Attractive Learning Media for Introduction to Popular Fruits Using Computer Vision

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***Abstract*— Early Childhood Education (ECE) starts from the age of 1 year to 4 years, this program helps children to prepare for school. Because children have a short range of concentration power so that children's attention will be easily distracted by other things that attract their attention. Learning media usually use books, cards (flash cards) or items made of paper and cause students to get bored quickly, so alternative learning media are needed to increase student learning motivation. Another method is the use of computer vision as an attractive learning media for early childhood. Fruit recognition is a learning material that is easy to apply to early childhood. The stages in this research consist of a collection of popular fruit datasets, converting RGB color space to HSV color space, segmentation process, feature extraction and classification of popular fruits using the KNN method. Parameters used for fruit recognition based on color and shape features. The results of the system accuracy in recognizing popular fruit types are 100% for the value of K is 1 for both blue images and saturation images.**

Keywords—attractive learning media, computer vision, K-Nearest Neighbor, popular fruit

I. Introduction

Early Childhood Education (ECE) starts from the age of 1 year to 4 years, this program helps children to prepare for school [1]. Every child has different abilities and potential [2]. Every child has its own uniqueness in terms of talent, interest, learning style and so on. In addition, children like to fantasize and imagine [3] so to support early childhood development through the presence of objects and based on the experience of concrete objects [4]. According to DePorter and Hernacki (1992) based on the type of information displayed, individual learning styles are divided into three categories, namely visual, auditory and kinesthetic. Visual learning style is a learning style by seeing, observing, looking, and so on. The auditory learning style is a learning style by listening while the kinesthetic learning style is a learning style using movement, touching or taking action [3].

Methods, media and technology are needed to support the learning process so as to produce a better quality of the learning process [5]. Because children have a short range of concentration power so that children's attention will be easily distracted by other things that attract their attention. Learning media usually use books, cards (flash cards) or items made of paper and cause students to get bored quickly, so alternative learning media are needed to increase student learning motivation [6]. Along with the development of technology, learning media uses multimedia (a combination of several elements such as text, sound, images and animation) [7] which helps users to understand the learning material. Another method is the use of computer vision as an attractive learning media for early childhood [8].

Fruit recognition is a learning material that is easy to apply to early childhood. The fruits chosen are fruits that are quite familiar and have a distinctive shape for children. The introduction of fruit using two languages or bilingual such as Indonesian and English. In the introduction of the fruit, the researchers used a combination of digital image processing techniques and intelligent systems known as computer vision.

Several reference studies related to the introduction of fruit as a digital learning media such as fruit recognition educational games for kindergarten-age children [9] and the use of AR as a digital learning media for the introduction of fruit [10]–[13]. The similarity of these references is the use of learning media such as educational games and augmented reality (AR). Augmented reality (AR) is a technology that is able to combine picture cards that will be captured by the camera and processed and displayed 3D animation on the cellphone screen in real time[10]. But the drawback of this AR technology, students can only see 3D objects so visual learning styles are applied, while auditory and kinetic learning styles have not been met.

In order to fulfill the three learning styles, the use of computer vision is made for real-time fruit recognition. So that the reference that is also used is the introduction of fruit types in the image using a classification approach based on color and texture features[14]. Besides these two features, features such as fruit size and shape can also be used for fruit recognition[15]. Then the reference to the use of computer vision related to fruit recognition such as the introduction of fruit types based on color and texture parameters using K-Nearest Neighbor with the highest accuracy of 92% [14] and the Naïve Bayes method is able to classify fruit with an accuracy of 81%[16].

Based on the explanation above, the intelligent system used in this research is the K-Nearest Neighbor (KNN) method. The difference with previous research is the type of fruit dataset used. In previous studies, there were 12 types but there are several types of vegetables such as agata potato, asterix potato and onion. This study used 10 types of fruit that have unique shapes and names that are popular in early childhood. Another development is that researchers add output in the form of text and sound that have been adapted to the bilingual language used.

II. METHODOLOGY

The stages in this research consist of collection of popular fruit dataset, convert RGB color space to HSV color space, color space component separation process, segmentation process, feature extraction and classification of popular fruits using the KNN method as shown in Figure 1.

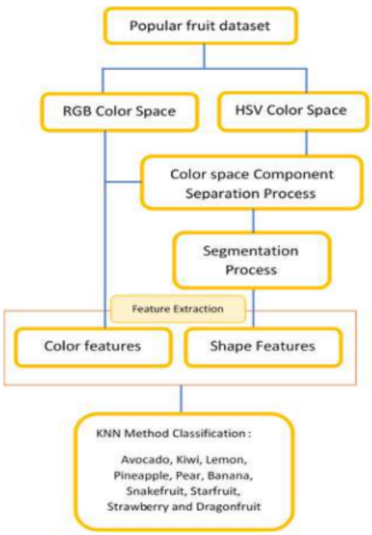


Figure 1. Block diagram of popular fruit recognition system

A. Collection of Popular Fruit Dataset

The data used in this study is primary data taken using a digital camera and a ministudio box with 3 LED lights as shown in Figure 2. The image size is 3601x1801 pixels with 10 popular fruit types and the amount of data used is described in Table I.

Figure 2. (a) Types of Fruit and (b) The Process of Collecting Popular Fruit Datasets

TABLE I. TYPES AND NUMBER OF POPULAR FRUIT DATASETS

No.	Fruit Name	Amount of data
1	Avocado	75
2	Kiwi	49
3	Lemon	51
4	Pineapple	61
5	Pear	100
6	Banana	28
7	Snakefruit	55
8	Starfruit	52
9	Strawberry	125
10	Dragonfruit	90
Total amount of data		**686**

B. Convert to Another Color Space

The original image is an image that has an RGB color space. Next, the color space is divided into the components of the color space to find out which color space component best represents the object of research. In addition, the image is converted to another color space such as the HSV color space [17] using the equation :

$$Hue = tan\left(\frac{3x(G-B)}{(R-G)+(R-B)}\right) \quad (1)$$

$$Saturation = 1 - \frac{min(R,G,B)}{V} \quad (2)$$

$$Value = \frac{R+G+B}{3} \quad (3)$$

After the color space conversion process, the HSV image is also divided into components such as in the RGB image. After getting the component image that best represents the shape of the object, the next process is the segmentation process. In addition to the segmentation process, the RGB image is extracted its color features.

C. Segmentation Process

The segmentation process aims to separate the object and background with the equation (2) :

$$biner(x,y) = \{if\ f(x,y) < T\ then 1\ if\ f(x,y) > T\ then\ 0 \quad (4)$$

Determination of the threshold value (T) based on the histogram of the image of the RGB color space component and the HSV color space component. In addition to segmentation based on the gray value threshold, then segmentation is carried out based on the area threshold value (A) [18] with the equation (3) :

$$Area_{new} = area_{old} \geq A \quad (5)$$

D. Feature Extraction

Feature is a distinctive value that can distinguish each class of popular fruit. In this research, color and shape features are used. The color features used are red, green and blue color components while the shape features used are area, perimeter [18], shape [19] and diameter [20] features using the formula equation:

$$Area = \sum\ number\ of\ pixels\ by\ chain\ code \quad (6)$$

$$Perimeter = \sum\ even\ code + \left(\sum\ odd\ code\ x\sqrt{2}\right) \quad (7)$$

$$Shape = \frac{Perimeter^2}{Area} \quad (8)$$

$$Diameter = \frac{major\ axis\ length + minor\ axis\ length}{2} \quad (9)$$

To get the area and perimeter features using the chain code technique where the white object is labeled 1 by calculating it based on the 8 neighboring direction [17]. The major axis length value is the furthest distance between the centroid and the outermost pixel coordinates, while the minor axis value is the closest distance between the centroid and the pixel coordinates [20].

E. K-Nearest Neighbor Method

The K-nearest neighbor method is a 'lazy' classification method where the data is classified based on the K value which is calculated based on the closest distance to the Euclidean distance (ED) calculation using the formula equation :

$$ED(a,b) = \sqrt{\sum_{r=1}^{n} (air - aij)^2} \quad (10)$$

Where air is the testing data and aij is the training data.

In general, the KNN algorithm is as follows.

1. Determine the number of neighbors (K) to be used for class considerations.
2. Calculate the Euclidean distance from the new data to each data point in the dataset.
3. Take a number of K data with the closest distance, then determine the class of the new data

III. Result and Discussion

The original image is an image that has an RGB color space. In addition, RGB images are converted to HSV color space using the equation (1) - (3). Furthermore, the color space components are separated by color space components to find out which color space component best represents the object of research as shown in Figure 3.

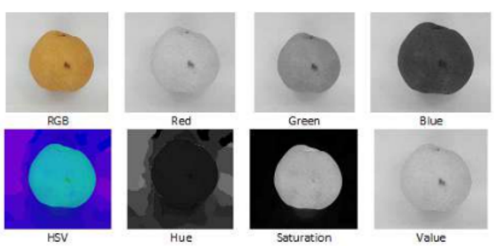
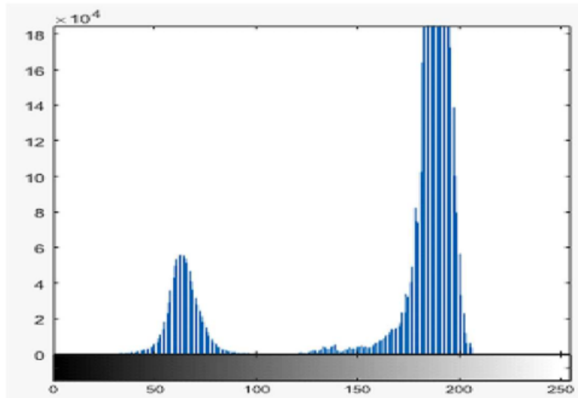


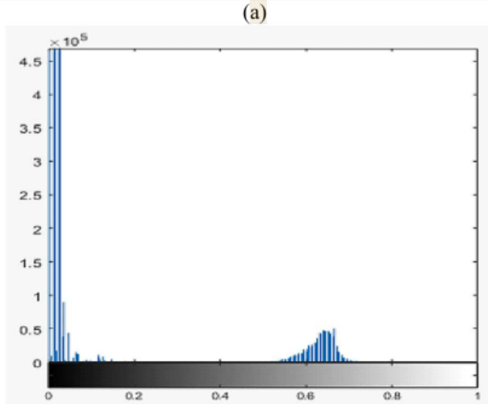
Figure 3. Result of HSV Color Space Conversion and Splitting of RGB and HSV Color Space Components

Based on Figure 3, in the process of separating the RGB color space components, the blue component is the best color space component in representing the fruit object because there is a significant difference in the gray value between the object and the background. When the RGB image is converted to the HSV color space and each color component is separated, the saturation color component is the color space component that best represents the fruit object. The next process is the segmentation process using the equation formula (4). determination of the threshold value (T) based on the histogram image of the blue image and the saturation image as shown in Figure 4.

Based on the results of Figure 4, there are two discrete signals in both the blue histogram and the saturation image. In the blue image, the gray value is in the range of 120 – 210 with the number of pixels more than 18 x 10^4, but this value is not a fruit object but a background. This can be seen from the blue image (Figure 3), while the histogram of the saturation image, the fruit object has a gray value ranging from 0.5 to 0.7 with a number of pixels of 0.5 x 10^5 or 5 x 10^4 based on the saturation image (Figure 3). Then the threshold value for the blue image is 118 while the threshold value for the saturation image is 0.13 so that the segmentation image results are shown in Figure 5.



(a)



(b)

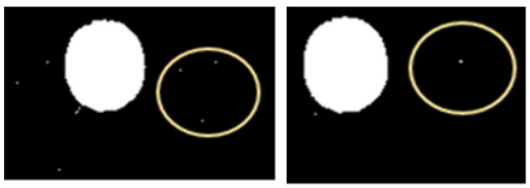
Figure 4. Histogram (a) Blue Image and (b) Saturation Image

Blue Image Saturation Image

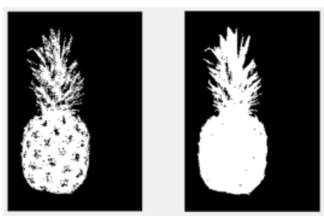
Figure 5. Image Segmentation Results

The example of a pear, the segmentation results on the blue image are better than the segmentation results on the saturation image. However, the segmentation results can be different if other fruits such as kiwi and pineapple are used as shown in Figure 6.

Figure 6 (b) shows that both the blue image and the saturation image have the same threshold value as Figure 5 and produce an imperfect segmentation image that requires an "imfill" code to fill in the blank (hollow) object areas. While Figure 6(a) also shows the results of imperfect image segmentation in both the blue image and the saturation image. The result of the segmentation image is that there are small white objects around the fruit object. To overcome this, segmentation is carried out based on the area threshold value or the Channel Area Thresholding (CAT) method. Image segmentation results using a combination of code 'imfill' and the CAT method produce image segmentation results shown in Figure 7.



(a)



(b)

Figure 6. Image Results of Segmentation (a) Kiwi and (b) Pineapple

(a)

(b)

Figure 7. Image segmentation result

The next step is the feature extraction process. Feature extraction using color and morphological features using equation (6) - (9) and the results of these features are shown in Table II for color features and Table III for morphological features.

TABLE II. AVERAGE COLOR FEATURES ON EACH FRUIT CLASS

Class	**Red**	**Green**	**Blue**
Avocado	195	195	190
Kiwi	176	175	170
Lemon	171	170	161
Pineapple	179	174	157
Pear	176	173	164
Banana	173	171	163
Snakefruit	170	170	167
Starfruit	187	197	191
Strawberry	166	166	163
Dragonfruit	161	145	146

TABLE II. AVERAGE MORPHOLOGICAL FEATURES ON EACH FRUIT CLASS

Class	**Area**	**Perimeter**	**Shape**	**Diameter**
Avocado	614533	4125,02	32,04	846,57
Kiwi	324171	2250,87	15,06	646,84
Lemon	339533	2569,42	19,51	665,14
Pineapple	2307359	24665,31	273,16	713,66
Pear	684575	3518,89	19,02	919,94
Banana	458288	3926,85	33,83	948,34
Snakefruit	185916	1857,41	18,89	495,97
Starfruit	707939	3312,69	16,30	989,15
Strawberry	83916	1642,56	32,59	351,93
Dragonfruit	1088247	6985,29	46,32	1201,34

From the results of the features in Table II and Table III, there are 7 features that are used as input from the K-Nearest Neighbor (KNN) intelligent system. In this study, the amount of data used is 686 image data consisting of 10 types of popular fruit which are described in Table 1. Calculation of the KNN method by calculating the closest distance using the Euclidean distance calculation in the equation (10), then the fruit data is grouped (classified) based on the K value. In this study, we used a value of K = 1 to a value of K = 10 for both blue images and saturation images, then the system accuracy results are shown in Table IV.

TABLE IV. THE SYSTEM ACCURACY RESULTS

K Value	Accuracy (%)	
	Blue Image	Saturation Image
1	100,00	100,00
2	91,84	92,27
3	91,25	90,38
4	87,76	89,80
5	88,19	87,32
6	86,88	87,61
7	86,88	86,30
8	84,84	85,71
9	85,28	84,26
10	84,40	83,82
11	84,99	84,11
13	85,13	84,69
15	84,55	83,53

Based on the accuracy results shown in Table IV, both blue images and saturation images with a value of K = 1 produce a system accuracy of 100%, but the accuracy decreases as the value of K increases. The KNN method is quite simple in classifying data because the data is sorted from the shortest to the longest distance is then adjusted based on the value of K and checked for the dominant or priority data class, the data sought will be in accordance with the priority data. If more and more K values are used, the priority classes will be many. this causes the possibility of errors in classification. Therefore the feature data from the fruit must be compared with other methods such as Naive Bayes or Artificial Neural Networks to get the optimal level of accuracy.

The display of the introduction of popular fruits using computer vision and we have also implemented the application as a Community Service Activity with the Community Science and Technology Application Scheme at KB Nurul Kharomah as shown in Figure 8.

(a)

(b)

re 8. (a) Display of Popular Fruit Recognition Applications and (b) Our Community Service Activities

IV. Conclusion

This study aims to create an attractive learning media for early childhood with materials such as the introduction of popular fruits using two languages (bilingual), namely Indonesian and English. This application uses computer vision which is a combination of digital image processing techniques and intelligent systems such as K-Nearest Neighbor (KNN). The steps of the image processing technique consist of HSV color conversion, RGB and HSV color component splitting process, segmentation process and feature extraction. From the results of the study, it is known that the blue image and the saturation image are the best images that represent the shape of the fruit perfectly with a threshold value (T) of 118 for blue images and 0.13 for saturation images.

Advanced segmentation is needed such as Channel Area Thresholding to remove noise in the segmented image. When the researcher applies the KNN method, the optimal K value used is K = 1 to produce a system accuracy of 100%. but when we use K = 1 then we classify based on one sample which is the nearest neighbor and it can cause overfitting.

The factor that causes it is the possibility that the testing data has a high similarity to the training data and each class has a clear shape feature. If we use a lot of K values, then this method will classify the class based on the priority class of its K value, thus allowing for errors in classification. Therefore the feature data from the fruit must be compared with other methods such as Naive Bayes or Artificial Neural Networks to get the optimal level of accuracy.

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