Automatic Recognition of Rupiah Currency using Naïve Bayes Classifier

by Dewi Yanti Liliana

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Automatic Recognition of Rupiah Currency using Naïve Bayes Classifier

Dewi Yanti Liliana[1]
Informatics Engineering Program Study,
Electrical Engineering Department,
State Polytechnic of Jakarta
Indonesia
Email: dewi.liliana@gmail.com

Indri Neforawati[2]
Informatics Engineering Program Study,
Electrical Engineering Department,
State Polytechnic of Jakarta
Indonesia

***Abstract*—Money is defined as a medium of exchange that can be universally accepted. When someone withdraw or save money which requires identification of cash transactions accurately, sometimes often mistaken because the color of money is almost the same. It will certainly harm others. Along with the development of technology, it is necessary to use intelligent techniques to recognize the Banknote automatically. With the identification of this Rupiah currency, expected the computer to recognize or classify Banknote quickly and accurately, even if the money is not grouped or in random order. This application uses an image of money as input, in any kind of Rupiah currency. The application can recognize and classify types of currencies by using the RGB color feature with Naïve Bayes Classifier. The test results demonstrate the accuracy of the recognition system is very good.**

***Keywords* : Banknote, Naive Bayes Classifier, pattern recognition, rupiah currency**

I. Introduction

Money plays an important role in human life. Apart from being a medium of exchange, a calculator, as well as a means of fulfilling human needs. On purchase transactions without cash register, for example in the vending machine problems can occur if there is a mistake in recognizing the money paid. Mistakes can also occur in transactions that require identification of appropriate value of money; where the money piled up at random condition, and is not grouped based on its value. That requires the ability of computer vision in order to recognize the value of money automatically, quickly and accurately.

One simple machine learning method that is reliable in recognizing patterns Naïve Bayes Classification. Naïve Bayes Classifier (NBC) works by finding the posterior probability of a pattern and classify them into a class that has the largest posterior value [1]. This is a supervised learning method that requires a training phase to provide learning data in order to be recognized by NBC. Automatic recognition of Rupiah currency input using NBC with a color feature is expected to help the process which involves automatic money recognition system.

Bayesian Theorem

Bayesian decision theory is a fundamental statistical approach used in pattern recognition. The approach is based on quantification of trade-offs between various classification decisions using probability and the costs incurred in the decisions making. Bayes method is also a good method in the machine learning based training data, by using conditional probability as basic [2]. The conditional probability is expressed as:

$$P(X \mid Y) = \frac{P(X \cap Y)}{P(Y)} \quad (1)$$

where $P(X|Y)$ denotes conditional probability of event X given event Y. $P(X \cap Y)$ is the intersection probability of X and Y, and $P(Y)$ is the probability of event Y. Equation 1 can be depicted as follows:

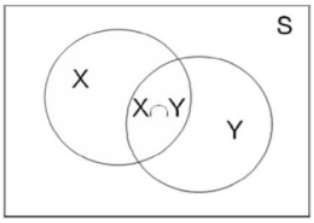

Figure 1. The intersection of two events X and Y

Using figure 1, the probability of X given condition Y is the probability of the intersection of X and Y, given by probability Y, or with other languages $P(X|Y)$ is the percentage of the number of X in Y.

The general form of Bayesian equation is:

$$P(H \mid \mathbf{X}) = \frac{P(\mathbf{X} \mid H)P(H)}{P(\mathbf{X})} \quad (2)$$

where:
X is the data of unknown class
H is the hypothesis of data X in a specific class
$P(X)$ is the probability of X
$P(H)$ is the probability of hypothesis H (prior probability)
$P(X \mid H)$ is the probability of X given condition H

P (H | X) is the probability of *H* given condition *X* (posterior probability).
P(X|H) is the conditional probability or known as likelihood of event *X* given condition of class *H*. The value of prior probability and likelihood can be obtained from the experiment or training data. *X* is classified as member of class *C* if the posterior probability of $P(C_i|X)$ is greater than the $P(C_k|X)$ of all classes *k*. For the continues dataset we can apply equation 3 (Gaussian distribution) to find the likelihood [1].

$$P\left(X_i = x_i \middle| Y = y_j\right) = \frac{1}{\sqrt{2\pi\sigma^2_{ij}}} \exp^{\frac{(x_i-\mu_{ij})^2}{2\sigma^2_{ij}}} \quad (3)$$

where *P* denotes the probability, X_i denotes *i*-th attribute
Y specify the class y_j. μ_j and σ^2_j is the mean and variance of class *j*.

Naïve Bayes Classifier

Naïve Bayes Classifier (NBC) is simple probability classifiers that apply Bayes theorem assuming highly independence [3]. Advantages of using NBC is that the method only requires the small amount of training data to estimate parameters needed in the classification process[4]. NBC estimates the probability of class conditional by assuming that attributes are conditionally independent given the class label. Conditional independent assumption can be expressed in the following form [1]:

$$P\left(X \middle| Y = y\right) = \prod_{i=1}^{d} P\left(X_i \middle| Y = y\right) \quad (4)$$

where $X = \{X_1, X_2, \ldots, X_d\}$ is the number of features (*d features)*.
To classify a test data, Naive Bayes Classifier calculates the posterior probability for each class Y and decide the highest posterior probability as the corresponding class.

$$P\left(Y \middle| X\right) = \frac{P(Y)\prod_{i=1}^{d} P\left(X_i \middle| Y\right)}{P(X)} \quad (5)$$

Color Feature

Color model is an abstract mathematical model that describes how colors can be represented as a tuple of numbers, usually three or four values or color components. RGB color model is an additive color model in which the emission color red, green, and blue was added along with a variety of ways to reproduce a wide color array. Color additives are used for lighting, video, and monitor. Monitor, for example, creates color by emitting light through red, green and blue phosphors.

The main purpose of the RGB color model is to represent, and display the image in electronic systems, such as the television and the computer. RGB color model is also used in conventional photography.
RGB is a color space that is dependent on the device. Different devices to detect or reproduce RGB value differently. To form a color with RGB, three colored light beams (one red, one green, and one blue) must be superimposed (e.g. by emission from a black screen, or by reflection from a white screen). Each of the three beams is called a color component, and each can have a different intensity. RGB color model can be used as a color feature or as a characteristic which distinct a specific pattern from another.

II. Method

Since NBC is a supervised learning method so we must provide a dataset or training data to the classifier as a guidance to recognize pattern of each class. The dataset are contains of seven different rupiah currencies: Rp.1000, Rp.2000, Rp.5000, Rp.10.000, Rp. 20.000. Rp.50.000, and Rp.100.000. The feature vectors we use are the mean intensities of each RGB band on specific captured area on the image. We compute the posterior probability using eq. 6.

$$P(J \mid X) = P(RED \mid J)P(GREEN \mid J)P(BLUE \mid J) \quad (6)$$

The methodology of Naïve bayes classifier to classify the rupiah currency can be seen in the following flowchart:

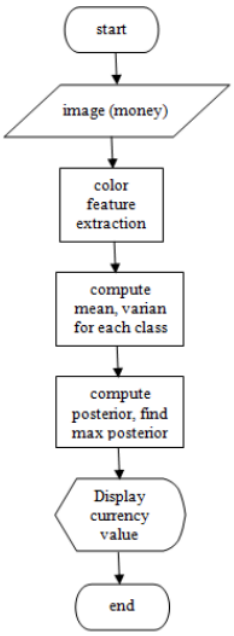

Figure 2. Naïve Bayes Classifier flowchart

At the beginning there are some training data which consist of several classes (different images of rupiah currencies) which provide an example (pattern) for classifier learning. We extract the RGB features from the dataset and compute mean and variance of each class to obtain the likelihood ($P(X|Y)$).
We can directly get the prior probability, which is the occurrence of a class pattern within a training data. If we already have likelihood and prior probability, we can easily compute the posterior probability of testing pattern for each class using eq. 5. The decision is made by choosing the class with maximum posterior probability. The reason is because it defeats all other classes and has a bigger probability to be the intended class.

III. Results

We conducted several experiments with different number of dataset. For each currency class we tested it with three different images. The result is shown on table 1. Here are some examples of the classification results.

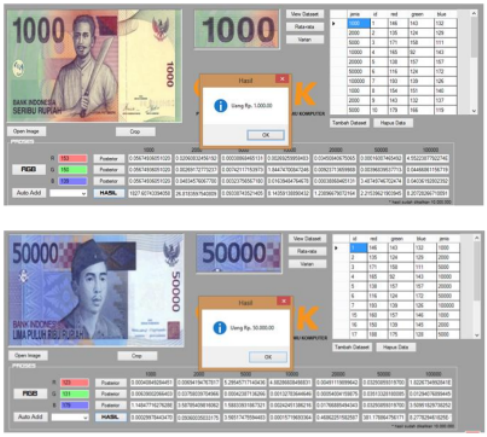

Figure 3. The classification results

Table 1. Experiments and results

No	∑ Exps.	∑ of Dataset	Result		Accuracy (%)
			correct	incorrect	
1	21	14	21	0	100
2	21	21	21	0	100
3	21	28	18	3	85.71
4	21	35	18	3	85.71
5	21	42	17	4	80.95
6	21	49	20	1	95.24
				average	91.27

From the experiments we can see the highest accuracy rate occurred in the 1st and 2nd experiments, using 14 and 21 datasets and the accuracy rate are 100%. The average accuracy rate is 91.27%, which means the proposed method was successfully recognized the rupiah currency.

IV. Discussion

Naive Bayes Classifier is a statistical approach to perform inference induction in classification problems. This method uses the conditional probability as basic. It can be used to classify the Rupiah currency value automatically, by using the mean intensities of RGB features. For a better accuracy, the number of dataset as a training data should be increased. More features to be used will also increasing the result, becoming better.

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