Original and Counterfeit Money Detection Based on Edge Detection

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Abstract-With the increasing of incidence of money counterfeit from year to year as a result of technological advances, many ways have been used to detect forgeries however still very dependent on the presence of a machine and equipment that are sometimes less effective and need more time. The process of identification is done by comparing the original images of money that will be tested with reference of original currency paper image that has been extracted and capture its characteristics and with the help of Canny operator to make edge detection where the previously existing image has to be pre-processing, including extraction characteristics. Results from experiments show that the applications created in MATLAB is able to perform detection and currency verification with precise and fast of original and counterfeit money.

Keyword: Counterfeit detection, image processing, Canny operator, currency verification, money

I. INTRODUCTION

Even though society has enjoyed the great technological advances in color printing, duplicating and scanning, counterfeiting has become problems in the society. The ability to make counterfeiting has not just come from a printing house especially for paper currency, but it is also possible anyone to print counterfeit bank notes simply by using a computer and a laser printer at house. Beside that right now all country in the world has their own currency with different characteristics, size and totally different between each other's.

There are many currencies all over the world but the paper is different, the same as the color and pattern [1]. It is not an easy job to distinguish different types of currencies. Staffs who work for the money changer companies, financing corporations etc have to remember the symbol of each currency. This may cause some failure or wrong recognition, so they need an accurate, fast and reliable system to help their work [2].

In modern banking services, automatic method for paper currency recognition plays an important role in many area of application. The need for automatic banknote recognition systems encouraged many researchers to develop corresponding robust and reliable techniques [3]. The accuracy of recognition and how fast of the processing become two important things for the systems.

II. RELATED WORKS

There are so many research related to the money or currency detection especially for counterfeit, one of them is a currency verification using image processing where the proposed system explain a method for verification of Indian currency by using image processing techniques [1]. The method that used consists of a number of process including image processing, edge detection, image segmentation, characteristic extraction, comparing images.

Other technique [2] using edge detection and with the canny method to create application that can distinguish between original money and counterfeit money where this the effort to minimize the circulation of counterfeit money from year to year as increase caused by an easy to get information on how to make counterfeit money on the internet.

There are another approach technique that using image processing for the detection of currency where this approach using of matching a retrieved note with existing database of notes images as a templates method [3]. The technique used paper currency (note) recognition and also compared with existing recognition methods like Local Binary Pattern (LBP), Image Subtraction and Gabor Wavelet.

For the automatic of currency note recognition, characteristic become a variable that different in each country [4]. The solution offered on minimizing false rejection of notes. With the implementation of edge detection right after the transformation will provide better robustness in case of noise and fair representation of edges among new or old damaged notes. And also with the used of three layer back propagation neural network is using with the number of edges that have been detected in row order of the notes in certain classification.

Another research study explains a method that related to recognize the digit of the serial numbers on the Chinese currency banknotes. Proposed solution performs a number of process including image preprocessing, image binarization, segmentation, digit recognition, feature extraction, and morphological filtering [5]. The use of newest developed software called Labview where rely on the virtual instrument technique utilized for image processing and recognition of the currency.

Proposed technique as an alternative solution for paper currency recognition are using of three characteristics of paper currencies, which is color, texture and size are performed in the

recognition [6]. And by utilized image histogram, therefore a plenitude of different colors in a paper currency is calculated and compared with the existing reference paper currency.

III. Methodology of the Proposed Works

Currency Sorting Machine will help to recognize different kinds of currencies including counterfeiting. The main working processes of "Currency Sorting Machine" are image acquisition and recognitions. It is a technique named "optical, mechanical and electronic integration", integrated with calculation, pattern recognition (high speed image processing), currency anti-fake technology, and lots of multidisciplinary techniques. It is accurate and highly efficient. But for most staffs, they have to keep a lot of different characteristics and anti-fakes label for different commonly used currencies in their mind. However, each of them has a handbook that about the characteristics and anti-fakes labels of some less commonly used currencies. Even for that, no one can ever be 100 per cent confident about the manual recognition.

Recently there are so many type of technology that used to catered the counterfeit problems such as the using of ultraviolet light, edge detection etc. One of currency characteristic to make it secure especially in particular to distinguish the original and counterfeit one in case of Indonesian currency is the presence of a threads, watermarking, differences in color and texture and the material of currency paper.

As an alternative solution to detect counterfeit, image processing techniques become more important and growing rapidly of using and techniques. One of the techniques that so familiar to use for currency recognition and verification is edge detection, edges in an image represents the regions that have the abrupt changes in the pixel values. Edges carry information content in the image. Edge detection in image processing means the process or operation that can distinguish the edge regions from the non-edge regions. Edge detection has several applications in image processing and computer vision applications. Common edge detectors are Sobel, Roberts, Prewits, Canny, Laplacian of Gaussian.

In practical the use of edge detection operator will use together with others image processing techniques to get more accurate result but in faster processing like image filtering, segmentation, extraction etc. All that function will be get from MATLAB with easy to use interface including faster background process. For the purpose of image processing related to the identification of money whether it is an original or counterfeit commonly using the main steps in such a system are :

1. Input and read an image source can be from scanner or camera and the format could be in bmp or jpeg.
2. Performs a pre-processing method like removing noise, smoothening image etc.
3. Performs image processing, edge detection, segmentation, pattern matching
4. Result printing.

The overall system should be used a scanner or camera to capture image, PC to make a processing and algorithm where the aid of algorithm is located in the unique figure, include the process of RGB to Gray, image binarization, noise elimination, segmentation, pattern matching etc. All this usually will be programmed with MATLAB and the flow of process can be shown in Figure 1, flow of process edge detection

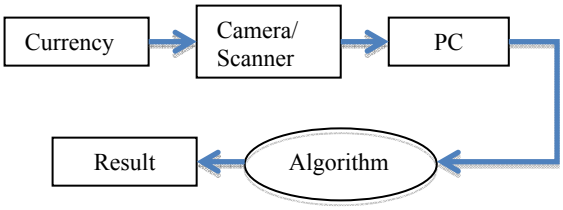

Fig. 1. Flow of process edge detection

A. Edge Detection

A key factor in extracting characteristic of an image is the ability to detect the presence of edges of the object in the image. Edge detection become the first step to cover information inside the image, edge characterize object boundaries and because it is useful for the edge segmentation and identification in the image. Edge detection is the goal to improve the appearance of lines boundary of an area or object in the image.

B. Canny Operator

One of the edge detection algorithms is edge detection using Canny method. Canny edge detection was found by Marr and Hildreth were examined modeling of human visual perception.

There are several criteria for optimum edge detection that can be met by Canny algorithm:

- Properly detect (detection criteria)
  Ability to lay and mark all the edges that are applicable to the selection of the parameters of convolution is performed. It also gives a very high flexibility in terms of determining the level of detection of the desired edge thickness.
- Localize properly (localization criteria)
  Produced by Canny possible minimum distance between the edges detected by the edge of the original.
- Clear response (response criteria)
  There is only one response for each edge. So easy to detect and do not cause confusion in the subsequent image processing.

Canny edge detection parameter selection greatly affects the outcome of the resulting edge. Some of these parameters include:

- Standard deviation value of the Gaussian
- Threshold

Canny operator is the optimum-approaching operator of the product of SNR and the location. Canny algorithm smoothers image by Gaussian filter, calculates the magnitude and direction of gray level gradient, has the non-maxima suppression on gradient magnitude, and detect and connect the

edge from the candidate points by the high and low thresholds. Figure 2 shows Canny algorithm basic step.

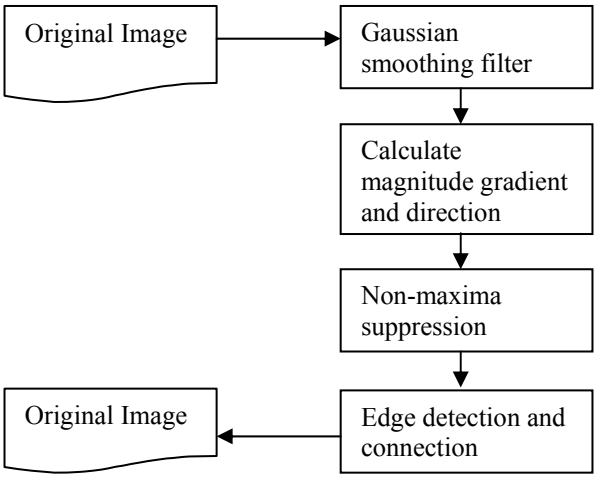

Fig. 1. Canny Algorithm basic step

C. Image Format

The image we get from camera or scanner is formatted by JPEG or BMP. JPEG (Joint Photographic Experts Group) is a standard for destructive or loss compromising for digital images.

In this project, two input images were used the first image is original image of the paper currency and in this case is Rp 100, 000, an Indonesian currency which is often to be counterfeited. The first image is used as a reference currency note, and the second is the test image and is also the currency that to be verified by the system. The main focus is to verify and check its watermark. It is known to determine the authenticity of a paper currency several ways can be used, such as by looking at the presence or absence of a security thread, the presence of water marks, color difference and the texture difference. With the human eye view, we can distinguish authentic bills with counterfeit banknotes in a way be seen, touched and keep seeing it. Genuine banknotes have a security thread, watermark, glossy prints, embossed and feels rough to the touch.

The algorithms used in this proposed study related to paper currency verification system is described below:

1. Image of the original paper currency which is Rp100,000 will be acquired using a scanner and also can use a digital camera.
2. Convert the image that has been acquired from RGB into Gray Scale.
3. Fixing the quality of image using histogram equalization that enhances the contrast of images by transforming the values in an intensity image
4. Perform Binarization, dilation, erosion.
5. Perform edge detection of the whole that gray scale image
6. The characteristic of the paper currency will be define and then segmented
7. Segmented characteristics of the paper currency then to be extracted and boundary of the characteristics will be computed then the pixel region will be calculated either of test image or reference image and will be compared.
8. So if the result is the same or below the reference, the currency is genuine otherwise is counterfeit

The application has been developed under MATLAB. For the first time after the application run, it will capture the original image of banknotes and banknote image reference (Figure 3).

Original paper currency»Camera»Characteristics captured»Gray scale of image

Fig. 3. Acquiring process of paper currency

Once the input is successful then the application will continue to perform several processes, among others: binarization process, the process of dilation, erosion, dilation-erosion process, the process of classification, the process of selecting the final watermark and edge detection is the process for coding the watermark has been found. Variables derived from original currency image will be compared with the variable of currency image reference (Figure 4).

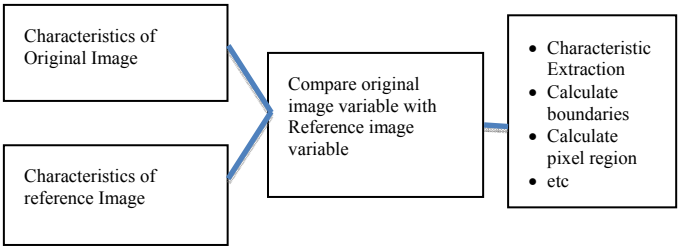

Fig. 4. Flow of process comparison of extracted characteristic of two images

There are a several steps that have been used to perform analysis of the proposed work, such as:

1. Inputting and process of original image

Image that has been input will be process as follows:

a. Binarization

Binarization is a process for the conversion of images into gray level image has only two colors (binary) that is black and white.

b. Dilation

Dilation process is done to increase the size of the segment object by adding layers around the object.

c. Erosion processes

Erosion operation is the inverse of the dilation operation. At this operation, the size of the object is reduced to scrape around the object.

d. Edge Detection Process

Edge detection is a process, which results in the edges of image objects whose purpose is to mark a part of the image detail. Of this process will be obtained variables

used for comparison with the other banknotes image (reference).

e. BW Boundaries

This process traces the exterior boundaries of objects, as well as boundaries of holes inside these objects of binary image.

f. Measure properties of image regions

Measures a set of properties for each connected component (object) in the binary image

g. Calculation Process

Part of the original image selected banknote marks the middle of the watermark and calculate pixel boundaries properties of binary image.

2. Input Image reference of the banknote will be tested whether original/genuine or not.
3. Image Processing Reference

Just like the previous process, after input the banknote other processes will follow image reference, such as:

a. Binarization

Binarization is a process for the conversion of images into gray level image has only two colors (binary) that is black and white.

b. Dilation process

Dilation is done to increase the size of the segment object by adding layers around the object.

c. Erosion processes

Erosion operation is the inverse of the dilation operation. At this operation, the size of the object is reduced to scrape around the object.

d. Edge Detection Process

Edge detection is a process, which results in the edges of image objects whose purpose is to mark a part of the image detail. Of this process will be obtained variables used for comparison with the other banknotes image (reference).

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This process traces the exterior boundaries of objects, as well as boundaries of holes inside these objects of binary image.

f. Measure properties of image regions

Measures a set of properties for each connected component (object) in the binary image

g. Calculation Process

Part of the original image selected banknote marks the middle of the watermark and calculate pixel boundaries properties of binary image.

III. Result and Discsussion

Applications calculate the original image also with the image reference of banknote and will make analysis by comparing that two image result whether it is original or counterfeit banknotes. If the image to be tested has a water mark, then the application will get a watermark image that has been converted into an image with edge detection (Figure 5). If the image to be tested does not have a water mark, then the application will not get the watermark image. So that the final result of the calculation values will be obtained more than the original values and it can be concluded that any one banknote image is false.

Fig. 5. Output process of application On MATLAB that detect a currency paper counterfeit

Some of the tests that are analyzed the value of calculation between that two image as one image value act as a reference and the other one will be use as a testing image to see whether it is original or counterfeit and the result will displayed directly by the program. The proposed works that have been done can be summarized as the following two paragraphs.

The result of the comparison between the original image of Rp 100,000 as reference and Rp. 100.000 counterfeit shows that if an image does not have a banknote watermark as one of characteristic that extracted the calculation process will have higher result compared with the original one, and the application will be analyzed and pop up the message that the money is counterfeit (Table I).

TABLE I
Result of Comparison Between Reference and Counterfeit Image

Reference	Iktotal	Counterfeit	Iktotal	Annotation
Ref1.jpg	3.4858	Fke1.jpg	6.3954	Counterfeit
Ref2.jpg	3.2952	Fke2.jpg	4.0601	Counterfeit

Ref3.jpg	3.5889	Fke3.jpg	3.7878	Counterfeit

The following result is a comparison between the original image Rp 100,000 and image with another original currency paper Rp 100,000. The process is done the same as before. It's just that there is a difference, because the image of each of these currency paper images has a watermark. So that the final result of the calculation values will be obtained and looks like the result is equivalent or below the reference original image of Rp 100,000. It is found that the original image that has been tested is a genuine one compare with the result from the reference of the original image of Rp100,000 where the value from the original reference image after testing and analyzed then determined the average of a value pixel boundaries properties of binary image: iktotal <= 3.6910 analyzed as genuine or original and if iktotal > 3.6910 analyzed as counterfeit. The comparison between all banknote images that have been tested can be seen in the table and the graph below (Table II, Figure 6).

TABLE II
RESULT OF COMPARISON BETWEEN REFERENCE AND ORIGINAL

Reference	Iktotal	Original	Iktotal	Annotation
Ref1.jpg	3.4858	Ori1.jpg	3.4479	Genuine
Ref2.jpg	3.2952	Ori2.jpg	3.5511	Genuine
Ref3.jpg	3.5889	Ori3.jpg	3.4414	Genuine

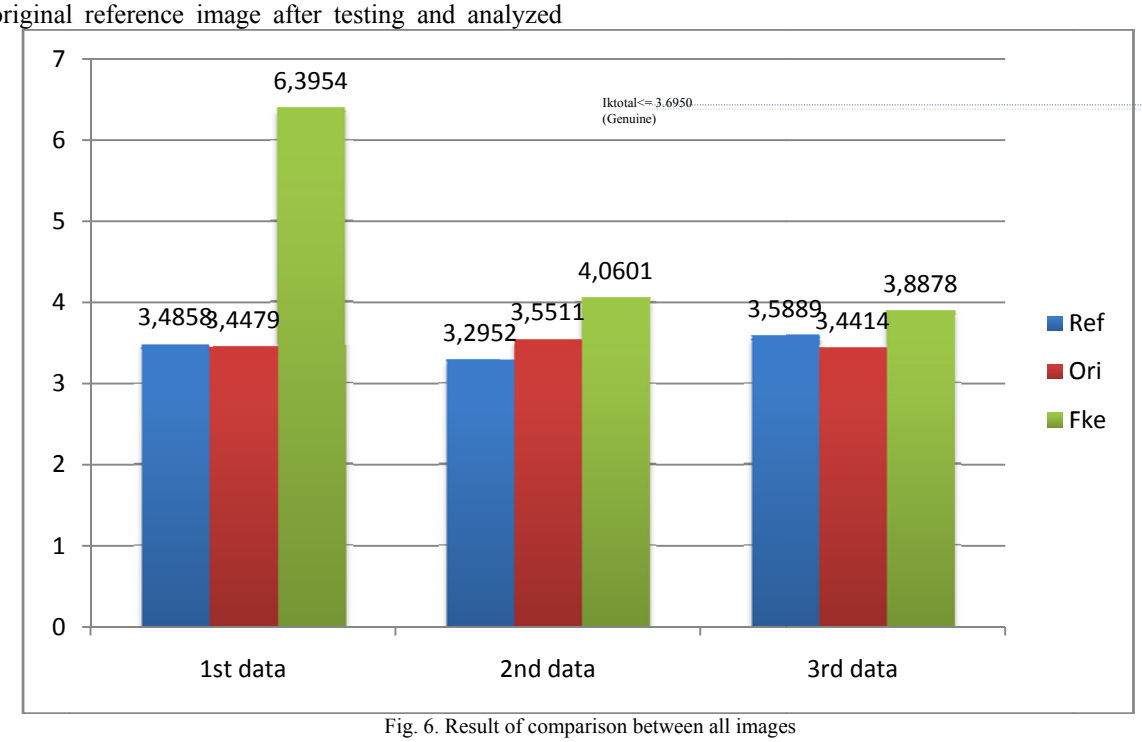

Fig. 6. Result of comparison between all images

III. CONCLUSIONS

Based on the proposed work that has been implemented, the results of experiments conducted by using multiple images of banknotes can be concluded as:

- By using canny operator for edge detection and also image segmentation it is an effective and fast process on detect original currency paper and counterfeit.
- Currency paper which has the image variable or characteristics like watermark (genuine banknotes) compared with the other notes image that has a watermark (genuine paper currency) then the value of its boundaries properties can be process calculate and to be compared for the money detection.
- From the all the experiments are carried out on the original image of currency paper, the application succeed to detect the watermark and become the one of the determinants of the number of results in determining the final result whether original or counterfeit.

With all the experiments conducted on the image and copy counterfeit banknotes, the application successfully detect original currency paper and counterfeit from the absence of a watermark.

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