Develop an Olive-based Grading Algorithm using Image Processing

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***Abstract*—Olives come in a number of external and internal varieties. The Shengeh kind, which is available in three colours—green, brown, and black—was chosen at random by the researchers to ensure that the sample was diverse. To avoid discoloration throughout the experiment, 150 healthy olives were harvested and stored correctly. These olives had not been subjected to any external harm, such as crushing or milling. The particular kind of olives were kept chilled at 2°C and preserved in water. This study investigates the possibility of grading Shengeh cultivars from olives that have different uses, based on color using image processing. After preparing images of olives using MATLAB software and image processing techniques, olives are graded based on their color in three categories: immature with green, semi-ripe with brown, and ripe with black. The results showed that image processing technology can be used to grade olives of the Shengeh type in terms of their ripeness as a single-color grain with acceptable accuracy. The HSV color space is one of the best color spaces to separate the colors of the olive cultivar. The accuracy of the software for detecting olives with the mentioned degrees is 98%, 96%, and 100%, respectively.**

Keywords—Image processing; grading; color; olive; MATLAB; HSV

I. Introduction

Olives are native to the Mediterranean and sub-Mediterranean climates, and altitude has a definite effect on their composition. Olives grow well at altitudes of 400 to 2000 meters depending on the climate [1,2]. Olea europaea is almost a small tree species of the Oleaceae family and is widely distributed from the Mediterranean, North Africa, South Asia, North to South China, Scotland, and Eastern Australia. The olive tree is evergreen and has small, solid leaves that are stacked on top of each other [3]. The fruit of the olive plant is of the shaft type. The most famous species of this plant is called Olea europaea, which used since ancient times to prepare olive oil and to eat its fruit. Olive trees grow very slowly [4], even when they grow freely without pruning, but when they are able to grow normally over several years, sometimes their trunk diameters increase dramatically.

One of the salient features of olives is their ability to adapt to different geographical areas. In modern olive cultivation, in order to select suitable cultivars, a set of traits such as fertility, resistance to pests and unfavorable natural conditions, high oil content, good oil quality, suitable size and shape, and high ratio of meat to the kernel are important. For example, in Iran, a number of cultivars have survived under local conditions, but on the other hand, due to being confined to a specific area, there has not been much genetic diversity [5]. Most of the olive groves in Iran are composed of local yellow and oily cultivars and Fish mi, Shengeh, and Mari cultivars are also observed at limited levels.

Today, the quality of appearance of fruits and agricultural products cannot be evaluated using color methods using traditional methods. Olive is a valuable product that has nutritional and medicinal value and has different cultivars in different regions with different climates that are offered to the consumer market both as canned products and as its products (Eaton oil). Grading of olive products, in order to be used in the production of various products, is always considered by food industry factories. Most existing traditional olive grading systems have the disadvantages of reduced efficiency, low grading speed, and high cost [6,7]. Therefore, it is important to increase the speed and reduce the cost in the grading and recognition system of size, color, shape, and defects of olives; one of the procedures used for this purpose is the use of machine vision and image processing.

Image processing, computer image analysis, or more precisely, the ability of a machine to perceive what it sees around it simultaneously without the need of human observation. This technology is actually one of the branches of electronic engineering that aims to achieve a kind of robotic eye. This technology is used in various fields such as agriculture, medicine, automated industrial production, remote sensing of machine guides, robots, and of course the food industry. One of the important features of the car's visual system, in addition to its high speed and accuracy, and economic efficiency, is the possibility of examining materials in all types of visible and invisible light (infrared, ultraviolet, etc.). Exploration and development of machine vision methods for grading and fruit separation operations accelerate new techniques for estimating the quality characteristics of agricultural products [8,9], due to the importance of olives as valuable products with high nutritional, medicinal, and cost values. Traditional systems use machine vision and image processing in isolation, grading, and other applications that are cost-effective and have higher speeds.

The machine vision system is a non-destructive and scientific method for measuring the spectrum of colors at non-uniform levels. Usually, the color factor is examined to evaluate the quality of agricultural products by image processing. Among the physical characteristics of agricultural products, color is expressed as the most important appearance properties of products [10]. Color is the most important property of an image; in fact, everything in an image is a component of the color stored in the pixels of the image [11-

13]; based on the fact that each color can be reconstructed based on a combination of three main colors. Placing the image in different color spaces and calculating the mean and standard deviation of color intensity in image pixels, in different color spaces, the color information of the image can be extracted.

Traditional olive grading methods have many uses for a variety of purposes, but they are time-consuming and costly. In addition, the performance of these methods is not guaranteed. These factors make it possible to develop practical methods of grading olives. Olive color image processing is one of these methods, which is non-destructive, efficient, and cost-effective through the methods of computer vision systems, and also provides more stable results. In general, computer vision systems are based on olive imagery; even while crossing the production line and then processing the image and analyzing the image's work. Computer vision systems not only recognize the size, shape, color, and texture of olives but also determine the numerical properties of the olive with the shooting scene. The use of machine vision systems in olive processing factories in addition to the separation and grading of high quality and low-quality olives in terms of color, size leads to the development and design of new olive grading systems in olive product production lines for various uses that can be mentioned as one of the applications of researches [19-25].

This study investigates the possibility of grading Shengeh cultivars from olives that have different uses, based on color using image processing, and the question that image processing is the ability to provide an algorithm for grading cultivars, canned and oily olives for increasing the speed of grading and reducing waste in each of the production lines is responsible. The main objectives of this paper are to investigate the possibility of presenting the Schengen diet olive grading algorithm based on color using image processing. In addition, the possibility of developing an olive grading system using artificial intelligence (artificial neural networks or emphysema) is being investigated.

In summary, this paper has the following contributions:

1) Proposing an image processing algorithm to olives' grading of the Shengeh type in terms of their ripeness using intesity-level based oin HSV color feature analysis.

2) Developing an automated olive grading system in order to tackle the interior and exterior feature analysis of the different types of olives.

3) Conducting extensive experiments and performance analysis to evaluate and validate the efficacy of the proposed algorithm.

The remainder of this paper is consists of Section II which presents the related works, Section III that describes materials and methods, Section IV presents results and discussion. Finally, conclusion is presented in Section V.

II. Related Works

Pronce et al. [22] used a computer vision-based system to automatically count and calculate the quantity and size of individual olive fruits. The suggested method separates the olives from the background using image processing techniques, and then utilises machine learning algorithms to calculate an estimate of the olives' mass and size based on attributes taken from the segmented pictures. The findings demonstrate the efficacy and precision of the suggested approach, with a counting accuracy of 97.5% and a size and mass estimation error of less than 5%. The efficiency and precision of the procedures involved in olive harvesting, grading, and quality control might all be enhanced by using this technique. However, this work is conducted under controlled laboratory conditions.

This research [23] suggested a 3D imaging-based vision-based system for automatically evaluating mangoes according to their volume. The system takes several 2D pictures of the mangoes from various perspectives, and then it uses stereo vision and form from shading algorithms to create a 3D model. The 3D model is then used to determine the mangoes' volume, and a grading system is created using the volume measurements. The outcomes show how well the suggested strategy performs when it comes to precisely grading mangoes according to their volume. A drawback of the study is that it only analyses the system on a small sample size; bigger datasets and testing in more scenarios are required to determine the system's generalizability and scalability.

The authors in [24] proposed a method for categorising various types of olive fruits based on their visual traits using image processing and convolutional neural networks. The method employs a convolutional neural network to categorise the types based on the derived characteristics after extracting features from the photos of olive fruit using image processing techniques. The outcomes show that the suggested approach can categorise different types of olive fruit with an accuracy of up to 97.5%. The system's generalizability and scalability must be tested further on bigger datasets, which is one of the study's limitations because it only analyses the system on a very small dataset.

III. Materials and Methods

The method of conducting the research is after photographing the object or the desired fruit (olive of Shengeh cultivar) which is inside a box with lighting. Image storage eliminates factors such as image noise, image background, as well as reduced light reflection in images for detailed examination, and then image processing by MATLAB software to identify and grade olives based on perceptible changes in the color spectrum. The tree of this cultivar is olive with medium growth power, with a tall crown, and thin and medium distance between nodes. Medium leaf size, oval bayonet leaf shape, medium leaf size with leaf length 6.8cm, leaf width 1.1cm. The surface of the leaf is glossy, smooth with dark green top color and the back color of the leaf is gray-green, as shown in Fig. 1.

The flowering of this cultivar of olives is such that it flowers very early but the browned petals fall later than other cultivars. Medium inflorescence length (26 mm); the number of flowers in the average inflorescence is 12 flowers. The inflorescence has many branches and lateral flowers [14,15]. The average fruit weight (average 5.2 mg), average fruit size, and ovoid shape (fruit length is 2.6 mm, and fruit diameter is 1.9 mm). Lentil or low, the ratio of flesh to the medium core (8.6), the shape of the fruit in position A is almost asymmetric, in the position of the largest diameter in the center of the fruit, the tip of the fruit is round, early ripening, the color of the fruit when ripe is black. The percentage of oil in the dry matter is medium (50%) as shown in Fig. 2.

As you can see in Fig. 3, the closed weight of this cultivar of olives is on average 0.6 g, with a core length of 46.5 mm. In unfavorable dry climatic conditions, Shengeh olives that are sensitive to the cold, shrink and fall off the tree. In the tropics, the skin of the trunk and main branches suffers from sunburn [16-18].

After preparing the desired photos of olives, MATLAB software will be used to process the images. Content software has different toolboxes that students and engineers in each field can use the toolbox to suit their problems. One of these tools is image processing, which will be used in the present study. After saving the images, the olives are transferred to MATLAB software for detailed examination. First, actions such as noise cancellation, light reflection, image background, etc. are performed on the images. Then, by placing images in color spaces, determining different color parameters of HSV and RGB, drawing histogram diagrams of color parameters, and determining the noticeable color spectral changes of three random samples in color spaces, grading olives samples based on color characteristics (transparency and opacity). Canned and oily types and the separation of waste samples of olives are discussed.

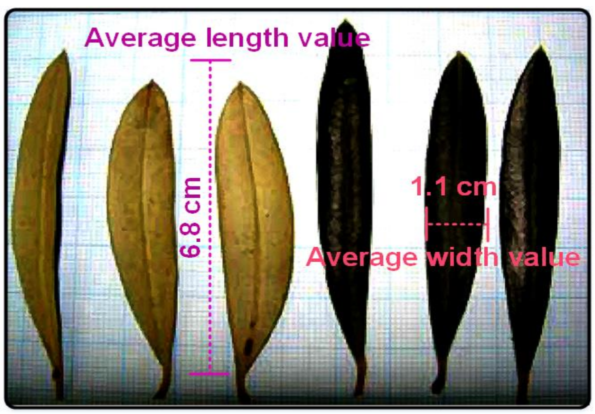

Fig. 1. View of the surface and back of the leaves of the olive tree of the shengeh cultivar.

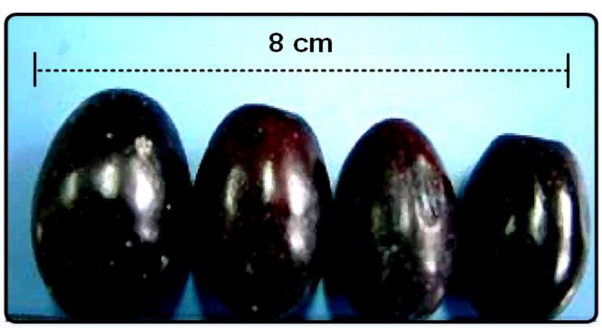

Fig. 2. Shengeh olives are ripe in different weights.

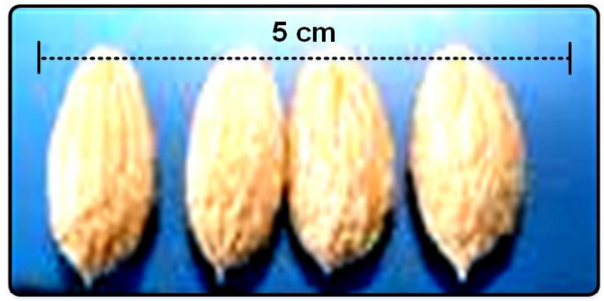

Fig. 3. Shengeh olive kernel.

IV. Results and Discussion

Olive is one of the fruits that is consumed orally and its oil is used for medicinal, food, and industrial purposes. Today, with the increase in production of this product, the need to produce mechanized equipment with high accuracy in measurement and separation, to increase the efficiency of harvesting and processing of the product is essential, and in recent years the use of non-destructive and fast sight machine with computers and cameras Digital has become widespread and popular. Among the applications of machine vision in the agricultural sector is the classification of products. Traditional sensory evaluation methods have applications in determining food quality, but these methods are time-consuming and costly. In addition, the performance of this method is either not guaranteed and uniform and stable quality control of food products with this method are either not possible. These factors motivated the development of alternative methods such as image processing. In traditional methods, computer vision systems are efficient and cost-effective, and also provide more stable results.

In this study, an olive-based grading algorithm has been developed using image processing. Due to the fact that olives have a variety of domestic and foreign cultivars, Shengeh cultivar olives with three colors of black, brown, and green are randomly selected, of which 150 cultivars are processed as a research sample. Shengeh cultivar olives are prepared after a random collection of 150 healthy and without external damages such as crushing for olives (black, brown, green) in two different stages of harvest (late summer and mid-autumn). The olives are stored in water and refrigerated at 5°C for proper storage and to prevent discoloration in the experimental process. After preparing the images of the olives, they are manually classified by the author into three categories according to color: immature (green), semi-clay (brownish), and ripe (black). Then, for color grading of olives, HSV color space is used in MATLAB software and the accuracy of the software for grading olives is evaluated.

The L*A*B* color space is used less frequently than the HSV color space in other works. However, due to the advantages of this color space, it has been considered in this study. For example, to filter green in an image, this range includes a spectrum that is dark green on one side and light green on the other. To separate it in RGB color space, it is not possible to select linearly, i.e. each channel with a desired color range condition. Because of such problems, the image is transferred to the HSV color space, which is composed of Hue, Saturation, and Value components. Olive is also suitable for HSV color space due to its green color spectrum.

In the first step, a graphic interface is designed in Fig. 4. By pressing the loading button, you can select the type of olive that is displayed in the first image box. By pressing the HSV Show button, first, the image goes from RGB color space to HSV color space and then three layers of this color space are displayed in order. In the end, by pressing the Grade button, the type of olive is determined in terms of immature, semi-ripe, and ripe.

Fig. 5 shows the graphical interface execution view. In designing the graphical interface, various elements such as buttons or other elements are used so that the user can use the program in a simpler and more understandable way.

In Fig. 5, by clicking the loading button, the desired image is selected from a database of 150 olive varieties, of which 50 are immature olives, 50 are semi-ripe olives, and the last 50 are related to ripe olives. In the image below, an example of a ripe olive is selected, which is black. Fig. 6 shows the selected olive image by the program and displays it.

At this stage, according to Fig. 7, the olive type selected in the previous step, which is in RGB color space, is converted to HSV color space, which can be seen as HSV image in the image below, and then three layers of this color space include hue, saturation, and value that the appearance of olives in these three layers can also be seen in the image. Fig. 8 shows the determined degree of the olive by pressing the Grade button.

In the final step, by pressing the Grade button of the olive grade, according to its color in the HSV color space, it is determined that it is immature, semi-ripe, or ripe.

In the following, the results obtained from the software and its accuracy in diagnosis are examined, which can be seen in Table I and Fig. 9.

The table and diagram above show information about Shengeh cultivar olives and indicate that in total the number of samples is 150, of which 50 olives are in the category of immature with green color, 50 are semi-ripe with a brownish color. And the last 50 numbers belong to the mature category, the color of which is black. According to the male output, the number of correct diagnoses of the olive grade of Shengeh cultivar for the immature category is 49%, which is 98%, for the semi-mature category, 48, which is equivalent to 96%, and for the mature category, this number is equal to 50, which is equal to 100%, which is the highest. The diagnosis belongs to the degree of ripe olives and the lowest diagnosis belongs to the semi-ripe olives.

In order to classify using a neural network, among the extractive properties, different sets are selected as input and transferred to the neural network as input. Among 150 samples, the percentage of samples (105 samples) is used randomly for neural network training and validation and the remaining 30% (45 samples) are used for neural network testing. The structure of the multilayer perceptron neural network is shown in the Fig. 9.

Fig. 10 shows the structure of the multilayer perceptron neural network, which includes input, layers 1 and 2 as input and output layers, and finally network output. Table II contains the values of the artificial neural network parameters of the multilayer perceptron, including the number of layers and neurons in these layers, the transmission function used, the reverse propagation network training function, and the reverse propagation weight/bias learning function. The transfer function is selected by default.

In artificial intelligence topics, this table is used to determine the value of evaluation indicators such as accuracy. Accuracy is how many of the selected samples are correct. True depends on how many of the available correct samples are selected. Table II shows the results of test data classification using a multilayer perceptron artificial neural network classifier.

According to the values in the table above (perturbation matrix), the accuracy of the algorithm is expressed in the grading of olives of Shengeh cultivar, the accuracy of the algorithm is 98% for immature with 49 correct diagnoses, 96% for semi-ripe with 48, and 50 for mature olives. It is exactly equal to 100%. It is clear that the numbers on the main diameter of the matrix represent the number of correct classifications. Therefore, if all the numbers that are not on the original diameter are zero, the algorithm has maximum accuracy. To obtain the function of a classifier, it is sufficient to divide the sum of the elements of the original diameter by the sum of the total elements of the matrix. The efficiency for classifying the above algorithm is 98. This is divided by the division of the elements of the original diameter, which is equal to 147, which is equal to the total number of samples, which is 150.

Table III shows the performance criteria of the perturbation matrix for the classification of the artificial neural network, which indicates that the sensitivity and strength of the olive grading algorithm of the immature Schengen cultivar is 96, semi-ripe is 94, and ripe is 98. On average, the accuracy of the algorithm for grading olives of Shengeh cultivar is 98%.

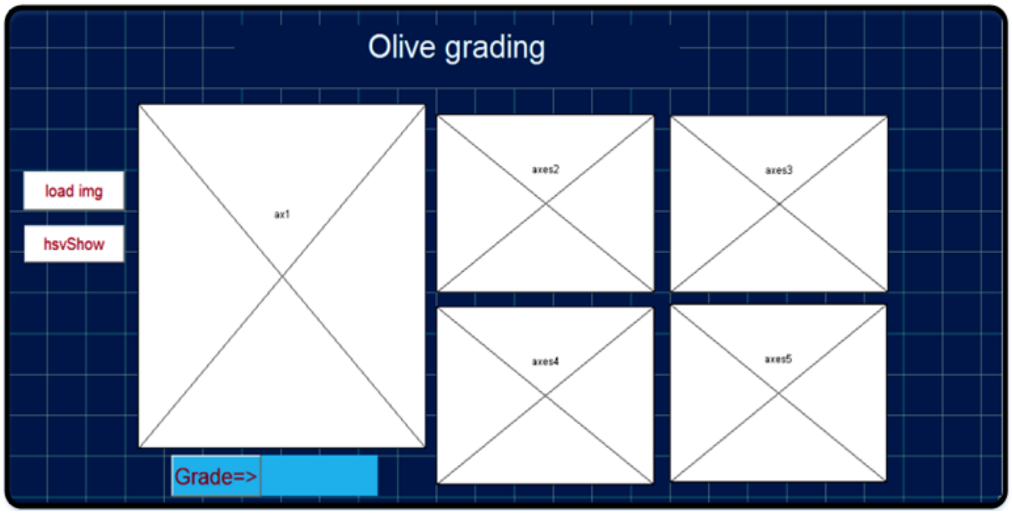

Fig. 4. Overview of graphical interface designed for grading olives.

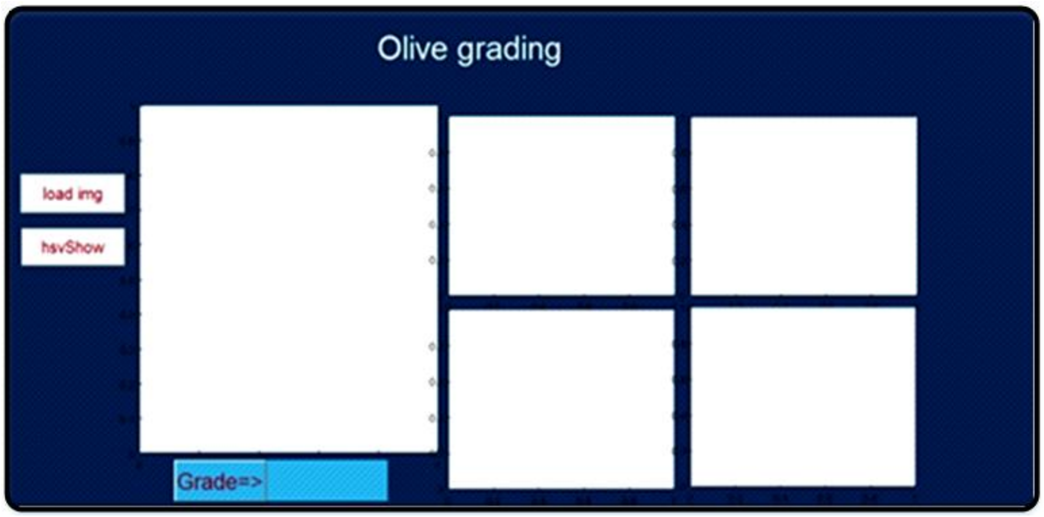

Fig. 5. Graphic interface execution view.

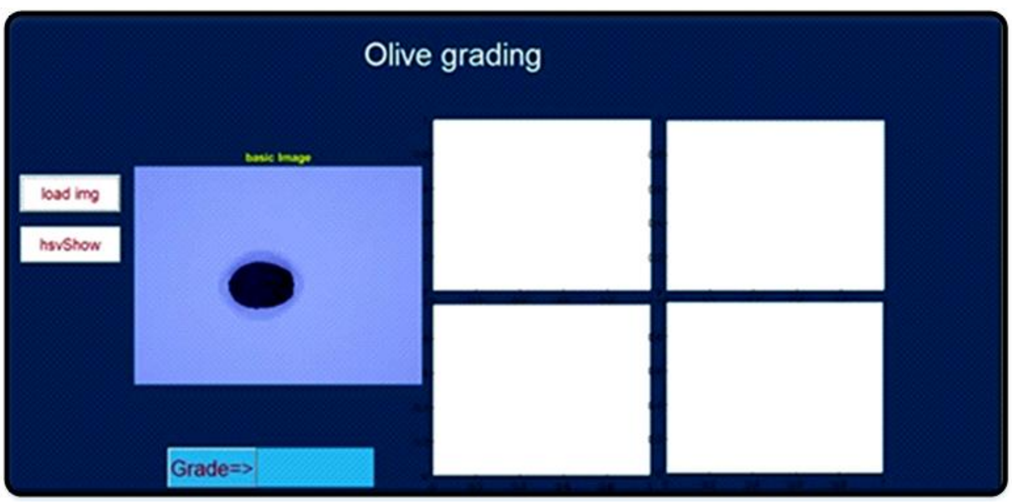

Fig. 6. Read the selected olive image by the program and display it.

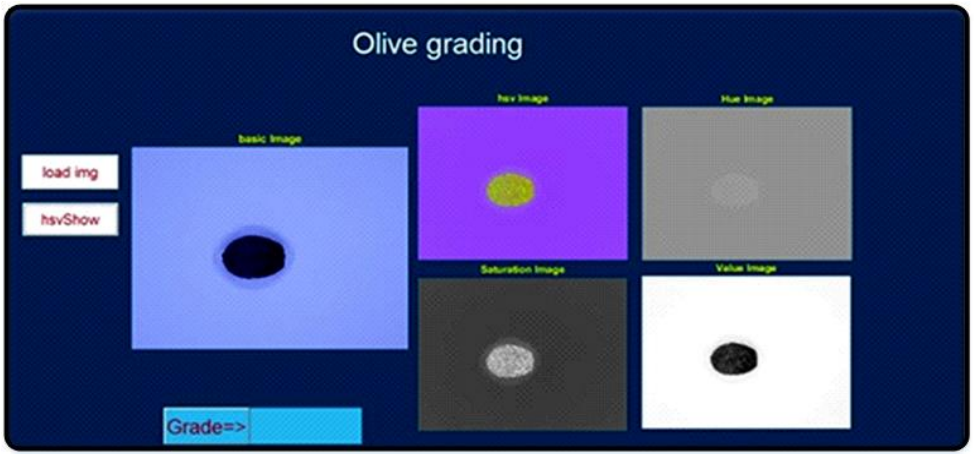

Fig. 7. Shows the olive image in the HSV color space and its components.

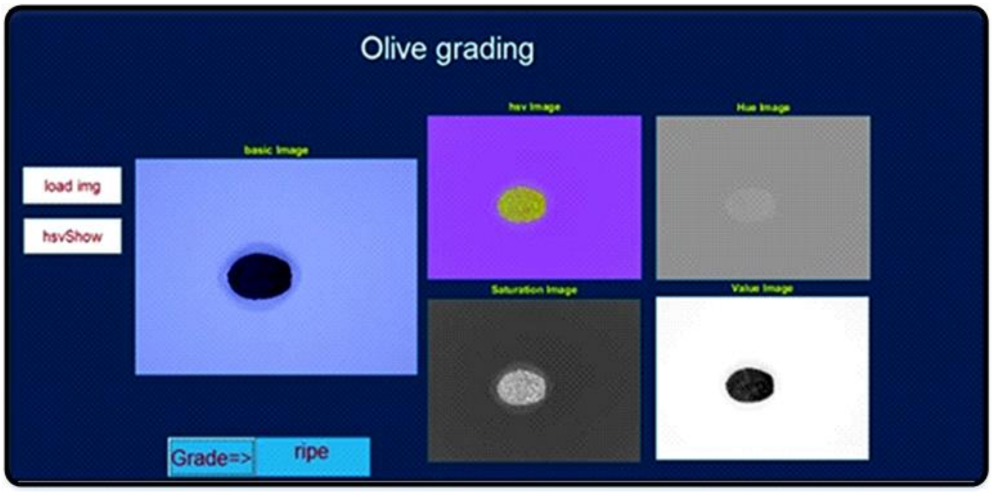

Fig. 8. Determine the degree of the olive by pressing the Grade button.

TABLE I. THE NUMBER OF SHENGEH OLIVES AND THE PERCENTAGE OF CORRECT AND INCORRECT DETECTION BY SOFTWARE

Olive Type	Number of samples	Number of Correct Detections	Correct Detection	Number of Incorrect Detection	Number of Incorrect Detections
Immature	50	49%	98	1	2
Semi-Ripe	50	48%	96	2	4
Ripe	50	50%	100	0	0

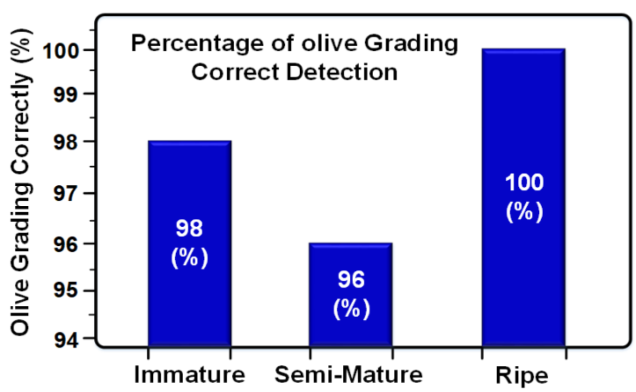

Fig. 9. Percentage of correct detection of degree of ripeness of Shengeh olive cultivar by software.

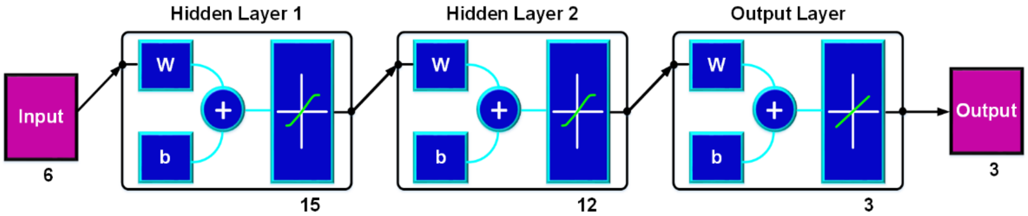

Fig. 10. The structure of the multilayer perceptron neural network.

TABLE II. COMPARISON OF CLASSIFICATION RESULTS OF IMMATURE, SEMI-MATURE, RIPE CLASSES

Classes	Immature	Semi-Mature	Ripe	Total Data	Wrong Classification	Total Correct Classification
Immature	49	1	0	50	2%	98%
Semi-Ripe	1	48	1	50	4%	96%
Ripe	0	0	50	50	0%	100%

TABLE III. THE SENSITIVITY, ACCURACY, AND PERFORMANCE VALUES FOR IMMATURE, SEMI-MATURE, AND MATURE CLASSIFICATIONS

Artificial neural network			
Classes	Sensitivity	Accuracy	Performance
Immature	98	96%	98
Semi-Ripe	96	94%	
Ripe	100	98%	

V. CONCLUSION

This paper presents an image processing-based method to grade the type of olive in terms of its ripeness as a single grain of color. In this method, the color-based feature using HSV color space as one of the best color spaces is used to separate the colors of the cultivar. Using this feature, the olive regions can be extracted. Then using analysis of extracted region, the grading task is performed. As experimental results showed, the accuracy of the method for detecting olives is 98% in the immature group, 96% in the semi-ripe group, and 100% in the ripe group. The average accuracy of the software is generally equal to 98%. However, the limitation of this method is sensitivity to light condition especially in olive region extraction. For direction of future study, deep learning-based methods can be explored to improve the proposed method.

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