

Fruits Sorting with Instance Based Image Processing

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Abstract— In the agricultural industry which is among the most prominent sectors on a world scale, image processing for efficiency and quality has also become an important domain. Automation systems are working with image processing to increase the efficiency of the classification of fruits. Image processing is a method developed for digital image formatting and performing some operations for obtaining or extracting useful information from a specific image. There are several methods and programs for processing images. In this study, the results obtained by the classification of apple, pear and peach fruits which are similar to each other, but which differ in terms of roughness and color, by using image processing techniques are presented. After the data sets of these fruits are formed, color and roughness are determined by image processing techniques, and success rates are compared by using Instance-Based (IB) and Bayesian Network classifiers in the analysis phase. Finally, the performances of the fruit classifications were investigated using Receiver Operating Character Curve (ROC).

Keywords—: *image processing, morphological Processes, classification, ROC.*

I. INTRODUCTION

Applications related to image processing and computer vision have been increasing day by day in recent years and these applications are widely used in many areas such as in-vehicle automation, security systems, military areas as well as in the agricultural sector. Quality assessment and classification processes on food products are an important problem. Since these processes are usually carried out manually and by eye by quality control workers, they cause misclassifications and create great losses in terms of time and labor. However, with the help of image processing, it is possible to automatically classify and determine fruit characteristics that are faster and in accordance with standards. Methods such as digital image analysis, classification, clustering are used to classify the objects under investigation according to their size, type or quality characteristics.

Many different studies have been done on the classification of fruits. In a study related to this, image processing method was applied on various apples in order to determine the color, size and spots on the apples and to classify the spots. In the first stage, photos of apples of different colors were taken and color and size classification was made by the software. The apple photographs to be classified later were taken in real time on a continuous flowing tape. In the software created in this study, the stain problem was tried to be solved by using various functions in it without the need for additional equipment such as filters [1].

In another sample study, it was aimed to classify the hazelnut fruit, and as a result, the objects found in the environment were detected in real time. A camera was used to obtain the image of hazelnut fruits and image processing techniques were used to process the obtained images. The area and size information covered by the hazelnut fruits on the image plane are calculated. By using average-based classification and K-means clustering algorithms on the resulting information, hazelnut fruit is classified into three real-time classes as small, medium and large [2].

Finally, the article reviewed is a study that classifies with image processing, considering the peach and apple characteristics. Diameter information is used in peach classification process, and size and weight information is used in apple classification. In classification, weight is used as a parameter apart from image processing. Load cell is used for weight detection. The load cell outputs an analog signal by looking at the weight information of apple and peach. These two analog information are converted into digital by analog-digital converter to transfer to the computer. Apple and peach classification is made with the software developed by taking weight information and fruit image [3].

In the study proposed by Ishikawa et al., The classification of strawberry fruits with machine learning techniques is presented. Values (MVs) including length, area, fruit length and width, fruit width / length ratio, Ellipse Similarity Index (ESI), Elliptic Fourier Identifiers (EFDs) and Chain Code Extraction (CCS) from digital strawberry images four different types of descriptors have been created. For the classification stage, the descriptors created by the Random Forest method were used together. As a result of the experiments, it was observed that the CCS descriptor makes a classification with a better performance than other descriptors [4].

Comparison of Artificial Neural Network (ANN), Support Vector Machine (SVM) and Random Forest methods was proposed by Piedad et al. For the classification of banana fruit. In the presented study, four characteristics of banana fruit are used for classification. As a result of experimental studies, the best accuracy was obtained with the Random Forest method with a rate of %94.2 [5].

A study on tomato classification was presented by Li Liu et al. An intelligent tomato classification based on machine vision technique is aimed. Accordingly, the histogram of the color model was used for the color characteristics of tomatoes in different sizes and maturity. Classification has been made in three different categories as small, medium and large. As a

result of experimental studies, the average duration of the system was 0.0687s and its accuracy was measured as 90.7% [6].

Another study on tomato classification, proposed to classify the defect types of tomatoes, used fewer features and image processing techniques compared to other systems. In the classification phase, SVM and MSVM methods were applied together and 98% accuracy was achieved [7].

In this study, three stages are applied to obtain the classification results of apple, pear and peach fruits in terms of roughness and color. In these stages, the data from each step is used in the next step. First, the images of various data sets from different locations are passed through the image pre-processing stage and the data obtained is passed through the object finding and feature extraction process in the second stage, and the features such as roughness and color of the objects are extracted. Objects are classified using the data obtained as a result of these stages.

First, 150 fruit images obtained from different places go through the image pre-processing stage. The data obtained as a result of this stage pass through the object finding and feature extraction process in the second stage, and properties such as roughness and color of the objects are extracted. Engineering calculations for preprocessing, object finding and feature extraction up to the classification stage; Matlab program, which is used for general purpose in numerical computing, data solutions and graphics operations, is used [8]. In the cluster obtained after the image pre-processing stage, the distribution pattern is learned by using IB and Bayes Networks classification algorithms, and the ROC curve is created and the performance is tested. For the classification and testing phases, Weka, the data mining application distributed as open source code by Waikato University, where requirements such as machine learning algorithms and data preprocessing are presented together, was used [9].

II. PROPOSED METHODS

A. Image Pre-Processing

At this stage, processes such as graying the data, morphological processes and determining the color are performed respectively. After these processes, the features related to the image are made more prominent and easy to process.

In the step of greying out the image, the colored images are first converted to gray tone so that we can do certain operations on the image in the data set. Image processing is performed on binary images, so grayscale images are converted into binary images. A threshold value is determined for this. By applying thresholding process on the image obtained, a double picture is obtained by assigning the values above the threshold value to 1, ie white, and the values below it to 0, ie black. The value used in the thresholding process is determined experimentally.

Morphological process is applied to eliminate the noises on the resulting image. With this process, the defects were removed by walking around the picture. In the proposed study, erosion, dilation and opening processes are applied on the double image as a morphological process.

The purpose of etching is to refine or shrink an object in the image. It is possible to remove unimportant and small objects in the binary image with this process. When the

etching process is applied, the objects in the image shrink and expand if there is a hole.

The enlargement process makes the object in the image thicker or larger. The structural element determines how the thickening or enlargement process will be done. Each pixel of the image to be processed is placed at the center point of the structural element and the enlargement process is applied. In an image where this process is applied, the holes and gaps in the image are expected to be closed.

The process obtained as a result of applying the abrasion process first and then applying the enlargement process on the image to be used is the opening process. After clearing the gaps in the image, the objects remaining on the image become smaller than the original image.

B. Feature Extraction

In the feature extraction stage, the features belonging to each of the binary images obtained as a result of the image pre-processing stage are extracted. The roughness and colors of the objects in the created data set were determined as feature inferences.

The best method to obtain the roughness value takes the difference between the binary image and the image that we apply morphological operations. Thus, if the overlapping pixel values are the same, it will give the value 0, but if the difference between the pixel values is greater than zero, it means that there is a change for that pixel. The greater the difference between them, the closer the pixel value to the white color. When the images are superimposed and subtracted, the different pixels become whiter and distinct. The difference is proportional to the roughness ratio.

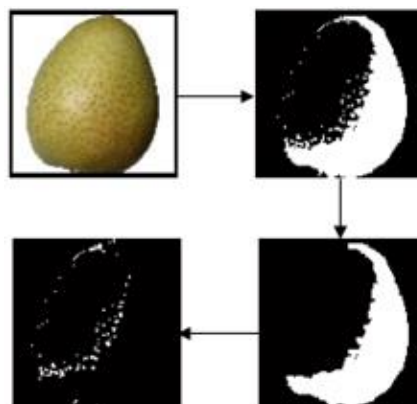


Fig. 1. Pear fruit; original, converted to a binary picture, morphological processes applied and the difference

RGB (Red, Green, Blue) color space was used to determine the colors of the fruits. It consists of RGB color layers. In order to determine the distinguishing feature in RGB color codes; The color code between 0-100 was given a value of 1, the color code between 100-200 was given 2, and the color code between 200-255 was given 3. At the end of this, a 3-digit color value consisting of the numbers 1, 2 and 3 was created for each picture.

In this paper, fruit images are classified using their features in terms of roughness and color after the image pre-processing phase is completed. Two different classification methods, IB and Bayes Networks, are proposed for the classification of objects.

C. Classification

Classification is the distribution of data between these classes by defining classes within a data set. By obtaining the training set, the distribution pattern is learned and the correct classification of the data whose test class is not specified is tried to be made. In this study, fruits are classified using their roughness and color characteristics. Two popular classification methods are suggested for fruits that pass through the image pre-processing stage.

In the IB classification algorithm, there are samples closest to the sample to be classified and all of these samples are dropped against a point in n-dimensional space. For continuous valued functions, the nearest k learning samples are averaged. IB algorithm gives the most seen class value in discrete valued functions. According to the IB algorithm, the value of k is determined first. The suggested value of k in this study is 1. Then the euclidean distances from other objects to the new object are calculated. The distances are listed and the closest neighbors are determined. After the nearest neighbor categories are collected, the most suitable neighbor category is selected. The following formula is used when determining the closest neighbor when the new object arrives [10].

$$Difference_e = \sqrt{(X_i - X_{new})^2 + (Y_i - Y_{new})^2} \quad (1)$$

The characteristic of Bayesian networks is that they are statistical networks and the edges of the nodes that pass between nodes are selected according to statistical decisions. In addition, they are non-directional networks and each node represents a separate variable. Bayes theorem is important for understanding Bayes networks [11]. Bayes' theorem is calculated as follows [12].

$$P(B_i|A) = \frac{P(A \cap B_i)}{P(A)} = \frac{P(A|B_i)P(B_i)}{\sum_{i=1}^k P(A|B_i)P(B_i)} \quad (2)$$

D. Criterias Used in Comparison of Classification Algorithms

a) Confusion Matrix: In order to evaluate the classification performance, the matrix is obtained by comparing the estimates of the target with the actual values. These classification estimates have one of four assessments.

- i. -True to mean right (True Positive - TP) TRUE
- ii. -True is false (True Negative - TN) FALSE
- iii. -To mean right to the one (False Positive - FP) WRONG
- iv. -That means you are wrong (False Negative - FN) TRUE

b) Error-Accuracy Rate: This ratio, which is found by the ratio of the number of correctly classified samples (TP + TN) to the total number of samples (TP + TN + FP + FN), is one of the most used methods in performance measurement. The error rate is found by the ratio of the number of incorrectly classified samples (FP + FN) to the total number of samples (TP + TN + FP + FN). Their formulas are shown below.

$$Accuracy = \frac{(TP+TN)}{(TP+FP+FN+TN)} \quad (3)$$

$$Error\ rate = \frac{(FP+FN)}{(TP+FP+FN+TN)} \quad (4)$$

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Precision: Precision is the ratio of True Positive (TP) samples with predicted class 1 to all samples with predicted class 1 (TP + FP) [13].

$$Precision = TP / (TP + FP) \quad (5)$$

Recall: The ratio of the results obtained by the correct classification of positive samples to the total number of positive samples is called recall.

$$Recall = TP / (TP + FN) \quad (6)$$

F-messure: Evaluating the precision and recall criteria together, the results are closer to the truth than evaluating each separately.

$$F = 2DK / (D + K) \quad (7)$$

E. Testing

At this stage, ROC curve is drawn with the ratio of TPs to FPs. The Recall and Precision values on the ROC curve consist of different threshold values for each point. Generally, low FPs obtained from threshold values have low TP's. In cases where the results are successful, the TP rate is high, but the FP rate, on the contrary, is low. As the curve obtained to the 'False Positive Rate' axis approaches, the success level decreases. The part under this curve is to show the success of the system with a single value. Expressing the success of the system with a single value is expressed by the area under the ROC curve, and the size of this area is directly proportional to reliability.

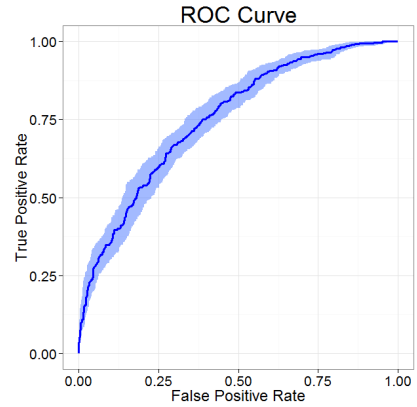


Fig. 2. Sample analysis showing the ROC curve [14]

III. RESULTS AND DISCUSSION

A. Dataset Preparation

A data set consisting of 150 apple, pear and peach images is created to implement the image processing steps. Some of the images are images recorded as a 20-second short film with a white layer on a low-speed traveling tape as a background, and a Logitech C920 camera is used [15]. Others are fruit images that have the same background and size as other images. These images pass through the pre-processing stage and analyze the data obtained according to the feature extractions determined.

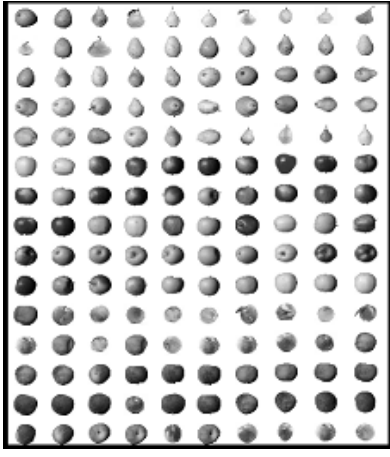


Fig. 3. Fruits-150 data set consisting of 3 classes with 50 shapes per class. Different images of the same objects in columns

B. Experimental Works

After the fruit images in the data set passed the pre-processing phase, the model was created with the IB and Bayes Networks classification algorithms in the Weka library. The performances of the images included in the data set were measured according to the comparison criteria described earlier.

TABLE I. ERROR MATRIX OBTAINED AS A RESULT OF IB CLASSIFICATION ALGORITHM IN WEKA APPLICATION

Classified as	<i>a</i>	<i>b</i>	<i>c</i>
a = pear	50	0	0
b = apple	1	49	0
c = peach	1	0	49

According to the error matrix we obtained in the IB classification algorithm that I determined the K value as 1, it is seen that the whole pear fruit is classified correctly, but one of the apple and peach fruits are mixed with apples. 98.6667 percent was obtained according to the accuracy criterion and 1.3 percent according to the error criterion. According to the precision and recall criteria, the results are 0.987. Since these criteria alone will not be sufficient to evaluate the result, the measured F-criterion also has a result of 0.987.

TABLE II. ERROR MATRIX OBTAINED AS A RESULT OF BAYESIAN NETWORK CLASSIFICATION ALGORITHM IN WEKA APPLICATION

Classified as	<i>a</i>	<i>b</i>	<i>c</i>
a = pear	30	7	13
b = apple	2	42	6
c = peach	4	13	33

According to the data in the error matrix we have obtained in the classification of Bayesian networks, it is seen that 7 of the pear fruits are mixed with apple and 13 are mixed with peach, 42 of the apple fruit are classified correctly, while 2 of them are classified as apples and 6 as peaches. While 33 of peaches were classified correctly, 4 of them were mixed with pear and 13 with apple. Looking at the error matrix, it is seen that IB1 classification is better than Bayesian networks.

Bayesian networks have an accuracy rate of 70 percent, and an error rate of 30 percent. According to the precision and recall criteria, the results are 0.715 and 0.700, respectively. The F-criterion required for more accurate results is 0.699. According to these results, it is seen that the IB1 classification algorithm has a better success rate than Bayesian networks.

After the classification process using IB1 and Bayesian networks, the performance of the model is checked and compared by drawing the ROC curve in the test phase with these two classifications.

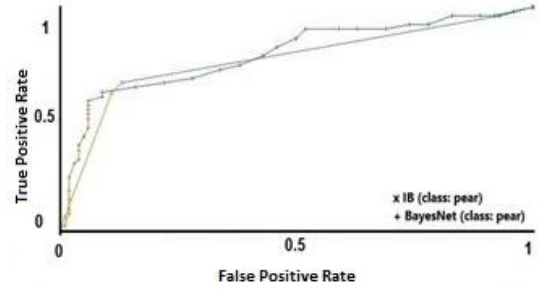


Fig. 4. ROC curve produced by classifying the pear class with IB and Bayes Networks

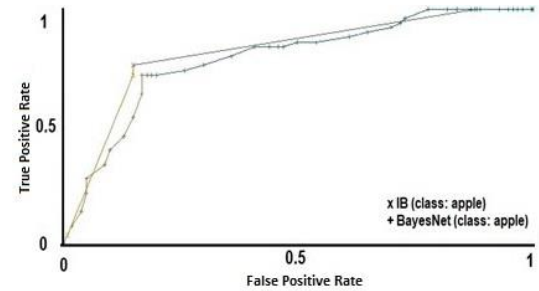


Fig. 5. ROC curve produced as a result of classification of apple grade with IB and Bayes Networks

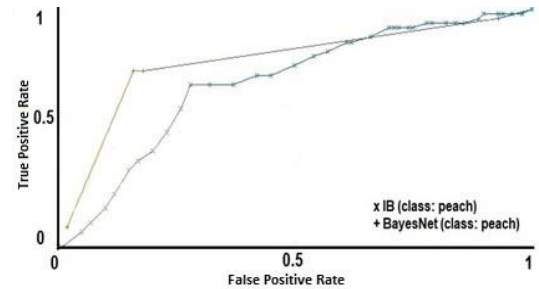


Fig. 6. ROC curve generated as a result of classification of peach grade with IB and Bayesian Networks

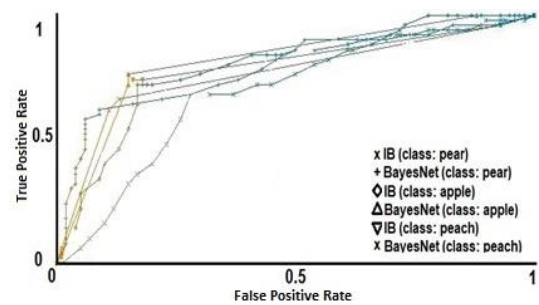


Fig. 7. ROC curve generated by classifying all classes with IB and Bayesian Networks

In the ROC analysis, it is seen that the curve in the Bayesian networks classification is closer to the False Positive axis compared to the curve in the IB classification, and since the size of the area under the curve is directly proportional to the reliability, it is understood that the success level of the IB classification is higher than the Bayesian networks.

IV. CONCLUSION AND DISCUSSION

In this study, the data set consisting of apple, pear and peach fruits was classified using image processing techniques. First, the data passed through the image preprocessing stage was binary for feature extraction, and the roughness ratio was calculated by taking the difference with the picture we applied morphological processes. For the other distinguishing feature, the colors of the data were determined by using the RGB color space. When the success rates were compared by applying the proposed IB1 and Bayesian networks classification to the obtained data, the IB1 method gave a better result with an accuracy of 98.6667 percent compared to the 70 percent success rate obtained in Bayesian networks. The ROC curve is used to compare and evaluate the success level of the classifications made at the last stage. According to the results obtained with the ROC curve, it is understood that the success level of IB classification is higher than Bayesian networks.

In the next study, it is planned to compare the success rates of deep learning and traditional machine learning classification methods using the Generative Adversarial Network (GAN), which can create realistic images to increase the data set.

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