ISSN 2278-3091
Volume 9, No.1.5, 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse2691.52020.pdf
https://doi.org/10.30534/ijatcse/2020/2691.52020

Analysis of Image Processing in Barcode Using the K-Nearest Neighbor (K-NN) Classification

Annisa Putri[1], Agus Virgono[2], Casi Setianingsih[3]
[1]Telkom University, Indonesia, ichasatul@student.telkomuniversity.ac.id
[1]Adviser, Indonesia, avirgono@telkomuniversity.ac.id
[1]Telkom University, Indonesia, casie.sn@gmail.com

ABSTRACT

Barcode is a product introduction method. Each product has a different shape on the barcode. The system created contains a barcode recognition based on the image you have. This system aims to recognize products based on barcode characteristics. The system being studied can be used by users when shopping. The method used in this system for feature extraction is Hough Transform and the classification method used is k-NN. This research is expected to be able to classify barcode correctly and have good accuracy. This application uses
distance parameters = 5cm, 10cm, and 15cm and uses angles = 0˚, 45˚, 90˚, 135˚ and 180˚. The best results are obtained from a distance of 10 cm with angles = 0, and compared with variations in the value of k. A value of k = 1, 3, 5 gets a 71% result which is the best accuracy result in this system. Based on the best results, therefore to improve the accuracy of the system, the best distance and angle are taken from the previous parameters. This system using the Hough Transformation feature extraction method and the k-NN class classification get an accuracy value of 100%, with a distance of taking 10 cm and an angle of 0°.

Key words : Barcode, Hough Transform, k-Nearest Neighbor

1. INTRODUCTION

Shopping activities are things that can be said to be routine every month, where everyone goes to the shopping center to buy personal monthly needs. Various kinds of products can be found in shopping centers, where each product will be equipped with a barcode. Barcodes are used as a product identification number where there is price info, product name, and others. Shopping activities such as taking goods to be bought by the public often feel confused after seeing the list of shopping prices at the cashier unexpected, and resulting in increased expenditure. Personal financial data is needed in managing a monthly expenditure. Personal data can be obtained by scanning a barcode because the barcode can already identify a product.

Image processing is an activity where images can be analyzed so that they can to recognize objects like humans. In this study, feature extraction is performed on barcodes using the Hough Transform with k-NN classification. Previous studies using the Hough Transform and K-NN classification resulted in an accuracy rate of 85.81% [1]. Hough transformation is a feature extraction on curves in the form of lines, circles, ellipses and so on. The k-NN classification is a classification of new data based on a many k closest neighbors . The advantage of k-NN classification is that it is relatively resistant to noisy training data.

2. PREPARE PAPER BEFORE

2.1 Barcode Character Defect Detection Method Based on TESSERACT-OCR

Detection of defects in the barcode using the Leveinsthein Algorithm. Tesseract-OCR detection must be carried out horizontally. Taking pictures using binary images so that the character is clearer. Barcode detection using Tesseract-OCR must be trained first and become a font library. How to detect a defective barcode using Algorithm Leviensthein which will calculate the similarity between two images, the more similarities make the barcode into a class. The data used are 1000 barcode images where the level of accuracy is 94.3% with a single barcode process requiring 0.642 s.

2.2 Neural 1 Dimension Barcode Detection Using the Hough Transform

This 1 Dimension barcode detection can be taken from the camera shots and uses a bounding box to determine the location of the barcode. Evaluation of the performance of the barcode difference detection method can increase the effectiveness of the dataset being carried out. Hough transform proves the image obtained by the difference in the angle of rotation that utilizes bounding boxes and barcode barriers bent or exposed to light can be detected properly, with a time of 270 ms.

3. RESEARCH METHOD

3.1 Barcode

Barcode is a line code consisting of black and white with a certain distance that can be read by the machine and to represent alphanumeric characters. Barcodes are used as the identity of a product. Product barcodes include numbers or letters to make reading easier. Barcodes consist of one-dimensional barcodes and two-dimensional barcodes.

3.2 Digital Image Processing

The image is an image that is used as a medium of visual information, as is known through images that will get more information. The image can be said as a representation of an object. A digital image is a line that contains real or complex values that are displayed with a specific string.

Image processing is a way to improve the quality of the image so that its characteristics can be interpreted. The coordinate system in the image of each point has x and y position coordinates which have the form of a metric (M X N), having an amplitude of A which can indicate the interpretation of the amount of gray at one point.. Values on a slice between rows and columns (position x, y) are called picture elements, image elements, peels, or pixels[5].

3.3 Barcode Classification

Barcodes have many kinds, each product has a different barcode. Barcodes have cash characteristics in each bar thickness. Barcode classification is needed to distinguish one barcode with another barcode, which will identify each barcode feature on the product that will be labeled. In this study, barcodes are manually labeled in the dataset. In retrieval of training data required a good image capture, required retrieval of images with varying distances, including 5 cm, 10 cm, and 15 cm. Image capture is also done with angular variations including, 0˚, 45˚, 90˚, 135˚ and 180˚. The dataset is distinguished by labeling it. Aside from the label, the product includes the product name along with the price. The following barcode table contains the label, item name, and price:

Table 1 *:* Data Training

Label	**Name of Product**	**Price**
1	Pop Mie	Rp4.000,00
2	Hansaplast	Rp5.000,00
3	Pocky	Rp7.500,00
4	CDR	Rp44.000,00
5	Panadol	Rp9.000,00
6	Walini	Rp35.000,00
7	Dove	Rp24.700,00

3.4 Hough Transform

Hough's transform was first introduced by Paul Hough in 1962 to detect straight lines [5]. Hough transform is an image information technique used as pattern recognition by recognizing the lines [5]. Hough Transform is a transformation that focuses on extracting features on curves, such as lines, circles, ellipses and so on. Hough transformation uses parametric and estimates parameter values by using the most voting mechanism or voting in determining the appropriate parameter values [8]. The Hough transform identifies a straight line with equation (1) [7]:

$$yi=mxi+c \qquad (1)$$

Straight lines in an image will be transformed into the -c parameter space, we will get several lines that intersect in a point in the m-c parameter space [8].

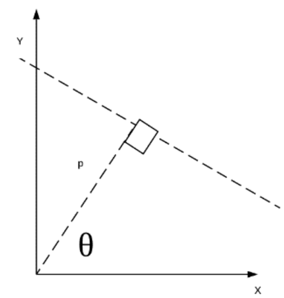

Figure 1: Forming Angle of Line Image

When a vertical line is found a problem will occur because the vertical line has a gradient of infinite magnitude, as an alternative solution used equation (2). [7]:

$$r = x \cos \square + y \sin \square \qquad (2)$$

The advantage of Hough Transformation is that it can be tolerant of gaps in an object and can not be affected by noise.

3.5 K-Nearest Neighbor (K-NN)

The k-Nearest Neighbors algorithm is a non-parametric method used as classification and regression [8]. The k-NN method is a method that uses a supervised algorithm [9]. K-NN The principle of k-NN is that if you have a set of sample data as training data then give a label for all the data then we know which data belongs to which class [8]. New data without labels will be compared with training data, they will see similarities (The Nearest Neighbors) and look for the label by looking at the top k that is most similar to the dataset [8].

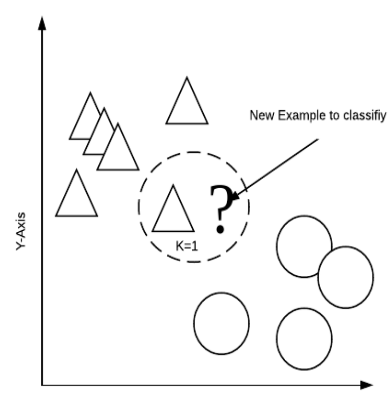

Figure 1 : k-NN Algorithm

The advantage of the k-NN algorithm is that it has a simple, powerful implementation in terms of search space, effective for calculating data on a small scale. The weakness of the k -NN algorithm is the need to determine the optimal k value.

4. DESIGN AND TESTING

4.1 Data Retrieval

The process of work is a process used as a reference for the author in carrying out testing activities. Training data is data used by the system to study barcode images. Barcode images that have been collected as training data are 7 products in .which each item is 150 times photographed. The amount of training data used is a total of 1050 dates. The captured image will be converted into pixels, with the number of pixels taken is 500. Here are the parameter data that will be used :

Table 1 : Angle and Distance Parameters

Distance (cm)	Angle (˚)
5	0
	45
	90
	135
	180
10	0
	45
	90
	135
	180
15	0
	45
	90
	135
	180

Tests carried out with data of 7 products, with one product as many as 15 times a photo. Test data will be compared between k values, i.e. k = 1 to 10. Accuracy results are obtained based on the level of success with different k values.

4.2 Preprocessing Image

1. Image Grayscale

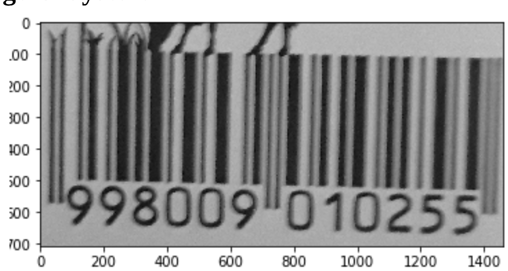

Figure 3: Image Grayscale

Figure 3 is a grayscale image implementation. The previously inserted image is an RGB image that has 3 layers. Grayscale is Cita converted to grayscale making 2-D images which makes it easy to convert images to black-white images.

2. Image Black and White (BW)

Figure 4 is an the implementation of Black and White (BW) images. BW images are images that only have values of 0 and 1. BW images are images that have been divided using thresholds from grayscale data with a threshold of 60.

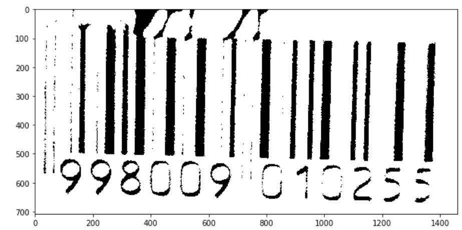

Figure 4 : Image BW

3. Canny Detection

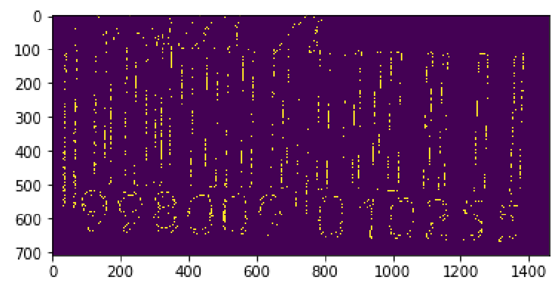

Figure 5 : Canny Detection

Figure 5 is an implementation image of Canny detection. Canny edge detection is detection that can detect the presence of lines in the barcode bar. Canny edge detection is done after the image has become BW and Canny edge detection can help feature extraction produce optimal results.

4.3 Feature extraction using Hough Transform

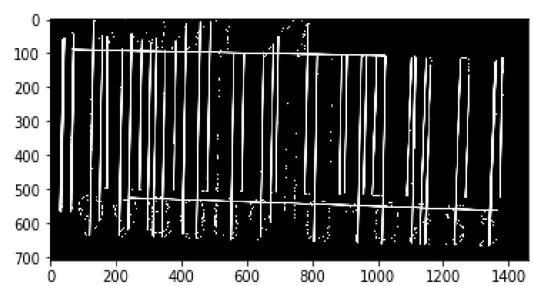

Figure 6 : . Hough Transform

Figure 6 is an implementation of the Hough Transform. Feature extraction is used as separating the image that has similarities with barcode bar lines. Hough Transform will detect the lines contained in the barcode. Barcode that has been extracted will be converted into rows of pixels.

4.4 Euclidean Distance

Euclidean distance is the distance obtained from calculations between pixels, from 1pixel array will be compared with 1050 pixel arrays. 1-pixel array consists of 500 types of binary numbers. Table 3 will give an example of 4 image arrays to be used.

Table 2 : Image Array

Number	Product	Pixel(500 Array)
1	Pop Mie	[1, 1, 1,…, 0, 0, 0]
2	Hansaplast	[0, 0, 0,…, 0, 1, 1]
3	Pocky	[1, 1, 1,…, 0, 1, 1]
4	CDR	[0, 0, 0,…, 0, 1, 1]
5	Panadol	[1, 1, 1,…, 1, 0, 0]
6	Walini	[0, 0, 0,… ,1, 0, 0]
7	Dove	[0, 0, 0,…, 1, 1, 1]

The calculation is obtained using the euclidean distance formula as follows (3) :

Table 3 : Euclidean Distance Score

Process
d = $\sqrt{(pixel1A - pixel1B)^2 + \cdots + (pixel500A - pixel500B)^2}$

Table 4 is the method that will be used to find the Euclidean distance. The method will be carried out as many as 1050 dates. The smallest distance will be selected as a class. Table 5 is the result of the closest Euclidean distance of each class and the closest distance to the class classified. The following is an example of data collection according to Euclidean distance, and here 3 products are displayed as samples:

Table 5 : Euclidean Distance Result

Product	Label 1	Label 2	Label 3
Pop Mie	0.288	0.582	0.664
Hansaplast	0.676	0.442	0.522
Pocky	0.522	0.552	0.532

Based on table 4, the smallest calculation results will be selected for classification. Labels 1,2 and 3 are the 3 closest distances. Do this distance calculation with 7 products and compare it with 1050 image arrays.

4.5 K- NEAREST Neighbor Classification Testing

The test for product 150 times of photographs and total data are 1050. Determining the value of K as a test is k = 1,2,3,4,5,6,7,8,9,10. Labeling on each product is intended to facilitate the training data, here are the label data on each product. Following is the search for the best k-value based on 1050 dates with a test data of 10%, then the error value is obtained based on k that has been determined.

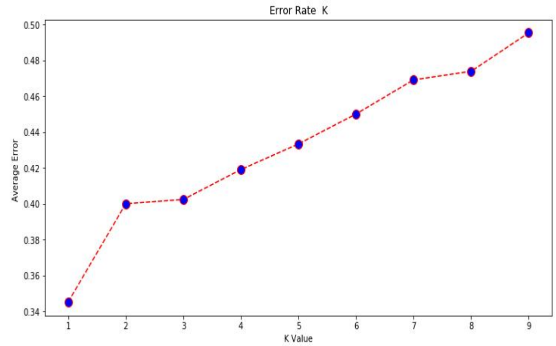

Figure 7*:* Error Rate k values

Based on figure 7, it can be said that the greater the value of k, the greater the error obtained. Retrieval of the error value k which is an even number can cause ambiguity. Therefore, the value that will be used in this test is an odd value for the value of k = 1,3,5,7.

4.6 Performance System

Barcode classification is used to determine which barcode has been purchased by the user. to find out the value of performance evaluation, calculation, precision, comprehension and F1 score is done. To find out the parameters of this system performance we can see in the Confusion Matrix.

Table 6 : Confusion Matrix

		Actual	
		Positive	Negative
Predicted	Positive	True Positive	False Positive
	Negative	False Negative	True Negative

Precision is the level of accuracy of the data requested by the user with the data generated by the system. The way in which precision calculations for barcode classification is: [10]:

$$\text{Precision} = \frac{TP}{TP+FP} \quad (4)$$

Recall is the level of success of the system in carrying out the classification or the ability to find all relevant examples in the data set. The method of recall calculation for barcode classification is:

$$\text{Recall} = \frac{TP}{TP+FN} \quad (5)$$

F1 score is an evaluation calculation that combines the results of precision and recall values. The formula of F1 Score is:

$$\text{F1-score} = 2 \text{ X } \frac{Precision \text{ X } Recall}{Precision+Recall} \quad (6)$$

4.7 Testing

The testing of each product will be carried out with the aim of comparing which position is the best with variations in the value of k. Accuracy values are obtained from the formula :

$$\text{Accurate} = \frac{\text{True Prediciton}}{\text{Total Data}} \text{ X } 100\% \qquad (7)$$

The following are the results of tests with varying k values.

Table 7 : Testing with Distance 10 cm and Angle = 0

K	Average Precision(%)	Average recall(%)	Average f1-score(%)	Accurate(%)
1	77.7	78.28	79.42	71
3	70.4	74.71	70.85	71
5	67.28	67	66.71	71
7	72.5	68.28	70	57

Table 8 : Testing with Distance 10 cm and Angle = 45

K	Average Precision(%)	Average recall(%)	Average f1-score(%)	Accurate(%)
1	80.57	74.14	78	57
3	69.28	74.28	70.28	28
5	77	65.14286	71	28
7	73.28	65.71	71.57	28

Table 9 : Testing with Distance 10 cm and Angle = 90

K	Average Precision(%)	Average recall(%)	Average f1-score(%)	Accurate(%)
1	72.71	81.85	76.85	42
3	70.57	67.14	66.57	42
5	58	64.71	56.85	42
7	70.42	64.14	65.42	42

Table 10 : Testing with Distance 10 cm and Angle = 135

K	Average Precision(%)	Average recall(%)	Average f1-score(%)	Accurate(%)
1	68	77.71	72.42	57
3	73.14	72	70.71	28
5	71.42	71.14	70.14	28
7	75.85	68	70.85	28

Table 11 : Testing with Distance 10 cm and Angle = 180

K	Average Precision(%)	Average recall(%)	Average f1-score(%)	Accurate(%)
1	75.85	76.57	74.71	42
3	77.42	68.28	70.8	42
5	72	57.86	62.71	42
7	65.85	56	60.14	42

4.8 Result

The following graph is obtained for a distance of 10 cm and an angle of 0 ˚, with variations in the value of k = 1,3,5,7.

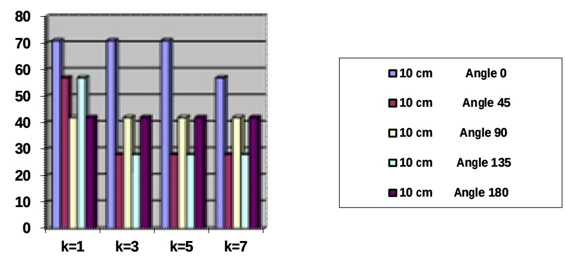

Figure 8 : Accuracy of k

This analysis proves a distance of 10 cm with an angle = 0 degrees produces the highest accuracy value, with a maximum value of 100% for k = 1.3.5, a value of 71% for k = 1, a value of 71 =% for a value of 71% for k = 5. Based on table Fig. 8 , on the results obtained the best distance and angle values can be taken 10 cm and 0˚. The following accuracy values for these parameters :

Tabel 12 : Result

K	Average Precision(%)	Average recall(%)	Average f1-score(%)	Accurate(%)
1	100	100	100	100
3	100	100	100	100
5	100	100	100	100
7	100	100	100	100

This can be done for training data focusing on 1 parameter only, which is 10 cm and the angle of 0˚ in order to get the best results.

5. CONCLUSION

The best accuracy results are obtained with a distance parameter = 10 cm and angle = 0 ˚ with a value of k = 1, 3, 5 with a value of 71%. The highest accuracy of 70% proves that this application is not suitable for barcode classification. Training data which only focuses on 1 parameter, which is a distance of 10cm and an angle of 0 ˚ produces an accuracy value of 100% for each k value.

ACKNOWLEDGEMENT

The author would like to thank all those who have helped and provided support in completing this Final Project. The author realizes that this paper is still far from perfect, so the authors highly expect suggestions and constructive criticism from readers for further research improvement. Thus the paper was compiled, hopefully this paper can benefit readers.

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