Available *online* at : http://jnte.ft.unand.ac.id/

Jurnal Nasional Teknik Elektro

| ISSN (Print) 2302-2949 | ISSN (Online) 2407-7267 |

Comparison of Classification for Grading Red Dragon Fruit (*Hylocereus costaricensis*)

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ARTICLE INFORMATION

Received: December 04, 2021
Revised: February 10, 2022
Available online: March 29, 2022

KEYWORDS

backpropagation, dragon fruit, grading, KNN, naïve bayes

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ABSTRACT

Pitaya is another name for dragon fruit which is currently a popular fruit, especially in Indonesia. One of the problems related to determining the quality of dragon fruit is the postharvest sorting and grading process. In general, farmers determine the grading system by measuring the weight or just looking at the size of the fruit, of course, this raises differences in grading perceptions so that it is not by SNI. This research is a development of previous research, but we changed the type of dragon fruit from white dragon fruit (*Hylocereus undatus*) to red dragon fruit (*Hylocereus costaricensis*). We also adapted the image processing and classification methods in previous studies and then compared them with other classification methods. The number of images in the training data is 216, and the number of images in the testing data is 75. The comparison of the accuracy of the three classification methods is 84% for the KNN method, 85.33% for the Naive Bayes method, and 86.67% for the Backpropagation method. So that the backpropagation method is the best classification method in classifying the quality grading of red dragon fruit. The network architecture used is 4, 8, 3 with a learning rate of 0.3 so that the training accuracy is 98.61% and the testing accuracy is 86.67%.

INTRODUCTION

Pitaya is a type of cactus from the genera Hylocereus and Selenicereus known as dragon fruit [1]. Dragon fruit is also a promising fruit to be developed in Indonesia. This fruit is usually red and green scaly, but the flesh of the fruit is of different colors, namely red, purplish-red and white [2]. Several problems related to determining the quality of dragon fruit, namely: fruit disease, harvest time selection, sorting process, and postharvest grading. Dragon fruit quality standards are divided into 3 grades: dragon fruit grade Super, grade A, and grade B. The quality division is based on 3 criteria, namely weight, sugar/Brix content, and fruit skin [3].

Generally, farmers determine the grade by measuring the weight or just looking at the size of the dragon fruit itself. However, the drawback is the difference in perceptions related to standards between farmers so that it makes the post-harvest grading assessment, not by SNI. Of course, this will affect the quality of dragon fruit when it is marketed. To overcome this, we created a postharvest grading classification system for red dragon fruit (Hylocereus costaricensis) by comparing several classification methods. The goal is to obtain a classification method with high accuracy so that a dragon fruit grading classification system is obtained that is automatic, accurate, and objective.

Previous research that has become a reference is research that uses image processing to determine the quality level of white dragon fruit (*Hylocereus undatus*) non-destructively, but this study could not detect any defects in dragon fruit. [4]. Then research was developed in 2015, using the Discrete Cosine Transform (DCT) technique to identify the maturity level of red dragon fruit (*Hylocereus costaricensis*) and get a system accuracy of 80% [5]. The next research is to implement the backpropagation method to identify the ripeness of the red dragon fruit with a system accuracy of 96.67% [6]. The K-Nearest Neighbor method is also another intelligent system method used to determine the maturity level of red dragon fruit with RGB color features and statistical features, namely the mean so that an accuracy rate of 93.3% is obtained [7].

Next, we developed the implementation of the backpropagation method for the quality sorting classification system on white dragon fruit (*Hylocereus undatus*) in 2021. The results of the study showed that the most suitable network architecture on the backpropagation method was 5,8,5,3 with a system accuracy of 86.67% [8].

https://doi.org/10.25077/jnte.v11n1.899.2022

Based on the results of our previous research, we developed a classification system for postharvest grading of dragon fruit, but we changed the type of dragon fruit from white dragon fruit (*Hylocereus undatus*) to red dragon fruit (*Hylocereus costaricensis*). We also adapted the image processing and classification methods in previous studies and then compared them with other classification methods so that a more accurate classification method was obtained than the previous classification method.

METHOD

The research method consists of 3 stages, namely red dragon fruit data collection, digital image processing, and the classification process as shown in Figure 1. Data collection techniques for red dragon fruit were carried out by measuring the weight, fruit length, and diameter of the fruit as in our previous study (the data used were primary data) [8].

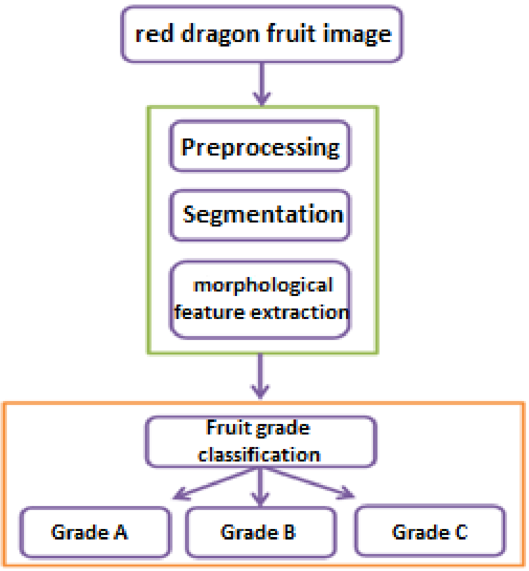

Figure 1. Red Dragon Fruit Grading System Block Diagram

Red Dragon Fruit Image

The location of data collection for red dragon fruit is in Kebun Argowisata Rembangan, Kabupaten Jember. The technique of taking the image is that the dragon fruit is placed in a studio mini box with a white base background and 3 LED lights are given for lighting. The process of taking images using a smartphone with a camera resolution specification of 13 MP is done one by one and stored in a file on a memory card or indirectly. Then the red dragon fruit is classified into 3 classes, namely Grade A, Grade B, and Grade C, based on direct observations, the grade is determined by weight as shown in Table 1 and Figure 2.

Table 1. Variations in Weight for Each Grade of Dragon Fruit Type

Types of Dragon Fruit	Weight (grams)		
	Grade A	Grade B	Grade C
Hylocereus undatus	> 500	400 - 500	< 400
Hylocerus costaricensis	> 350	250 - 350	< 250

Figure 2. Variation of Grade on Red Dragon Fruit (*Hylocereus costaricensis*)

Based on table 1, it is known that red dragon fruit *(Hylocereus costaricensis*) with grade A if it weighs more than 350 grams, for grade B if it has a weight range of 250-350 grams, and grade C if it weighs less than 250 grams. The weight determination was calculated using a digital scale while the diameter and length of the fruit were calculated using a caliper as shown in Figure 3. In this research, the amount of training data used was 216 images consisting of 78 Grade A images, 74 Grade B images, and 64 Grade C images, while the amount of test data used was 75 images consisting of 25 images for each grade of red dragon fruit.

Figure 3. Dragon Fruit Image Data Collection Process [8].

Image Preprocessing

The next process is a digital image processing technique. The digital image processing technique begins with an image preprocessing process where the image cropping process and the RGB color space component splitting are carried out. In our previous research, the initial size of the image was 2701 x 2701 pixels, then the cropping process was carried out to become an image with a size of 300 x 300 pixels [8]. The process is carried out to reduce the computational load [9]. After the cropping process is carried out, the next process is to split the RGB color space components, this is done because the RGB color image has a large value so it is difficult to segment [10]. Generally, RGB images are converted to other color spaces such as grayscale, HSV, or CIELab, but the focus of researchers is only on solving the RGB color space to determine which image components best represent the shape of the red dragon fruit among the red, green and blue components.

Image Segmentation

After the preprocessing process, the segmentation process is carried out where the purpose of the process is to separate objects and backgrounds. The final result of this process is a binary image where the image has two values, namely the value 1 (white) and the value 0 (black). To obtain a binary image, generally, a threshold value search process or thresholding is carried out using the formula equation [11]:

$$g(x,y) = \begin{cases} if\ f(x,y) \geq T\ then\ 1 \\ if\ f(x,y) < T\ then\ 0 \end{cases} \quad (1)$$

https://doi.org/10.25077/jnte.v11n1.899.2022

To get the threshold value (T), it is determined by looking at the histogram of the red, green, and blue component images depending on the component image that best represents the shape of the red dragon fruit.

The Morphological Feature Extraction

In this study, the extraction of morphological features consisting of length, diameter, area, and perimeter of the fruit was used. To get the area and perimeter features using the chain code technique where the white object is labeled by calculating it based on the 8 neighboring directions [12]. The formula equation used to get of area and perimeter (circumference) features [12]:

$$Area = Number\ of\ pixel\ in\ row-1 + row\ to-2 + \cdots + row\ to-8 \quad (2)$$

$$Perimeter = \sum even\ code + \sqrt{2}x \sum odd\ code \quad (3)$$

To get the length and diameter of the fruit by finding the major axis length and minor axis length. The value of the major axis length (object length) is the furthest distance between the centroid and the outermost pixel coordinates [13]. Meanwhile, the minor axis length is the distance between the centroid and the closest pixel coordinates. To get the diameter used the formula equation:

$$Diameter = \frac{major\ axis\ length + minor\ axis\ length}{2} \quad (4)$$

The Classification Method

These four parameters become the input of the classification system. In this study, we used three classification methods, namely backpropagation, K-Nearest Neighbor (KNN), and Naïve Bayes methods. The researchers adapted the K-Nearest Neighbor method which has succeeded in classifying platelets [14] and leukocyte abnormalities [15] in previous research. While the backpropagation method, the researchers also adapted previous studies that have succeeded in classifying platelets [16], the level of maturity of cayenne pepper [17] and were able to classify the quality of white dragon fruit with an accuracy rate of 86.67% [8]. The Naïve Bayes Classifier method was chosen because it uses simple probability calculations but is quite reliable in classifying, especially on numerical data [18]. Naïve Bayes Classifier is also used to classify data mining [19], identification of microscopic images of Acute Lymphoblastic Leukemia (ALL) with an accuracy of 80% [18], and classification of mushroom species based on first-order statistical characteristics with the highest accuracy rate of 98.75% [20].

The equation for the KNN method is based on Euclidean distance [12] :

$$ED(x_a, x_b) = \sqrt{\sum_{r=1}^{n} (x_{ar} - x_{ab})^2} \quad (5)$$

Where Xar is testing data and Xab is training data

The Naive Bayes algorithm used [21]:

1. Calculate the probability of each class that exists.
2. Calculate the average value (mean) of each feature and each class using the equation :

$$\mu = \frac{\sum n}{b} \quad (6)$$

where $\sum n$ is the number of data values and b is the number of data

3. then calculate the value of the standard deviation of each feature and each class with the equation :

$$\sigma = \left(\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2\right)^2 \quad (6)$$

RESULTS AND DISCUSSION

Digital Image Processing Techniques

The focus of the discussion is solving components in the RGB color space. The function of splitting the RGB color space is to facilitate the segmentation process because RGB is difficult to segment, so the color space must be split into components or converted to another color space. In the process of splitting the RGB color space components and converting them to other color spaces, namely grayscale and HSV, it is shown in Figure 4.

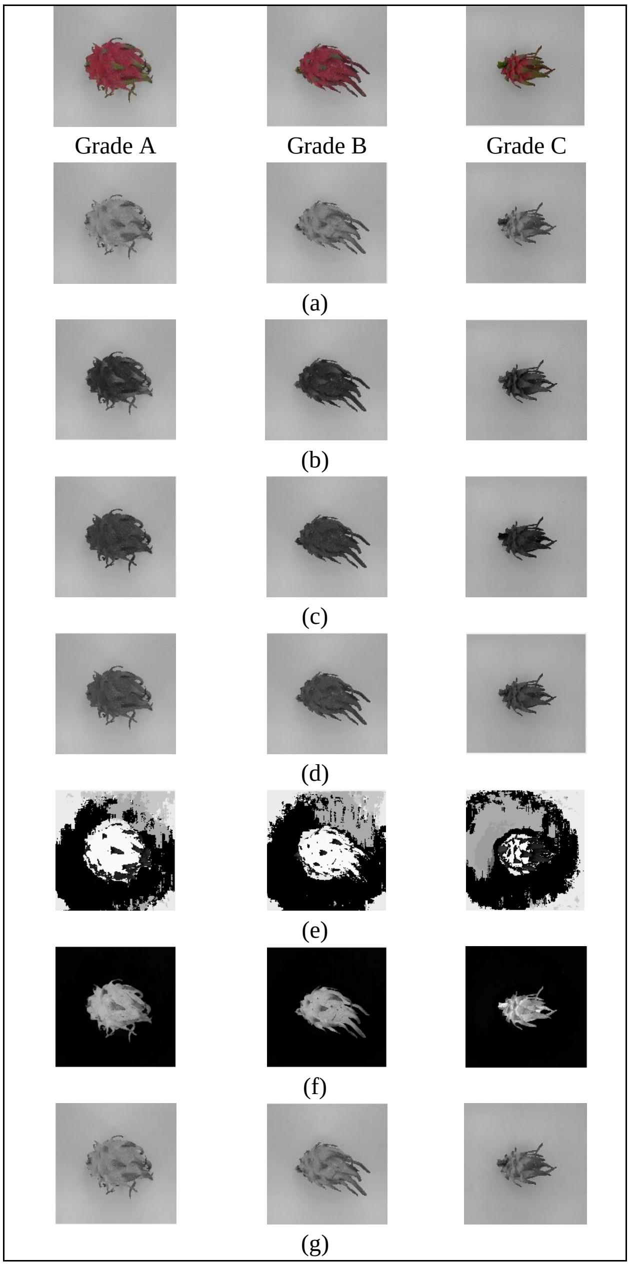

Figure 4. The Results of the Process of Solving the Color Components (a) Red, (b) Green, (c) Blue, Image Conversion (d) Grayscale and Color Components (e) Hue, (f) Saturation and (g) Value.

Based on the results shown in Figure 4, the component images that best represent the shape of the dragon fruit are Grade A, Grade B, and Grade C, namely the blue component image and the grayscale image. While the red component image and value component image are not used because the object and background colors have the same color when segmented the results are not good. The Hue component image cannot be used for segmentation because the resulting image does not have a clear boundary between the object and the background, while in the saturation component image there is a clear difference between the object and the background. This can also be seen with an image histogram as shown in Figure 5.

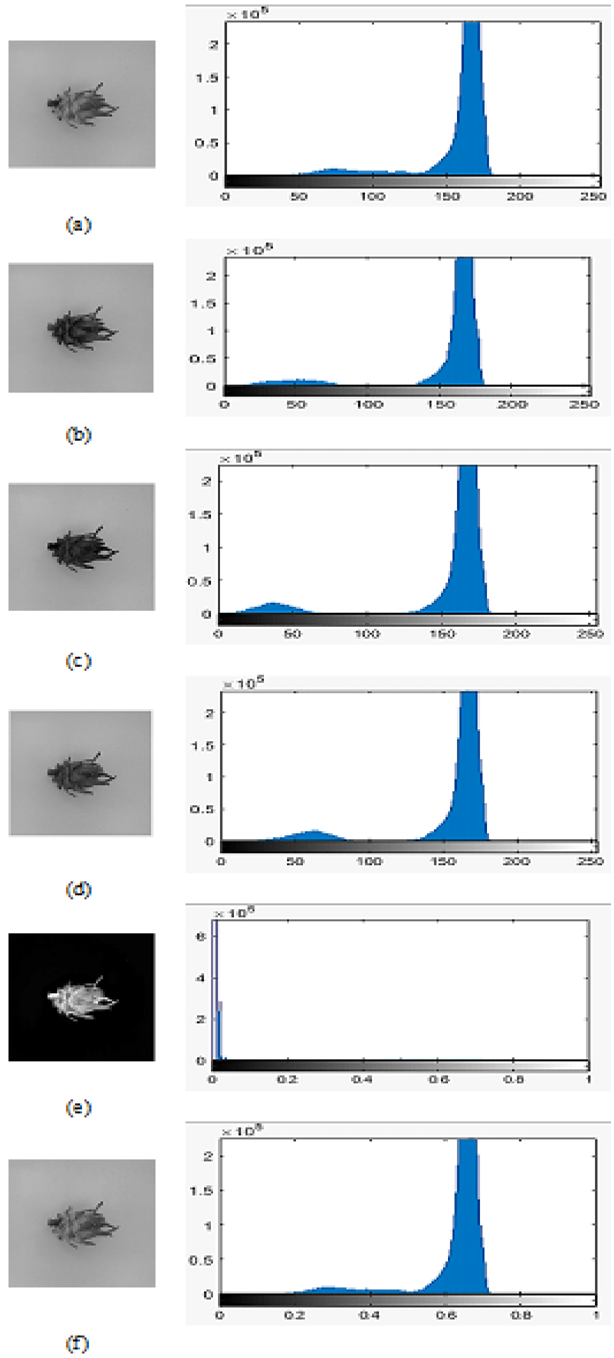

Figure 5. Histogram Image Components (a) Red, (b) Green, (c) Blue, (d) Grayscale, (e) Saturation and (f) Value.

Based on Figure 5, it can be seen that the histogram of the image in the red, green, blue, and grayscale color components has the highest peak which has a pixel value of more than 2 x 10^5 pixels and the range of gray values is 125 – 175. While in the image of the saturation component, the highest peak has a pixel value of more than 2 x 10^5 pixels and the gray value is less than 0.1. The value component image has a pixel value of more than 2 x 10^5 pixels and the range of gray values is 0.5 – 0.7.

These values are not objects (dragon fruit) but the background so finds the threshold value (T) is not in the range of values mentioned above. Determination of the threshold value is used to obtain a segmented image or a binary image using the equation (1). In this study, the focus used is the segmentation results on red component images, green component images, blue component images, and grayscale images.

To get the best threshold value, several experiments were carried out with values of 25, 50, and 125 which were tried on the red, green, blue, and grayscale component images according to previous research [8] and the results of the binary image are shown in Figure 6.

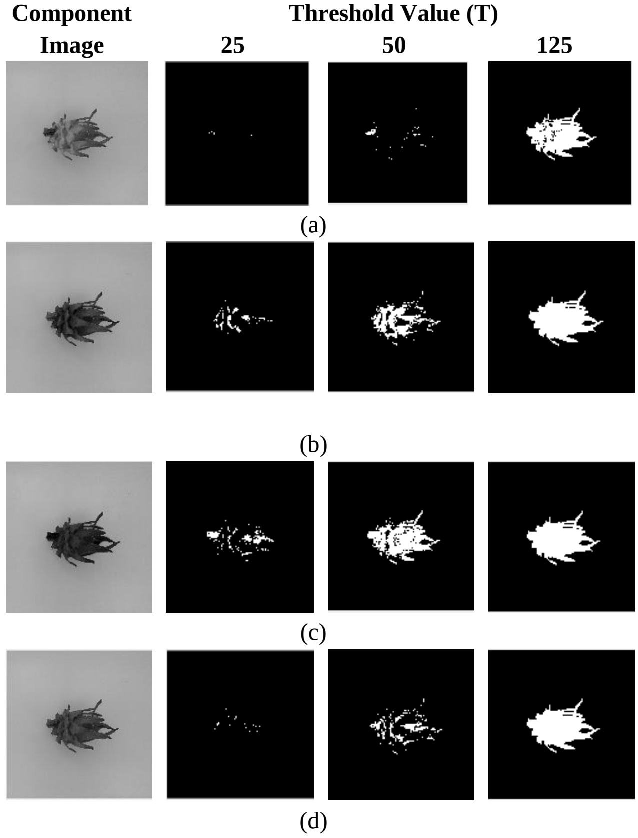

Figure 6. The Result of Image Segmentation of Components (a) Red, (b) Green, (c) Blue, and (d) Grayscale with Variations in the Threshold Value (T).

Based on the segmentation results from Figure 6, when the red, green, blue, and grayscale component images are given a threshold value of less than 125, it is the red component image that does not represent the shape of the red dragon fruit well. However, different things happen when using a threshold value (T) of less than 50, the image of the blue component best represents the shape of the red dragon fruit compared to the image of the red, green, and grayscale components. The results of the segmentation image shown in Figure 6 also show below the best threshold value, which is 125, where when the gray level value of the pixel is worth more than 125, then the pixel will be zero

https://doi.org/10.25077/jnte.v11n1.899.2022

(black) and when the gray level value of the pixel is less than 125 then the pixel will be one (white). So in this research, the image of the blue component that best represents the shape of the dragon fruit is used in Grade A, Grade B, and Grade C.

The next step is the feature extraction process which aims to take the characteristic value (feature) of the research object. The morphological features used to consist of length, diameter, area, and perimeter for training data shown in Table 2 and for testing data shown in Table 3. The amount of training data used was 216 images consisting of 78 Grade A images, 74 Grade B images, and 64 Grade C images, while the amount of test data used was 75 images consisting of 25 images for each grade of red dragon fruit.

Table 2. Extraction of Morphological Features on Training Data

Grade	Fitur Morfologi			
	Length	**Diameter**	**Area**	**Perimeter**
A	108 - 184	129 - 208	12301-24512	561 - 1463
B	93 - 144	112 - 174	9608 - 13081	469 - 929
C	73 -143	84 - 149	6905 - 10569	434 - 909

Table 3. Extraction of Morphological Features on Testing Data

Grade	Fitur Morfologi			
	Length	**Diameter**	**Area**	**Perimeter**
A	111 - 177	130 -183	12523 - 24062	566 - 1487
B	94 - 127	111 - 167	9922 - 13421	488 - 937
C	74 - 122	88 - 155	6404 - 10626	397 - 722

Table 2 and Table 3 show the average value of features on variations in dragon fruit grading. From the four feature values, it is found that Grade A has the greatest value in each feature when compared to Grade B and Grade C, both training data and testing data.

The Classification Method

The four parameters are used as input to the intelligent system method. The amount of training data is 216 data images and the number of testing data is 75 data images. The researcher compares three classification methods, namely the K-Nearest Neighbor (KNN), Backpropagation, and Naïve Bayes methods. The results of the percentage of system accuracy using the K-Nearest Neighbor method are shown in Table 3.

Table 3. The Accuracy of KNN Method with Variation of K

Variation of K Value	Accuracy Percentage (%)
1	84
3	82.67
5	78.67
7	82.67
9	78.67

Table 3 shows that the best level of accuracy for the K-Nearest Neighbor method is 84% with a K value of 1. Meanwhile, when the value of K = 3 and K = 7, the accuracy obtained is 82.67%, and when the value of K = 5 and K = 9, the accuracy obtained is 78.67. %.

The next step is to compare it with the backpropagation method. The backpropagation method is a classification method whose learning method is supervised where the target is known, if the classification results are not by the target, then the weight update (W) is carried out so that better accuracy results are expected. In this method, there are system training accuracy (Table 4) and system testing accuracy (Table 5).

Table 4. The Results of System Training Accuracy

Learning Rate					Network Architecture		
0.05	**0.1**	**0.3**	**0.5**	**0.7**	**I**	**H**	**O**
89.81	90.28	89.81	89.35	91.67	4	4	3
90.28	90.74	90.28	95.37	93.52	4	5	3
91.67	92.13	98.61	98.15	96.30	4	8	3
93.06	98.15	97.69	95.83	97.69	4	8,5	3

Description I : input, H : Hidden, O : Output

Based on table 4 shows that there are two best network architectures, namely 4,8,3 and 4,8,5,3. For the best training accuracy with a network architecture of 4.8,3 which is 98.61% with a learning rate of 0.3. While for the best training accuracy with a network architecture of 4,8,5,3 which is 98.15% with a learning rate of 0.1.

Table 5. The Results of System Testing Accuracy

Learning Rate					Network Architecture		
0.05	**0.1**	**0.3**	**0.5**	**0.7**	**I**	**H**	**O**
86.67	84	86.67	86.67	81.33	4	8	3
86.67	85.33	85.33	86.67	82.67	4	8,5	3

Description I : input, H : Hidden, O : Output

Table 5 shows that the best test accuracy is 86.67% with learning rates of 0.05, 0.3, and 0.5 on network architectures 4, 8, 3. For network architecture 4,8,5,3, the best test accuracy is also 86.67% with learning rates of 0.05 and 0.5. So that the best architecture is 4,8,3 because when a variation of learning rate is used, the highest accuracy testing is 86.67%. There is a difference in the accuracy of training and testing with a network architecture of 4,5,3 and a learning rate of 0.3 where the training accuracy is 98.61% and the testing accuracy is 86.67%. This shows that the training data and test data have a significant difference in value, this is also supported by the difference in feature values shown in Table 1 and Table 2.

Based on the results of the accuracy of the K-Nearest Neighbor (KNN) method and the backpropagation method, another method being compared is the Naïve Bayes method. Naïve Bayes is a classification method using probability methods to predict future opportunities (testing data) based on experience on previous data (training data). The advantage of using the Naïve Bayes method is that it is relatively easy to implement and efficient in training. The results of the comparison of the accuracy of the three methods are shown in Table 6.

Table 6. Comparison of Classification Method Accuracy

Classification Method	System Accuracy (%)	Classification Time (s)
KNN	84	0
Naïve Bayes	85.33	0
Backpropagation	86.67	0.97

Table 6 shows a comparison of system accuracy in the three classification methods. The accuracy of the K-Nearest Neighbor method is 84%, while the Naïve Bayes method is 85.33% and the

Backpropagation method is 86.67%. The required classification time is less than 0.97 seconds. The table also shows that the backpropagation method is the best classification method in classifying the Red Dragon Fruit (*Hylocereus costaricensis*) Postharvest Grading compared to the KNN and Naïve Bayes methods. The calculation of the accuracy of the backpropagation method is obtained from the calculations in the confusion matrix table as shown in Table 7.

Table 7. Confusion Matrix for Backpropagation Method

Output			Target
a	**b**	**c**	
21	4	0	A
1	22	2	B
0	3	22	C

Table 7 shows the test results of the backpropagation method. For class A, it is known that from 25 data, the system can classify 21 data correctly and 4 data are incorrectly classified into class B. The system can classify 22 data correctly according to the target (B) and 1 data incorrectly classified into class A and 2 data incorrectly classified into class C. While the system can correctly classify according to the target (C) as many as 22 data and 3 data are incorrectly classified into class B. An error occurred in classifying due to the similarity of feature values in class B to class A and class C.

One example of the fruit length feature for class B (Table 3), is stated that the range of length values for class B is 94 -127, while class A has a length value range of 111-177 and class C has a length value range of 74 -122. So that it will affect the classification process as shown in the confusion matrix table (Table 7).

CONCLUSIONS

Based on the results of the research above, it is concluded that digital image processing techniques play an important role in the classification process. Because the final stage of the image processing technique, namely feature extraction, determines whether the classification results are good or not. Errors in the system when classifying data due to feature values of a class that has similarities with feature values in other classes. so that the classification method misrecognizes the data and the output of the data classification results does not match the expected target.

For further research development, combine the two dragon fruits, namely the red dragon (*Hylocereus costaricensis*) and the white dragon (*Hylocereus undatus*) so that the system can classify the quality grading of dragon fruit varieties accurately.

ACKNOWLEDGMENT

Our gratitude goes to the Pusat Penelitian dan Pengabdian Masyarakat (P3M) of Politeknik Negeri Jember for supporting and funding this research.

REFERENCES

[1] F. le Bellec and F. Vaillant, *Pitahaya (pitaya) (Hylocereus spp.)*, vol. 4. Woodhead Publishing Limited, 2011. doi: 10.1533/9780857092618.247.

[2] F. le Bellec, F. Vaillant, and E. Imbert, “Pitahaya (Hylocereus spp.): A new fruit crop, a market with a future,” *Fruits*, vol. 61, no. 4, pp. 237–250, 2006, doi: 10.1051/fruits:2006021.

[3] Direktorat Budidaya Tanaman Buah, “Pedoman Baku Budidaya Standard Operating Procedure (SOP) Buah Naga (Hylocereus undatus) Kabupaten Sleman,” Sleman, 2009.

[4] D. Fitrada, “APLIKASI IMAGE PROCESSING UNTUK MENENTUKAN TINGKAT MUTU BUAH NAGA (Hylocereus undatus) SECARA NON-DESTRUCTIVE,” 2010.

[5] R. Wulanningrum and N. V. W. Lelitavistara, “Discrete Cosine Transform Untuk Identifikasi Citra Hylocereus Costaricensis,” *Simetris : Jurnal Teknik Mesin, Elektro dan Ilmu Komputer*, vol. 6, no. 2, p. 353, 2015, doi: 10.24176/simet.v6i2.472.

[6] R. D. M. Bimantaka, “IDENTIFIKASI KEMATANGAN BUAH NAGA MERAH MENGGUNAKAN METODE BACKPROPAGATION BERBASIS ANDROID,” Yogyakarta, 2017.

[7] F. Nisa’, “Sistem Identifikasi Citra Hylocereus costaricensis dengan Menggunakan Metode K-Nearest Neighbor dan Mean Statistik,” Kediri, 2018.

[8] Z. E. Fitri, A. Baskara, M. Silvia, A. Madjid, and A. M. N. Imron, “Application of Backpropagation Method for Quality Sorting Classification System on White Dragon Fruit (Hylocereus undatus),” in *IOP Conference Series: Earth and Environmental Science*, Apr. 2021, vol. 672, no. 1. doi: 10.1088/1755-1315/672/1/011001.

[9] Z. E. Fitri, W. B. Nugroho, A. Madjid, and A. M. N. Imron, “Comparison of Neural Network Methods for Classification of Banana Varieties (Musa paradiasaca),” *Jurnal Rekayasa Elektrika*, vol. 17, no. 2, 2021, doi: 10.17529/jre.v17i2.20806.

[10] Z. E. Fitri and A. M. N. Imron, “Classification of White Blood Cell Abnormalities for Early Detection of Myeloproliferative Neoplasms Syndrome Using Backpropagation,” in *Biomedical Engineering, and Health Informatics*, 2021, vol. 2020, pp. 499–508. [Online]. Available: http://www.springer.com/series/7818

[11] Z. E. Fitri, R. Rizkiyah, A. Madjid, and A. M. N. Imron, “Penerapan Neural Network untuk Klasifkasi Kerusakan Mutu Tomat,” *Jurnal Rekayasa Elektrika*, vol. 16, no. 1, pp. 44–49, 2020, doi: 10.17529/jre.v16i1.15535.

[12] Z. E. Fitri, L. N. Sahenda, P. S. D. Puspitasari, P. Destarianto, D. L. Rukmi, and A. M. N. Imron, “The Classification of Acute Respiratory Infection (ARI) Bacteria Based on K-Nearest Neighbor,” *Lontar Komputer*, vol. 12, no. 2, pp. 91–101, Aug. 2021.

[13] J. N. Anita, “Pengukuran Dimensi Retakan pada Citra Jalan menggunakan Filter Gabor,” Surabaya, 2018.

[14] Z. E. Fitri, I. K. E. Purnama, E. Pramunanto, and M. H. Purnomo, “A comparison of platelets classification from digitalization microscopic peripheral blood smear,”

2017 International Seminar on Intelligent Technology and Its Application: Strengthening the Link Between University Research and Industry to Support ASEAN Energy Sector, ISITIA 2017 - Proceeding, vol. 2017-Janua, pp. 356–361, 2017, doi: 10.1109/ISITIA.2017.8124109.

[15] Z. E. Fitri, L. N. Y. Syahputri, and A. M. N. Imron, "Classification of White Blood Cell Abnormalities for Early Detection of Myeloproliferative Neoplasms Syndrome Based on K-Nearest Neighborr," *Scientific Journal of Informatics*, vol. 7, no. 1, pp. 136–142, 2020, doi: 10.15294/sji.v7i1.24372.

[16] A. M. N. Imron and Z. E. Fitri, "A Classification of Platelets in Peripheral Blood Smear Image as an Early Detection of Myeloproliferative Syndrome Using Gray Level Co-Occurence Matrix," in *Journal of Physics: Conference Series*, May 2019, vol. 1201, no. 1. doi: 10.1088/1742-6596/1201/1/011001.

[17] Z. E. Fitri, U. Nuhanatika, A. Madjid, and A. M. N. Imron, "Penentuan Tingkat Kematangan Cabe Rawit (Capsicum frutescens L.) Berdasarkan Gray Level Co-Occurrence Matrix," *Jurnal Teknologi Informasi dan Terapan*, vol. 7, no. 1, pp. 1–5, 2020, doi: 10.25047/jtit.v7i1.121.

[18] S. Shidada *et al.*, "Identifikasi Acute Lymphoblastic Leukemia pada Citra Mikroskopis Menggunakan Algoritma Naïve Bayes Evaluas i," vol. 14, no. 1, pp. 78–83, 2021.

[19] H. F. Putro, R. T. Vulandari, and W. L. Y. Saptomo, "Penerapan Metode Naive Bayes Untuk Klasifikasi Pelanggan," *Jurnal Teknologi Informasi dan Komunikasi (TIKomSiN)*, vol. 8, no. 2, pp. 19–24, Oct. 2020, doi: 10.30646/tikomsin.v8i2.500.

[20] A. A. Mahran, R. K. Hapsari, and H. Nugroho, "PENERAPAN NAIVE BAYES GAUSSIAN PADA KLASIFIKASI JENIS JAMUR BERDASARKAN CIRI STATISTIK ORDE PERTAMA," *Jurnal Ilmiah NERO*, vol. 5, no. 2, pp. 91–99, 2020.

[21] Abd. Ghofur, "Implementasi Metode Klasifikasi Naive Bayes Untuk Memprediksi Kualitas Cabai," *Jurnal Ilmiah Informatika*, vol. 1, no. 1, pp. 32–38, 2016, doi: 10.35316/jimi.v1i1.441.

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