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Foreword: Message from the Rector Honorable Keynote Speaker, Mr. Ignasius Jonan, former Minister of the Energy and Mineral Resources, and previously Minister of the Transportation Ministry of the Republic of Indonesia, we are greatly honored to have you with us this morning. Distinguished keynote speakers, Prof. Ahmad M. Ramli (represented by Ikhsan Baidirus, S.H., LLM, Director of Post, General Directorate of Post and Information Technology, Ministry of Communication and Information Technology), Prof. John Silke, Dr. Ferry Sandra, Prof. Takayuki Arai, Prof. Young Ho Kim, Prof. Susy Tjahjani, Prof. Pim Martens, Dr. Dwinita Larasati, Prof. Chien-Hsu Chen, Prof. Wilson Bangun and Prof. Marcellia Susan, as well as all participants in the international conferences at Maranatha University. A very good morning and best wishes to you all, and good evening to our colleagues in the US. Greetings and a warm welcome to Maranatha Christian University (MCU), Bandung, Indonesia. I am delighted to be **(More)**

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Exploration of an Indonesian Currency Legality Detection System by Utilizing Image Intensity of RGB Mean Values

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Keywords: Naïve Bayes, Entropy, Contrast, Correlation, Energy, Homogeneity, RGB.

Abstract: Money is one of the objects used by the public to carry out legal buying and selling transactions in a country. The problem is there are fake bills that are printed by irresponsible people, so everyone needs to be able to know that the banknotes received is fake or genuine. But not everyone can detect the authenticity of a banknote, so a tool is needed to detect the banknote is genuine or fake. In this paper, software has been designed to detect the authenticity of Indonesian currency. In this paper, feature extraction of the grey level co-occurrence matrix with the features of entropy, contrast, correlation, energy and homogeneity is used to detect the nominal value of Indonesian banknotes and to detect the validity of Indonesian banknotes; the extraction of red-green-blue features with features is used mean R, mean G and mean B. The detected Indonesian currency was Indonesian currency from 2004-2016, with nominal values of Rp. 1000, Rp. 2000, Rp.5000, Rp. 10000, Rp. 20000, Rp. 50000, and Rp.100000. The classification process uses Naïve Bayes. From the test results, the system works well for reading the nominal value of Indonesian banknotes and detection the validity of the money can function properly.

1 INTRODUCTION

The rapid development of science and technology encourages humans to create tools that can simplify human work, one of which is a tool to read the nominal value of money and detect the authenticity of banknotes. After using this tool then humans will more easier to save and withdraw money from an automatic cash withdrawal deposit machine or also known as an Automatic Teller Machine (ATM) and there are also several machines that deal with money, for example vending machines that sell tickets trains, or sell drinks and others.

Some of the research that have been carried out will be presented here: detecting the authenticity of a currency through digital image processing, the Bit Plane Slicing technique is used to extract the most significant features and the application of the Canny

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edge detection algorithm is also used. The image of banknotes with 256 grey-levels is decomposed into 8 binary images. Images that have a higher bit order rate are evaluated for image grayscale banknotes by applying the Canny edge detection algorithm. Then the results are compared between real and counterfeit banknotes using the same detection technique. From the observation, it was found that the results of edge detection using an image that was sliced by bit-plane results were more accurate and could detect it faster than directly processing the original image without being sliced. The limitation problem in this study is that detection is only for Kuwait banknotes based on the features of the money and comparisons are made between real money and counterfeit money based on component connectivity features, average value, standard deviation and SNR. The further research suggested in this paper is carried out by expanding the scope of observations to colour images using six bit-planes to verify that will be produced more detail from grayscale bit-planes (Alshayeji et al., 2015).

In this paper discusses the detection of counterfeit banknotes using ordinary light rays, the observed attributes of watermarks and recto verso and currency ornaments. The image of banknotes is carried out by the process of converting a colour image into an image with a grey level, the process of edge detection, feature extraction, matching of results against predetermined areas. In this paper, there are no quantitative or qualitative observations (Giri, 2019).

In this article explains the detection Indian banknotes using digital image processing techniques. There are six characteristics of Indian banknotes chosen to detect counterfeiting, including: identification mark, security thread, watermark, numeric watermark, floral design and micro lettering. Extraction of characteristic features is carried out on the image and compared with the characteristic features of the original banknotes. Decision making is done by counting black pixels. In this article explain to design a low cost system and a fast decision making system. The proposed method is inspired by the analysis of hidden marks on the image of banknotes. The image of the banknote is obtained through the camera by applying a white backlight to the banknote, so that a hidden currency sign appears in the image. The image is further processed by applying image processing techniques, such as: image pre-processing, edge detection, image segmentation, characteristic extraction. The feature extraction process can be extended up to 100 Rupees. Six features are extracted within 1 second. The complete methodology was carried out for Indian banknotes of 20,50,100, 500 and 1000. The method is very simple and easy to apply. If the hardware is designed for image acquisition it helps to minimize the currency counterfeiting problem. This technique is used to extract six characteristics of banknotes which include identification marks, security threads, floral designs, numeric watermarks, and watermarks (Pambudi et al., 2016), and the micro letter on the security thread. The system also extracts hidden features, namely the latent images of banknotes. The proposed work is an approach to the extraction of the characteristics of Indian banknotes. The serial number can also be extracted using a latent image extraction procedure. The system can extract features even though the test image size is different when compared to the reference image (Prasanthi & Setty, 2015).

The circulation of counterfeit money in Indonesia at this time may not have invisible ink. Invisible ink is a security feature for banknotes, and money counterfeiters do not have the ability to counterfeit invisible ink in Indonesia. The banknotes genuine or fake are determined by identifying the presence of invisible ink. This research developed a software to determine the nominal value of a banknotes and its authenticity through one of the banknotes safeguards features, namely invisible ink.

This software uses Digital Image Processing technology as an authentication process and Artificial Neural Networks more specifically Learning Vector Quantization neural networks (Indradewi & Ariantini, 2018) as an identification process. In the authentication process, several processes are carried out, namely the segmentation process that uses the green histogram threshold value, the area calculation process using the chain-code method, and the area filter process, while the process of identifying the nominal Indonesian currency (IDR) is carried out by the feature extraction process with Discrete Fourier Transform (TFD) and LVQ neural network. The trial results showed that the average percentage of success at the authentication stage was 98.77% and the average percentage at the identification stage of the Indonesian currency (IDR) was 77.604% (Rijal, 2008).

The main hypothesis of a digital image processing system can be used to detect Indonesian currency (IDR) and read the nominal value of Indonesian currency (IDR). In general, Indonesian currency (IDR) detection and reading of the nominal value of Indonesian currency (IDR) can be realized with software using two lighting, namely an ordinary lighting and an ultra violet lighting with methods for digital signal processing.

2 METHODS

In this study, two procedures were used, namely, first using an ordinary lighting, the second using an ultra violet lighting.

2.1 Indonesian Currency (IDR) Nominal Value Detection System

The process of using an ordinary lighting aims to read the nominal Indonesian currency (IDR) using the Naïve Bayes classifier. The system design of this ordinary procedure can be seen in Figure 1. First to be done is inputting scanned normal image, then the system will do pre-processing. Pre-processing is the process in order to get optimal image results, so that it is easy to carry out the next process. After doing pre-processing, then the next step is feature extraction with analysis using the Grey Level Co-occurrence Matrix (GLCM) method. From the GLCM analysis, the entropy value, contrast value, correlation value, energy value and homogeneity value will be obtained. After carrying out the feature extraction stage, the next process will be classified with the naïve Bayes classifier, after being classified, the final value will be in the form of a nominal Indonesian currency (IDR).

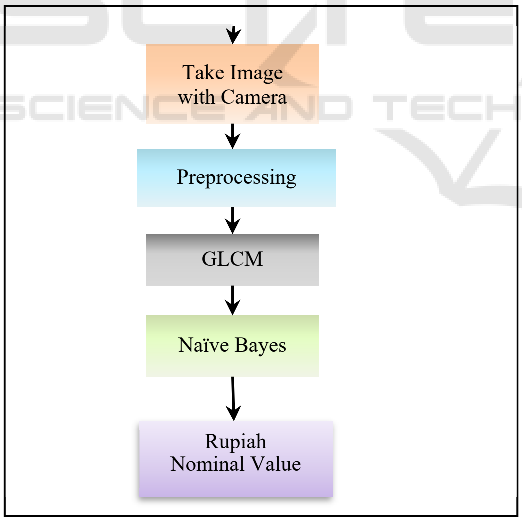

Figure 1: Ordinary detection system nominal value for money.

The second procedure is using an ultraviolet lighting which aims to detect the validity of the Indonesian currency (IDR). First of all to be done is that the money is irradiated with ultra violet then photographed and get a UV image, then the ultra violet image will be passed in the pre-processing process, namely crop at the water point you want to detect, after the pre-processing stage, then the features will extracted for each Red, Green, image. and Blue and will produce the mean r, mean g and mean b feature values. After getting the mean R, G and B feature values, it will be classified with the naïve Bayes classifier. Then the output will be generated whether the money is real or fake.

2.2 Nominal Value in Indonesian Currency (IDR)

Indonesian banknotes are money in the form of sheets made of paper issued by the Indonesian government, in this case Bank Indonesia, whose the usage is protected by Law No.23 of 1999 and legally used as a means of exchange for payments within the territory of the Republic of Indonesia. In this study, the money that will be examined is the Indonesian banknotes from 2004 to 2016 in the form of Rp. 1,000, Rp. 2,000, Rp. 5,000, Rp. 10,000, Rp. 20,000, and Rp. 50,000, Rp. 75,000, and Rp. 100,000 (Figure 2).

There are several characteristics of the authenticity of Indonesian currency (IDR), prior to 2016, namely: 1. Recto verso: the BI logo which will be completely visible when exposed; 2. Latent Image: the hidden BI logo can be seen from a certain point of view; 3. Watermark: in the form of a picture of a National Hero that will be visible when viewed; 4. Security thread: thread embedded in the paper bearing the inscription of Bank Indonesia and flashing red when under UV light; 5. Micro-writing: Bank Indonesia writing which can only be read with the assistance of Loupe; 6. Micro letters: BI letters which can only be read with the help of Loupe; 7. Serial number: consists of 3 letters and 6 numbers which will change colour when under UV light; 8. Blind code that has the shape of a rectangular box, two squares, a circle, two triangles and two circles that feels rough when touched; 9. Visible ink: ink in the form of Kalimantan ornaments, Palembang ornaments, Balinese ornaments that will brighten colours when under UV light; 10. Invisible ink: nominal numerical ink that will glow when under UV light; 11. Print a rainbow in a rectangular shape that will change colour when viewed from a different perspective.

Figure 2: Indonesian banknotes (a) after 2016 and (b) before 2016.

2.3 Indonesian Currency (IDR) Legality Detection System

The process of legality of the Indonesian currency (IDR) can be seen when using an ultra violet lighting. Ultra violet light hitting the special ink on the Indonesian currency (IDR) will cause the appearance of the banknotes to differ between fake and real money.

Figure 3 is an example of the appearance of real banknote when viewed with an ultra violet lighting, and Figure 4 is an example of the appearance of fake banknote when viewed with an ultra violet lighting. Figure 5 is banknote photographed with a regular lighting. The full design of the proposed Indonesian Currency (IDR) legality detection system can be seen in Figure 6. The presence of special inks used causes authenticity can be distinguished by calculating the mean value of each component Red, Green, and Blue.

Figure 3: Valid Indonesian currency (IDR) as seen in ultra violet light.

Figure 4: Fake Indonesian currency (IDR) seen in ultra violet light.

Figure 5: Valid Indonesian currency (IDR) seen with a ordinary lighting.

2.4 Gray-Level Co-occurrence Matrix (GLCM)

One approach in describing texture is to use a statistical moment of histogram of the intensity of an image. Statistics method such as a matrix of shared events are important to get valuable information about the relative position of neighbouring pixels of an image (Eleyan & Demirel, 2011) this method is used to identify textiles by (Azim, 2015). Co-occurrence matrix P is defined as described in equation 1.

The reviews of some features of a digital image by using GLCM are also given in this sub-section. Those are Energy, Contrast, Correlation, and Homogeneity (features vector). The energy known as uniformity of ASM (Angular Second Moment) calculated as given in equation 2.

$$P(i,j) = \sum_{x=1}^{N} \sum_{y=1}^{N} \begin{cases} = 1 & if\ I(x,y) = i\ and \\ & I(x+\Delta\_x, y+\Delta\_y) = j \\ = 0 & otherwise \end{cases} \quad (1)$$

$$\text{Energy} = \sum_{i=1}^{N} \sum_{j=1}^{N} P(i,j)^2 \quad (2)$$

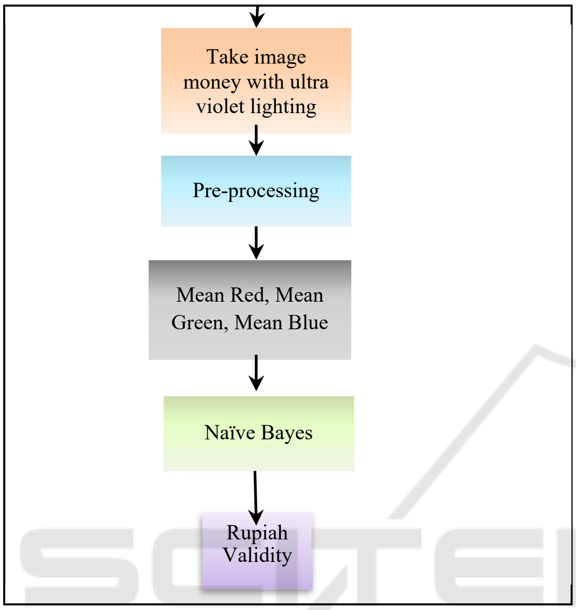

Figure 6: Indonesian Currency (IDR) legality detection system.

Contrast measurements of texture or gross variance, of the grey level. The difference is expected to be high in a coarse texture if the grayscale contrast is significant local variation of the grey level. Mathematically, this feature is calculated as defined in equation 3.

$$\text{Contrast} = \frac{1}{(N)^2} \sum_{i=1}^{N} \sum_{j=1}^{N} (i-j)^2 p(i,j) \quad (3)$$

Texture correlation measures the linear dependence of grey levels on those of neighbouring pixels. This feature is computed as defined in equation 4.

$$\text{Correlation} = \frac{\sum_{m=1}^{N} \sum_{n=1}^{N} mnp(m,n) - \mu_x \mu_y}{\sigma_x \sigma_y} \quad (4)$$

Where:

$$\mu_x = \sum_{m=1}^{N} M \sum_{n=1}^{N} p(m,n) \quad (5)$$

$$\mu_y = \sum_{m=1}^{N} N \sum_{n=1}^{N} p(m,n) \quad (6)$$

$$\sigma_x = \sum_{m=1}^{N} (m-\mu_x)^2 \sum_{n=1}^{N} p(m,n) \quad (7)$$

$$\sigma_y = \sum_{n=1}^{N} (n-\mu_y)^2 \sum_{m=1}^{N} p(m,n) \quad (8)$$

The homogeneity measures the local correlation a pair of pixels. The homogeneity should be high if the grey level of each pixel pair is similar. This is calculated by the function in equation 9.

$$\text{Homogeneity} = \sum_{m=1}^{N} \sum_{n=1}^{N} \frac{P(m,n)}{(1+[m-n])} \quad (9)$$

2.5 Naïve Bayes Classifier

The Naive Bayes algorithm is a simple probabilistic classifier that calculates a set of probabilities by counting the frequency and combinations of values in a given data set. The algorithm uses Bayes theorem and assumes all attributes to be independent given the value of the class variable. This conditional independence assumption rarely holds true in real world applications, hence the characterization as Naive yet the algorithm tends to perform well and learn rapidly in various supervised classification problems. Naïve Bayesian classifier is based on Bayes' theorem and the theorem of total probability. The probability that a document d with vector $x = \langle x_1, \ldots x_n \rangle$ belongs to hypothesis h is (Patil & Sherekar, 2019)

The Bayes Theorem formula is defined in equation 10 (Patil & Sherekar, 2019).

$$P(Q|X) = \frac{P(X|Q).P(Q)}{P(X)} \quad (10)$$

Where: X Data with unknown class; Q The hypothesis X is a specific class; $P(Q|X)$ The probability of the Q hypothesis refers to X; $P(Q)$ Probability of the hypothesis Q (prior probability); $P(X|Q)$ Probability X in the hypothesis Q; $P(X)$ Probability X.

To explain the Naïve Bayes theorem, it must be known that the classification process requires various clues to determine the class according to the sample analysed. Therefore, the Bayes theorem above is adjusted as given in equation 11.

$$P(Q|X_1 \dots X_n) = \frac{P(X_1 \dots X_n|Q).P(Q)}{P(X_1 \dots X_n)} \quad (11)$$

Where: Q variable is a representation of class, while variable $X_1 \dots X_n$ represents the characteristics of the instructions needed for the classification process.

2.6 Mean Value

The mean value of each image intensity on the Red, Green and Blue channels is calculated by using the equation in 12 (Ni'am, 2013):

$$\mu = \sum_{n} f_n p(f_n) \quad (12)$$

Where: f_n is a grey intensity value, while $p(f_n)$ is the histogram value (probability of the intensity appearing in the image).

2.7 Success Rate

The success rate is measured using the f-measure in equation 15.

$$precision = \frac{TP}{TP + FP} \quad (13)$$

$$recall = \frac{TP}{TP + FN} \quad (14)$$

$$f - measure = 2\frac{precision\,.recall}{precision + recall} \quad (15)$$

Where:

TP (True Positive) is a test to read the nominal value of banknotes based on the system and manual is correct. FP (False Positive) is a test to read the nominal value of banknotes based on the system that is not correct, but based on manually it is correct. FN (False Negative) is a test to read the nominal value of banknotes based on the system and manual is wrong.

3 RESULTS AND DISCUSSION

3.1 Classification of Indonesian Currency (IDR) Nominal Value

In the process of detecting the nominal value of the Indonesian currency (IDR), it has been successfully realized. At first, image of the money taken by the camera or scanned by a scanner, then the results of the photo or scan was entered in the program as shown in Figure 7.

Figure 7: Photograph or scan image.

The image will be cropped on the left side, namely on the part where there is a nominal, after that the RGB image was changed to a grayscale image and the intensity value is being adjusted. The results can be seen in Figure 8.

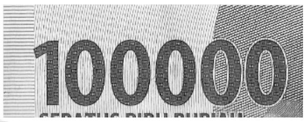

Figure 8: Image of cropped money.

It was continued with segmentation of grayscale images into foreground and background parts using active contour as shown in Figure 9.

Figure 9: Image of the active contour.

Followed by filling in the blanks in the image with the morphological structuring element technique. Images other than the nominal value will be removed using a dilation and erosion operation. Neighbouring pixels located 2 pixels from the element's centre point will be assigned a value equal to the binary value of the element's centre point.

Figure 10: Binary image.

```
    0.8285    0.0231    0.9402    0.5911    0.9885


naivetrain = 

  ClassificationNaiveBayes
              ResponseName: 'Y'
     CategoricalPredictors: []
                ClassNames: [1000 1001 2000 2001 5000 5001 10000 10001 20000 20001 50000 50001 100000 100001]
            ScoreTransform: 'none'
           NumObservations: 84
         DistributionNames: {'normal'  'normal'  'normal'  'normal'  'normal'}
    DistributionParameters: {14×5 cell}


  Properties, Methods

naivepredict
      100000
```

Figure 12: Output image of classification program.

The results of this binary image are used to calculate entropy, contrast, correlation, energy, and homogeneity. This value can be seen in Figure 11.

1	2	3	4	5
0.8305	0.0237	0.9389	0.5893	0.9882

Figure 11: Entropy, contrast, correlation, energy, and homogeneity value, respectively.

In the training process, 6 images are used for each Indonesian currency (IDR) with the same nominal value so that from 15 Indonesian banknotes there are 6 x 15 = 90 GLCM training data with supervised learning. The data is stored in a nominal.txt and class.txt file. In the testing process, the file is used as reference data for classifying nominal values. The classification here uses Naïve Bayes and the system will display the results of the test image data classification by displaying the nominal value of the prediction results of Naïve Bayes as a nominal value of 100 000 as in Figure 12.

In the test results with 30 test data, it is obtained that TP = 24, FP = 6, FN = 0, so that from the f-measure value, the percentage of system accuracy for reading the nominal value of Indonesian banknotes is 88%.

3.2 Classification of Rupiah Validity

The process of detecting the validity of the rupiah currency has been successfully realized. At first the money was exposed to ultra violet light and photographed, and then the photos or scans were included in the program as shown in Figure 13.

Figure 13: Ultra violet image.

The ultra violet image result cropped at position [0.5 0.5 1894 1730] in pixels and the results can be seen in Figure 14.

Figure 14: Cropped ultra violet image.

The cropped UV image was separated by Red, Green, and Blue channels, and then the mean intensity of each channel is calculated. The data stored in a file data_uv.txt and class_uv.txt. In the testing process, the file used as reference data to classify genuine or fake. The classification here uses Naïve Bayes and the system will display the results of the classification of the test image data by displaying the original or false information from the prediction of Naïve Bayes as in Figure 15.

```
meanR
   90.2910

meanG
   61.5160

meanB
  133.9527

naivepredict
asli
```

Figure 15: Program output for the validity of the Indonesian currency (IDR).

The results of the ultra violet image for fake Indonesian currency (IDR), which is different from the ultra violet image of the original Indonesian currency (IDR), can be seen in Figure 16 that the fake banknote is dominated by blue when viewed with ultra violet light.

Figure 16: UV image of 'fake' banknote

The cropped UV image at position [0.5 0.5 1894 1730] in pixels can be seen in Figure 17. The cropped UV image is separated by Red, Green, and Blue channels, and then the mean intensity of each channel is calculated. The data is stored and combined with the cropped UV image in a data_uv.txt and class_uv.txt file. In the testing process, the file is used as reference data to classify genuine or fake. The classification here uses Naïve Bayes and the system will display the results of the classification of the test image data by displaying the original or false information from the prediction of Naïve Bayes as in Figure 18.

In the training process, 6 images are used for each Indonesian currency (IDR) with the same nominal value so that from 15 Indonesian banknotes there are 6 x 15 = 90 training data mean Red, mean Green, and mean Blue with supervised learning. In the test results with 30 test data, we get TP = 30, FP = 0, FN = 0, so we get precision = 1, recall = 1, f-measure = 1. From the f-measure value, the percentage of system accuracy for reading the nominal Indonesian banknotes is 100%.

Figure 17: Ultra violet crop image of a 'fake' banknote.

```
meanR
   32.9054

meanG
   89.7520

meanB
  239.1182

naivepredict
palsu
```

Figure 18: Mean red, mean green, mean blue prediction of a 'fake' banknote.

4 CONCLUSIONS

The nominal value of Indonesian banknotes are Rp. 1000, Rp. 2000, Rp. 5000, Rp. 10000, Rp. 20000, Rp. 50000, Rp. 75000, and Rp. 100000 in the 2004-2021 edition has been successfully realized using the Grey-Level Co-Occurrence Matrix (GLCM). Several features of digital images, namely energy, contrast, correlation, and homogeneity, are used as input for the Naïve Bayes Classifier. From the experimental results obtained 88% accuracy and the validity of the Indonesian currency (IDR) can be detected using the mean of red, mean of green, and mean of blue channel values.

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