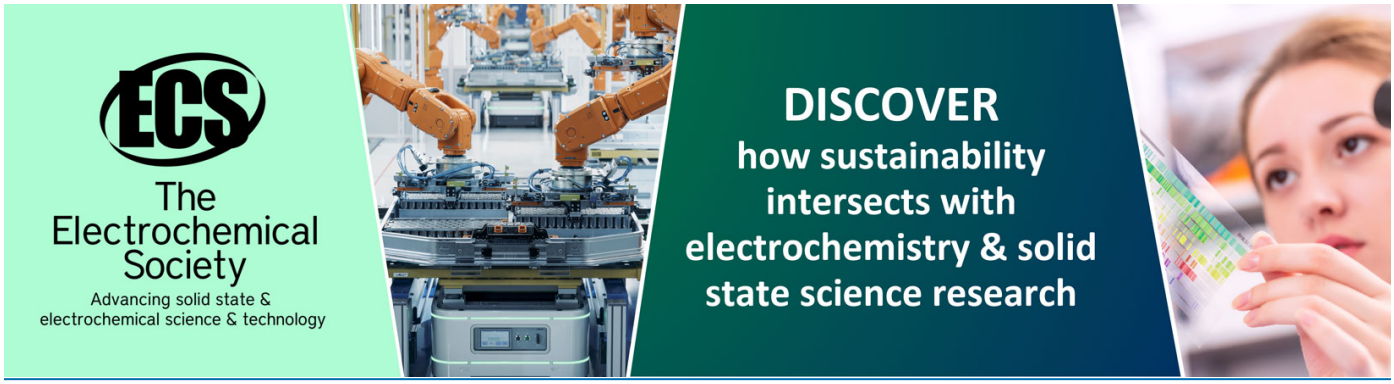
Authenticity of money using the method KNN (K-Nearest Neighbor) and CNN (Convolutional Neural Network)



Authenticity of money using the method KNN (K-Nearest Neighbor) and CNN (Convolutional Neural Network)

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Abstract. Nowadays, the circulation of counterfeit money is significantly increased, encouraging to conduct research related to genuine real money detection or counterfeit money based on digital imagery. Technological sophistication one of the quality of printers whose ink is very good and can print money like the original makes the layman should be more wary of money ownership. In this research conducted the authenticity of money using the method KNN (K-Nearest Neighbor) and CNN (Convolutional Neural Network). Accuracy KNN method is 87,75%. While the detection accuracy used by CNN is 96,67%. The results obtained from these 2 methods can still be improved with advanced research namely with pre production on the set and the image used. The data set used has the same exposure level, image capture angle and image size.

1. Introduction

Counterfeit money has become a serious problem in every country. The circulation of counterfeit money increased with the advancement of technology there. The more rampant circulation of counterfeit money, Bank Indonesia has designed banknotes that can be differentiated between genuine and counterfeit money. It is done by Bank Indonesia to distinguish the authenticity of money is to provide a wide variety of attributes, such as the size of the paper varied, different colors, and different patterns. With these differences, it is expected that the community can check the money manually. Manual techniques can be done by doing three things, namely seen, touched, and overlay. However, this method is not considered efficient on the amount of a lot of money because of the transaction with the money usually goes fast, while to do the checking manually takes a long time, so needed another way which is quick and efficient [1].

To overcome these problems, researchers have designed an algorithm by using the image processing as the basis of the detection system of counterfeit money. The algorithm of this system is expected can solve the problem of detection of counterfeit currency and can be used with financial transactions in the amount of a lot.

On this opportunity, the researchers have collected a variety of references related. For the example is book digital image processing and its programming techniques [2] it explains how to observe an image with the object of what was reviewed from the texture of the objects that will be observe. Perform the measurement of the texture with the contrast of colors is able to achieve an average accuracy of

74%. In distinguishing genuine and counterfeit money, Ginting [3] conducted research with edge detection using canny method. The results from the experiments performed show that the application successfully detects the sign of the water while the image of the counterfeit banknotes and a copy of the application does not successfully detect the watermark. In this study, the detection of the authenticity of the money by using 2 methods: method KNN (K-Nearest Neighbor) and CNN (Convolutional Neural Network).

Identification with the KNN method (K-Nearest Neighbor) using the color feature on the introduction of the value of banknotes. The colors provide meaningful information and values that are important in the process of describing an object [4]. The colors used are Red, Green, Blue (RGB). The process of detection of the value of banknotes using the value of the feature extraction, the Red, Green, Blue (RGB), then the result of the extraction of features used to classify the value of banknotes by the method of K-Nearest Neighbor (KNN) as the detection value of banknotes. There are several methods used for classification such as Naïve Bayes method [5], but in the Naïve Bayes method is based on the probability or conditional probability. Suyanto, in contrast with KNN method which calculates the distance to the nearest classification [6].

Research related to the detection of the value of banknotes with the KNN (K-Nearest Neighbor) have been conducted, such as research Hlaing and Gopalakrishnan [7] using texture features Gray-Level Co-Occurrence Matrix (GLCM) with a KNN method with a value of K=1. The hope of research conducted to build a model of the detection value of banknotes rupiah extraction using color feature and using the KNN method with a K value greater than the previous research to produce a good accuracy that can detect the value of banknotes with right as well as beneficial for those who need.

Identification method CNN (Convolutional Neural Network) with the cluster analysis K-Means Clustering which leads to the partitioning of N objects observations into K groups (clusters) where each observation object is owned by a group with a mean (average) closest. This method have been done by researchers Syaiful and Ahsan [8]. Application Recognition Imaging On bank notes To Know the money is counterfeit or original can show the authenticity of the money by the method of K-Means clustering using java programming on the hologram idr. 100.000. However this App can only help others in knowing the money idr. 100.000 with the description “accordance” or “not in accordance” with the results implemented on K-Means Clustering [8].

Research related to detection of banknotes with CNN (Convolutional Neural Network) is to detect the number of banknotes using the Image Processing Raspberry Pi. The method used in this research is digital image segmentation using Thresholding method with Python programming language. The results of this Study is to detect the number of banknotes using Image Processing in Raspberry Pi, where banknotes can be distinguished based on color [9].

2. A brief on related theories

2.1. KNN (K-Nearest Neigbor) method

For the research using the KNN (K-Nearest Neighbor) method can be seen in figure 1:

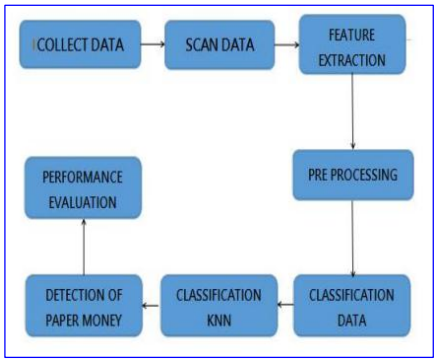

Figure 1. Process KNN method.

2.1.1. Data collection. Data used use of banknotes fractional to idr. 2000 new model, idr. 2000 old model, idr. 5000 new model, idr. 5000 old model. The number of each banknote is 10 selected from the start that the quality of the good until the quality of the crumpled because of the factor of the old or the movement of money from one hand to the other.

2.1.2. Scan data. The stage scan is done to capture the image of the banknotes using the features RGB color. Using scan the scanner tool so the authenticity and color on banknotes become more clear. On banknotes there are two different sides, namely the side of the face and the back side, so do a scan against the banknotes with two different sides. Repetition performed three times. Scan with a repetition of three times is performed to determine whether each of the stages of the scan are different have different results.

2.1.3. Feature extraction. Feature extraction is necessary to determine an image. The technique of feature extraction that is used to extract the color image RGB (Red-Green-Blue). Retrieval of color features using RGB applications in Graphic Design.

2.1.4. Preprocessing. The results the extraction of features on banknotes is the value of every feature the color Red-Green-Blue. There is the same value on the value of the feature RGB so that made the cleaning process against the same data, in addition, data processed with the draw patterns in the same class and distanced patterns of different classes so that the patterns will be cataloged and neat and separate from other classes [10].

2.1.5. Data sharing. Data Sharing used for classification on the results of detection banknotes. The model of classification takes an input learning data (training data) and testing data.

2.1.6. Classification K-Nearest neighbor. KNN (K-Nearest Neighbor) including algorithm classification is a supervised learning which classifies an object into a new class based on the training data and the attributes of the class [11]. The method of KNN (K-Nearest Neighbor) on the testing data will compare data that has been studied, namely the learning data (training data). This method is very dependent on the value of K, so one of the initial stage is to determine the value of K. Next calculate the distance from new object to data training, before the determined category of object based on the majority of value of K is made sequence data of the testing data that have the smallest distance from training data.

2.1.7. Detection banknotes. Detection is performed on the file of paper money which has been scanned as a new data to be determined banknotes is included in one of four categories class (class) who have previously carried out learning data (training data). This research uses the application of R to detect, the categories of detection of the banknotes i.e. the money 5000A to the value of banknotes idr. 5000 the old model, the 5000B to the value of banknotes idr. 5000 new model, 2000A to the value of banknotes idr. 2000 old model and 2000B to the value of the banknotes idr. 2000 new model.

2.1.8. Performance evaluation. Puidrose of performance evaluation is evaluate and analyze the model used in the study. Process of calculating the accuracy of classification results using the Confusion matrix. Confusion matrix is a table that contains the results of predicted with the true and also not true by modeling classification, this table is necessary to determine the performance of classification model.

2.2. CNN (Convolutional Neural Network) method
For the research using the CNN (Convolutional Neural Network) method can be seen in figure two:

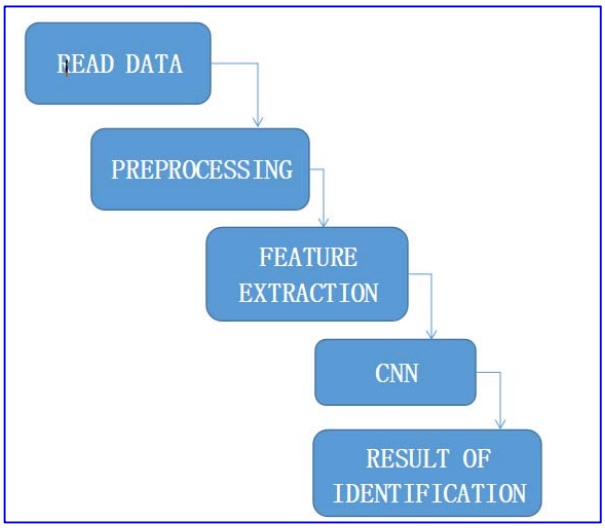

Figure 2. Process CNN method.

This research was conducted to identify the authenticity banknotes by converting color image into grayscale then the results of a new image to extraction of features in order to become a reference in detecting whether or not the original banknotes. As for the object that is used is idr. 50,000 and idr. 100,000 identify that surface texture of banknotes through the binary pattern can determine the authenticity of money accurately.
Explanation of figure 2 is:

2.2.1. Read data money. In this research, the first performed reading of the data. Process read data is a process for reading image data that has been captured, and saved in the format of *jpg.

2.2.2. Preprocessing. The stage of preprocessing is done before performing pattern recognition on image the money, at the beginning of process, the image of money will be converted to format of image grayscale (grayscale). This process to get new image with better results and is ready to be processed in the next stage.

2.2.3. Extraction of features. The next stage is performing pattern recognition. At this stage, the feature extraction of image money. Method using local binary pattern to find out the texture the surface banknotes become a reference in detection of the number value banknotes.

2.2.4. Results identification. By doing the technique of testing the accuracy by utilizing the whole data set. So the obtained result of detection genuine and counterfeit money with a level of accuracy that is able to achieve 96,67%.

3. Results and discussion

3.1. Result of KNN (K-Nearest Neigbor)
Results of research using the KNN (K-Nearest Neighbor) method is

3.1.1. Result of scan banknotes. Banknotes has two different sides, so the scan is carried out two times against the sides of retrieval feature extraction color. Examples scan paper money with three times the experiment shown in figure 3:

Figure 3. Result of scan banknotes.

Results of scan carried out repeated three times to produce different values for color features RGB, but there is also contained the same value between scan 1 and 2 or scan 2 and scan 3.

3.1.2. Result of feature extraction. Result of feature extraction in paper currency by issuing a value of RGB (Red, Green, Blue). The results of value color feature extraction is shown in figure 4:

Figure 4. Result of feature extraction.

3.1.3. Result of preprocessing. Banknotes that has been scanned with the repetition of three times the same values that carried out a purge of the same value. Shown in table 1:

Table 1. Scanned with the repetition of three times the same values that carried out a purge of the same value

Banknotes 5000 old money									
	Scan Data 1			Scan Data 2			Scan Data 3		
Money	R	G	B	R	G	B	R	G	B
Money 1 back	187	167	144	188	167	145			
Money 1 front	187	168	147	188	169	147			
Money 2 back	167	144	125	168	145	126			
Money 2 front	168	145	124	168	145	125	168	146	125
Money 3 back	171	152	133	172	152	133	172	152	134
Money 3 front	174	154	135	174	155	136	175	155	136
Money 4 back	185	163	142	186	163	142			
Money 4 front	185	163	141	184	163	140	185	163	141
Money 5 back	195	172	147						
Money 5 front	195	177	153	195	177	152			
Money 6 back	163	139	119				164	140	119
Money 6 front	165	143	122						
Money 7 back	193	171	148	195	172	148	194	171	148
Money 7 front	192	173	151	193	174	151	192	173	150
Money 8 back	171	148	129	170	148	128	172	149	129
Money 8 front	170	148	128	169	147	128	170	147	128
Money 9 back	186	166	145	188	167	146	187	166	145
Money 9 front	186	165	145	188	166	146	187	165	145
Money 10 back	192	172	150				193	173	150
Money 10 front	190	173	151	190	173	152			

In table 1 there is a null value of RGB is the result of cleaning the same data. Next draw patterns in the same class and distanced patterns of a different class, shown in table 2:

Table 2. Patterns in the same class and distanced patterns of a different class.

R	G	B	Money
163	139	119	5000 A
164	140	119	5000 A
165	143	122	5000 A
167	144	125	5000 A
168	145	126	5000 A
168	145	125	5000 A
171	142	120	5000 B
172	142	119	5000 B
173	143	119	5000 B
174	141	118	5000 B
177	154	129	5000 B
177	146	122	5000 B
159	153	146	2000 A
159	146	136	2000 A
160	147	136	2000 A
160	145	132	2000 A
160	145	133	2000 A
162	147	133	2000 A
143	140	124	2000 B
144	142	130	2000 B
144	139	123	2000 B
144	142	129	2000 B
146	147	136	2000 B
148	150	137	2000 B

Data are separated into four classes (class) according to type of money that has been extracted. Here's an explanation of the some classes is 5000A: banknotes idr. 5000 old model, 5000B: banknotes idr. 5000 new model, 2000A: banknotes idr. 2000 old model and 2000B: banknotes idr. 2000 new model.

3.1.4. Results detection of banknotes. Results of testing detection value of banknotes using the 16 test data conducted on 160 training data. Process detection is done using K-Nearest Neighbor method with value of K=5. Results from testing detection using the R programming shown on figure 5:

```
          Accuracy : 0.8775
            95% CI : (0.6977, 0.9984)
No Information Rate : 0.25
P-Value [Acc > NIR] : 1.141e-08

              Kappa : 0.9167
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Figure 5. Result detection of banknotes.

3.2. Result of CNN (Convolutional Neural Network)
Results of reasearch using the CNN (Convolutional Neural Network) method is

3.2.1. Read data money show in figure 6

Figure 6. Data money.

3.2.2. Result of conversion grayscale show in figure 7

Figure 7. An example conversion grayscale.

3.2.3. Result of feature extraction local binary pattern show in figure 8

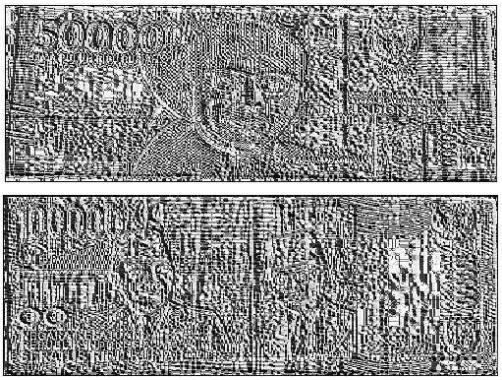

Figure 8. An example extraction local binary pattern.

3.2.4. Result of Identification

Final results obtained from testing each image of banknotes is 96,67% with image size 352 x 156 pixels. Results of identification test with the variation of accuracy different can be seen in table 3:

Table 3. Results of identification with image size 352x156.

Currency	Original Money	Counterfeit Money	Accuration
50k Ori	29	1	96,67%
50k Counterfeit	2	18	90%
100k Ori	27	3	90%
100k Counterfeit	1	23	95,8%

From the results of trials conducted in table 3, that the shaidrness in capture early through the camera smartphone greatly affect the detection of the image banknotes. Cleaning background on image the currency also affects the level of accuracy that will be obtained. Image data 50k Original, has the highest accuracy compared to image of the other because process cropping background image is done manually so that detection image of new focus to texture of surface resulting from the extraction the feature pattern on the image.

The end result without cropping the image on background image, where the accuracy of system average accuracy is 25% as seen in table 4:

Table 4. Result of identification without croping image.

Currency	Original Money	Counterfeit Money	Accuration
50k Ori	2	3	40%
50k Counterfeit	6	5	45%
100k Ori	1	3	25%
100k Counterfeit	3	1	25%

From the results of trials conducted in table 4, without process of cropping image is also very affect the value of accuracy the image money. Because the background original image of money is detected as a pattern so that authenticity of paper money difficult to detect. As on the image data 100k original and 100k false, have the same accuracy in the below average standards of accuracy, i.e. 25% as compared with the image that has been through the process of cropping. For the time testing with the 5 data is 7 seconds. So more less amount data are taken as testing sample, the faster the time of testing. There is a difference long time testing between each genuine and counterfeit money. For 50k original with 6 data testing time 8 seconds, with the low accuracy 40%. As for the 50k counterfeit with 11 data testing time 13 seconds and the accuracy is also low, namely 45%.

4. Concluding remarks

Based on the results of tests performed with two methods KNN (K-Nearest Neighbor) and CNN (Convolutional Neural Network). The accuracy obtained with the KNN method is 87,75%. While the detection accuracy with CNN is 96,67%. Of the two methods is affected when capture image at the beginning and pixel size of the image.

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