Estimating Yield for Fruit Trees Using Image Processing and Artificial Neural Network

Gamze Hikmet Yaşar, Bayram Akdemir

***Abstract*—**Today, image processing is widely used in literature to improve to solve problems in many kinds of sectors. For agriculture, Image processing is a simple and easy way to estimate the amount of yield related to area or easy to evaluate damaged or pre-grown plants in a taken picture. This study is focused on trees to estimate yield in fruit trees. In order to create a library, real orange tree pictures were taken in Serik, Antalya. 150 real pictures were taken from different views and different trees and pictures were classified related to orange harvest one by one for every tree. the pictures least influenced by light intensity were normalized to same dimensions to reduce estimation error. Scrutinized pictures were evaluated before execution via artificial neural network. Artificial intelligence is widely used in literature to solve nonlinear problems such as medical, aerospace, computing and etc. in this study, one of the famous and common intelligence model, Artificial neural network is used. Artificial neural network acts as neurons and has learning ability. Artificial neural network is used to estimate yield for fruit trees to how many kilograms fruit could be obtained. in order to test the discussed method, orange trees were used. Proposed method were achieved 89.8% success on estimation of yield in orange trees. In order to reduce error level, harvested oranges for every tree were recorded and obtained weights (kg) were correlated to Artificial neural network. The obtained success was calculated after two fold cross validation as 89.8%.

***Keywords*—**Artificial neural network, Estimation of yield of fruit, Image processing, Orange trees.

I. Introduction

IMAGE processing is famous method to solve the problems for many areas such as criminal, medical aerospace and etc. This study image processing is used for agriculture. Today, agriculture sector tries different technological materials to improve product efficiency and to be fast [1-3]. This study, tries to estimate for fruit trees before the harvesting. Fruit yield for a tree may be related to many parameters such as irrigation, pruning, spraying and etc. Moreover trade for the fruits, may be arranged just before the harvesting because of urgency or else. This study, offer a artificial intelligence based estimator how many kilograms fruits could be harvested for any tree. Artificial intelligence is widely used in literature to solve nonlinear problems from aerospace to medical [4-5]. In this study, artificial neural network (ANN), one of the famous artificial intelligence is chosen. ANN is based on a neuron behavior and learning ability [6-7]. ANN estimates the yield of fruits from any taken image. ANN was trained evaluated pictures and tested un executed pictures. Thus results for estimation is based on ANN capability without any equations and formulas. Images were taken from orange trees in Serik. Serik is one of district of Antalya in TURKEY and has lots of orange gardens. In order to test ANN ability orange trees' images and orange harvesting are used. Images were taken from an ordinary camera such as cell phone camera and under daylight and filtered in case of light and shadow problems. light scattering and shadow are two big problems to be encountered before image processing as pre-processing [8-10]. in this study, all pictures were purified from shadows and light scattering noises.

After preprocessing the pictures, ANN was executed. The obtained success was achieved as 89.8%.

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II. Materials and Methods

Fruit trees may have different fruit yield due to different irrigation, spraying or pruning. This study, gives a clue about the tree how many kg fruit could be obtained. According to results, owner could execute the next step. In this study, images taken from different orange trees were used. After purified the pictures, oranges filtered from the pictures regarding the tree skeleton.

A. Image Processing

All images were taken from oranges trees in Serik. Serik, a district, belongs to Antalya in TURKEY. Serik has many orange gardens and has popularity on orange production. Many cameras uses RGB formatted and CCD cameras due to cost and simplified [11]. In this study, all pictures were taken 24 bit RGB formatted and 1200x1600 pixels. Pictures were turned to gray format regarding Equ. 1 [12-13].

$$x = 0{,}299red + 0{,}587green + 0{,}114blue \quad (1)$$

where x is gray value of RGB pixel. Obtained value x is turned to digital value as next step from 0 to 255 as unit8 formatted. From fig. 1 shows taken a picture before purified and after purified. In order to improve ANN response all pictures were cleaned and resized. After purified the picture, features of picture were extracted from gray and RGB pixels.

Huge, Saturation and Value (HSV) are features of any image in color space [14-16]. In order to improve ANN answer, RGB based picture convert to HSV color space.

Fig. 1 Taken picture (left) before purified and (right) after purified

The HSV model was created in 1978 by Alvy Ray Smith [17]. It is a nonlinear transformation of the RGB color space. The HSB (Hue, Saturation, Brightness) color model defines a color space in terms of three constituent components:

Hue: the color type (such as red, blue, or yellow). Ranges from 0 to 360° in most applications. Each value corresponds to one color : 0 is red, 45 is a shade of orange and 55 is a shade of yellow.

Saturation: The intensity of the color. Ranges from 0 to 100% . Zero means no color, that is a shade of grey between black and white; 100 means intense color. Also sometimes called the "purity" by analogy to the colorimetric quantities excitation purity.

Value (Brightness): The brightness of the color. Ranges from 0 to 100%. Zero is always black; depending on the saturation, 100 may be white or a more or less saturated color. Fig. 2 shows HSV features on same picture.

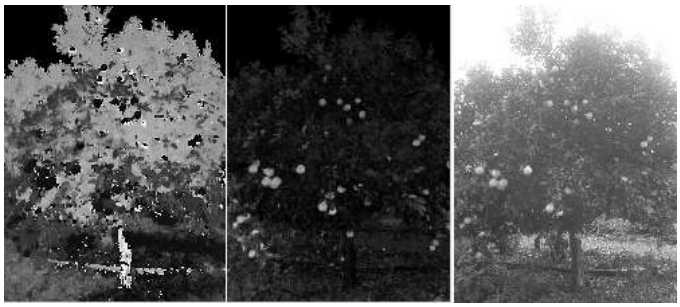

Fig. 2 Effects of HSV features on the picture. (left) Hue, (middle) Saturation, (right) Value (brightness) images.

Threshold: Threshold is one of the simple ways to reduce noise and obtain the target features which ones necessary. Threshold can be arranged according to experience. low level threshold can't be filtered the picture on the contrary, high threshold level can loss the useful features of a pixel [18-20]. In this study, same picture after threshold executions for HSV features created again. After threshold level execution, HSV values can be masked one by one to see what happened to picture. Thus, absence of HSV features shown in fig. 3.

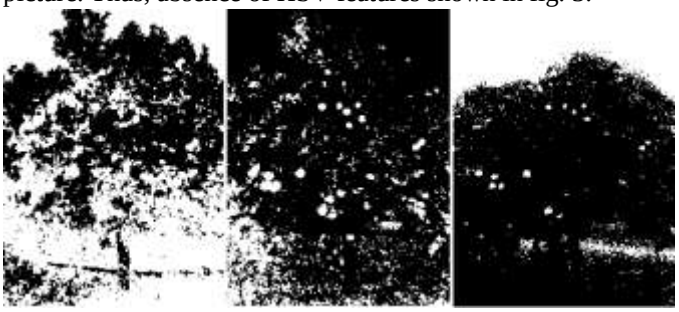

Fig. 3 Absence of HSV features on the picture. (left) Hue, (middle) Saturation, (right) Value (brightness) masked images.

Threshold and HSV are used to obtain features of the picture to grab fruits in the picture without mixing the other objects.

B. Artificial Neural Network

Artificial intelligence is widely used in literature to solve nonlinear problems. Artificial Neural Network is one the famous methods to solve the problems. ANN is an emulation of biological neural system based on the operation of biological neural networks. An ANN has lots of paralleled interconnected computational unit which are connected as a hierarchical structure. The elementary of this unit is called as neuron which has computational ability. Learning ability of ANN is hidden in its weights and bias values. A multi layer perceptron (MLP) ANN structure is shown in Fig. 4.

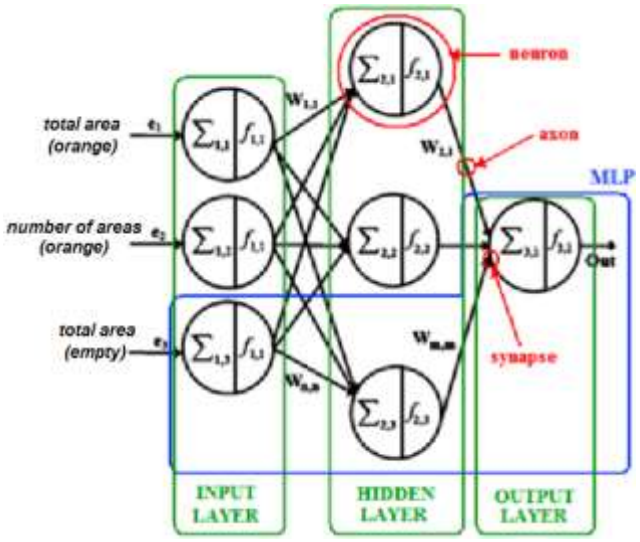

Fig. 4 MLP-ANN structure

ANN learns by examples like human through the learning process [21,22]. An ANN structure consists of an input layer with three neurons, a hidden layer with three neurons, and an output layer. ANN can generate a valid solution for any kind of nonlinear problems [23-25]. This problem can be related to

pattern recognition, predictions or data classification and so on. For an ANN, one input, one hidden and one output layer are called MLP and this configuration is common [26]. This is miniature of an ANN. The back propagation is widely used to adjust connection weights and bias values using training. Each MLP layer is formed by a number of predefined neurons. The neurons in the input layer can be explained as a buffer which distributes the input signals x_i to next neurons in the hidden layer without humiliating the signal. Each neuron j in the hidden layer sums the input signals x_i after weighting them with the strengths of the respective connections w_{ij} from the input layer, and computes its output y_i as a function f of the sum (Eq. 2):

$$y_i = f(\sum w_{i,j} x_i) \quad (2)$$

where, f is the activation function which is needed to transform the weighted sum of all signals influence a neuron. Although there are many activation function for ANN application due to different data set groups, logsig is very common activation function. All activation functions have different transfer curve that may be threshold, linear tangent etc. In the end, the output neuron in the output layer can be calculated similarly.

III. Implementation of Proposed Method

Proposed method based on image processing and ANN application. Taken orange trees pictures from real orange gardens were evaluated using HSV and threshold parameters to obtain pictures' features. First of all, pictures were purified removing shadows and possible light scattering on the picture. Fig. 1 shows (right side) cleaned picture and ready to use for next image processing. Fig. 6 shows implementation of proposed method. In order to create a library to evaluate the pictures, 150 picture were taken from 20 trees from different sides to improve ANN response. After purified and processed the picture, Fig. 5 shows the target picture before the apply to ANN.

Fig. 5 Obtained fruits from the real images. (left) real, (right) masked pictures.

ANN was trained using half of the pictures. the rest of the pictures were tested to ANN performance. After first execution, test and training picture structure were switched to each other and test and train procedure executed again.

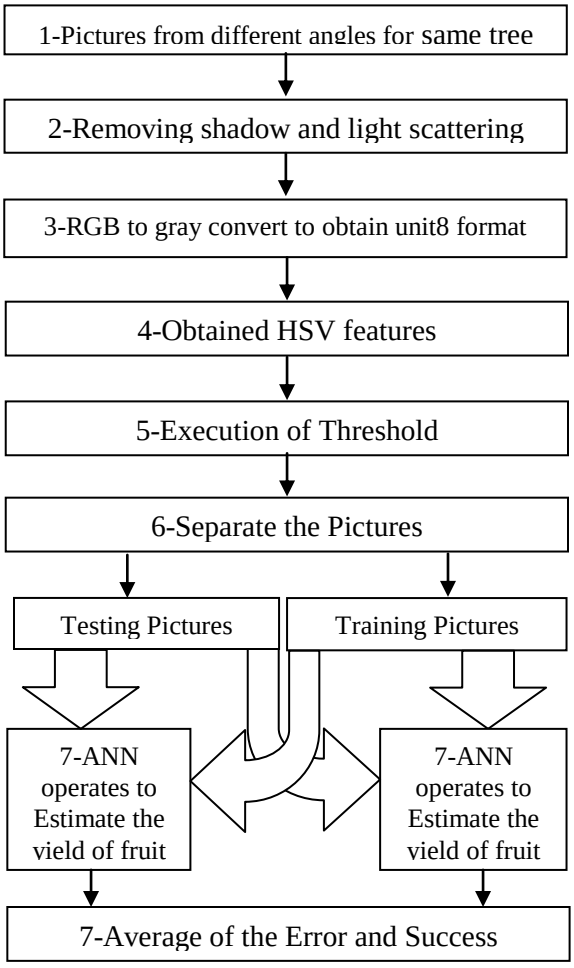

Fig. 6 Implementation of proposed method

The obtained errors and success were averaged to improve ANN reliability. testing and training pictures were switched and re-named test as training and training as test data. this method is called two fold cross validation.

	Training (%)	Testing (%)
ANN^1	99.9980	92.7
ANN^2	99.9990	86.9
ANN^T	99.9985	89.8

where, ANN^1 is first execution, ANN^2 is second execution and ANN^T is average value for two ANN applications.

IV. Evaluation of ANN Results

Two fold cross validation was used to evaluate the ANN results [27-39]. Data structure, obtained pictures, were separated two sections as training and testing. After first execution of training and testing data, data set were switched each other. ANN was executed second time and test and

training errors were recorded after two executions. Obtained values are got average of test and train errors separately. Thus, reliability of ANN was improved applying two fold cross validation.

V. Conclusion

In this study, image processing and ANN application were merged to estimate yield of fruit for fruit trees. Estimating fruit yield for trees have importance to evaluate the trees separately. this study, offers an ANN based estimator. As first, pictures taken from real trees were purified and obtained the HSV values. after threshold execution to remove the noise from the picture, picture were divided as 50% training and testing to apply to ANN. first data set training data were applied to ANN and tested the rest of data pictures. after first execution, test and training data were switched each other and applied ANN to again. the obtained values for two executions were averaged using two fold cross validation. Two fold cross validation is a simple way to improve ANN reliability. In this study, the success was obtained as 89.8%.

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