect of user feedback on application performance is performed using six (α, β) values (0.25, 0.25), (0.5, 0.5), (1, 1), (2, 2), (4, 4), and (8,8). This test aims to derive a comparison of values (α, β) and their effect on increasing accuracy. The result of comparison of value (α, β) and its effect on increasing accuracy can be seen in Table 1.

Table 1 Test result with different values α and β

α	β	*Iteration*	*Accuracy*
0.25	0.25	10	0.65
0.5	0.5	10	0.68
1	1	5	0.71
2	2	3	0.71
4	4	2	0.71
8	8	2	0.68

From the table above can be seen that the best accuracy obtained is 0.71 using the value α and β is (1, 1), (2, 2), and (4, 4). And the value α and β = (4, 4) has a small iteration to get the best accuracy value that is 2 times iteration. Then another test is done using the value α = 4 and β the change. Test results can be seen in Table 2.

Table 2 Test result using value α = 4 and various β values

α	β	*Iteration*	*Accuracy*
4	0.25	2	0.68
4	0.5	2	0.68
4	1	3	0.71
4	2	4	0.68
4	4	2	0.71
4	8	2	0.48

Another test is done by using fixed value of β and various α values, as shown in Table 3.

Table 3 Test result using value β = 4 and various α values

α	β	*Iteration*	*Accuracy*
0.25	4	1	0.46
0.5	4	1	0.46
1	4	1	0.46
2	4	2	0.49
4	4	2	0.71
0.25	4	1	0.46

The values of α and β are the weight values of the similarity limit variables. The greater the value of α and β then the change in similarity parameters that occur will be greater. When seen from Table 1 it can be seen that the smaller α and β values require longer iterations to obtain the best parameter values compared with larger α and β values. However, in large α and β values it can cause decreasing accuracy because it passes the best possible resemblance so that accuracy decreases.

In the test process using a fixed value of a value b smaller than 2 causes the distance of the similarity limit to be large. This is because the value of a small feedback multiplier Y, so feedback X will have a greater effect. While testing using a fixed value b with a value smaller than 2 causes the increase in the distance of the resemblance limit from one iteration to the next iteration becomes smaller.

In addition to using several parameters (α, β), tested using two similarity parameters are 0.88 and 3.62 obtained from the user feedback. The two similarity parameters are then used on 40 pieces of test data. Accuracy obtained is 77.5%.

Tests performed using two similarity parameters have higher accuracy than using one similarity parameter. This is because there are some suitable images using low similarity parameters, and there are some images that are more suitable to use a high similarity parameters. A suitable image using a low similarity parameters is a manipulated image with copy-move technique without other operations such as rotation and scaling. While suitable images using a high similarity parameters are images manipulated with copy-move techniques with scaling and / or rotation operations.

VI. Conclusion

Based on the research and experiment that has been done. The following conclusions are obtained.

1) The use of relevance feedback algorithm gives an accuracy increase to 77.5%.
2) The use of α and β parameters on the great relevance feedback can speed up the process of formation of the best similarity parameters but increase the probability of the resulting parameters is too large, causing a decrease in accuracy. Meanwhile, the use of small parameters slows down the detection process but the possibility of the formation of parameters that are too large gets smaller. From the test results, the parameter values α and β which produce the best accuracy with the lowest iteration count are 4 and 4.
3) The use of two or more similarity parameters can improve accuracy. This is because there are images that match the small similarity parameters that are smaller than one and there are images that match the big similarity parameters that is greater than three.

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