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An Empirical Investigation of Olive Leave Spot Disease Using Auto-Cropping Segmentation and Fuzzy C-Means Classification

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Abstract: The objective of this research was to investigate an image analysis and classification techniques for detection and severity rating of olive leaf spot disease. Samples of olive leaves were collected from field and imaged under uncontrolled illumination. Images resolution were resized to 256×256 pixels and transformed from RGB to L*a*b* color space. The transformed images were then cropped polygonal to segment the region of interest and classified using fuzzy c-mean clustering for statistical usage to determine the defect and severity areas of plant leaves. Imaged enhancement was performed using median filtering. The severity percentage was calculated based on classification of detected diseased and total leaf areas. Comparative assessment of FCM and KCM was conducted with reference to mean opinion scoring of image data. The results showed a good agreement between FCM and manual scoring and by image analysis at an 86% accuracy rate comparing to KMC with 66%.

Key words: Olive leaf spot disease · Cropping · Color transformation · Segmentation and Image classification

INTRODUCTION

The olive is the most important fruit tree grown in Jordan. The total cultivated area with olives is about 130,000 ha representing 72% of the total planted area with fruit trees and 36% of the total cultivated area in Jordan[1]. One of the important foliar diseases affecting olive trees in Jordan and many other countries in the world is peacock spot disease also called olive leaf spot (OLS) and bird's-eye spot [2]. Twig death may occur in infected trees as a result of defoliation and productivity is eventually further reduced with great damage of plantation. Symptoms of disease start as sooty blotches on leaves develop into muddy green black circular spots 2.5 to 12 mm in diameter, there maybe a yellow halo around the spot [3]. Spots quantities are considered the important units indicating the severity of diseases, Figure 1.

The relationship between proportions of olive leaves diseased and the amount of affected tissue is a valuable tool for disease assessment and management. Although the area of infected tissue is the most commonly used measurement of severity, that why this work aimed to conduct assess the infected leaves to define the severity of OLS [4]. In this work an image processing techniques were used to identify OLS, make correct diagnostics and analysis of such disease. Objective assessments were used to get more accurate system for identification and recognition of this foliar disease.

Fig. 1: Olive leaf spot, also known as peacock spot

Previous Work: Plant disease was tackled using image processing techniques for the sake of disease detection, identification and recognition. Building vision system for disease detection to find defected area by color, shape and textures need to be determined feasibly based

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on image processing techniques, such a system must consist image acquisition, image enhancement, region of interest cropping, segmentation and classification. This paper will discuss all previous steps to reach the proper and accurate method. There is a consensus on digital cameras as a one of acquisition devices to acquire the digital images from the environment. Acquired images were used as input for image-processing techniques to extract useful features that are necessary for further analysis. Al-Hiary, *et al*. [5] used several analytical discriminating techniques to classify the images according to the specific problems. They did not mention anything about leaf cropping; it seems that they were using image leaves on white background. An RGB images were transformed into color transformation structure then applying K-means segmentation techniques from clustering, the infected cluster was then converted from RGB format to Hue Saturation Intensity (HSI) color space representation. Features extracted using Color Co-occurrence Method (CCM), A result of this paper were compared with [6] which used same steps except classification that based on Neural-networks. R. Pydipati in [7] conclude agricultural applications using image processing and pattern recognition techniques into: Object shape matching functions, color-based classifiers, reflectance-based classifiers and texture based classifiers. RGB transformation into HIS color space was used to generate CCM matrices for classification purposes. Patil, *et al*. [8] used controlled images where infected leaf is placed flat on a white background; the picture taken contains only the leaf and white background, in their study no need for pr-processing cropping. Bashir, *et al*. [9] used image color separation to subdivide an image into its constituent objects. They used texture segmentation to identify spots, K-means clustering and CCM were used to partition the leaf image into four clusters in which one or more clusters contain the disease in case when the leaf shows the symptoms that is has been infected by more than one disease. El-Helly, *et al*. [10] used segmentation based on fuzzy c-mean algorithm which use HSI transformation within histogram analysis and intensity adjustment. The results of fuzzy c-mean clustering were measured as features such as: color, size and shape to isolate and extract spots. Hernandez-Rabadan, *et al*. [11] combined a supervised and an unsupervised learning method to segment healthy and diseased plant images from the background.

Proposed Work: A proposed work was designed based on a combination of region of interest cropping for segmentation purpose and fuzzy c-mean classification (FCM) for statistical usage to determine the defect and severity areas of plant leaves. The region of interest was cropped using automatic polygon determination to segment the interested area and to leave out the background while the FCM is used to segment the internal defects inside each leaf area. A proposed method consist of three main steps which shown in Figure 2. To avoid the degradation and to enhance the quality of captured images, image enhancement was the first step of image pre-processing block of proposed work. It makes quality predictions in agreement with subjective opinion of human observer for the reason of performance check of proposed work. Image enhancement in this work was based on color filtration of captured RGB images Figure 3, where the enhancement quality score was increased in 0.7 from 10 according to quality score measurement over 10 [12]. Test was done on all database images and the given score was the average of enhanced database scores.

A second step in image pre-processing block was region of interest cropping based on automatic polygon cropping Figure 4. Polygon cropping follows the edging contour of entire image in the gray scale representation to define the masked polygon points of interested region. A determined mask was convolved with color filtered image to get auto cropping input image. Automatic polygon cropping was built on [13] with respect of color scaling and filtration. Auto cropping of leave region of interest was taken as a pre processing segmented area for next pre processing classification. It was a color content of tested leaves for extraction clusters of infection prediction and severity determining.

This approach provides both the possibility of improving the performance of clustering classification based on fuzzy c-means clustering and also the ability to use only the region of interest of the used image as a novel segmentation method for identification the exact region of foreground of leaf for percentage disease detection and future feature extraction usage.

Classification Pre-Processing: This block play important role in olive leaf spot detection because it defines the needed color transformation that will be used in cluster separation. Color transformation determines the luminosity and chromaticity layers which classify colors according to human vision system and that very useful in subjective analysis of leaf images judgment. In this study the L*a*b* color space was chosen due to the uniform distribution of colors and because it is very close to human perception of color. The L*a*b* color space is derived from the CIE XYZ tristimulus values. The L*a*b*

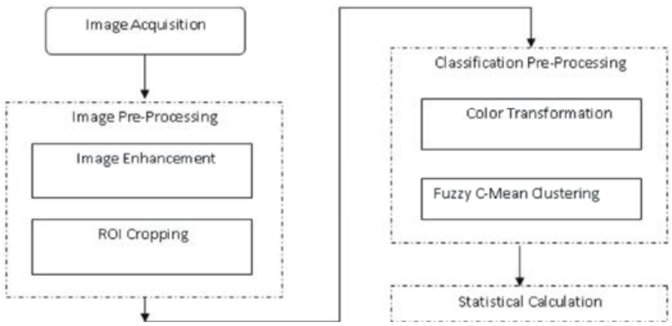

Fig. 2: Detailed description of proposed work

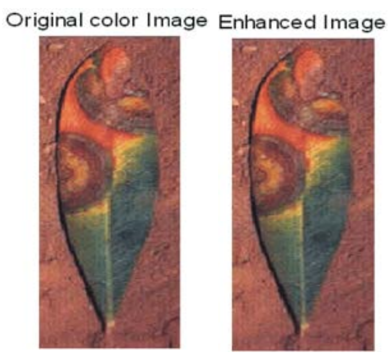

Fig. 3: Original and enhanced images using color filtration techniques

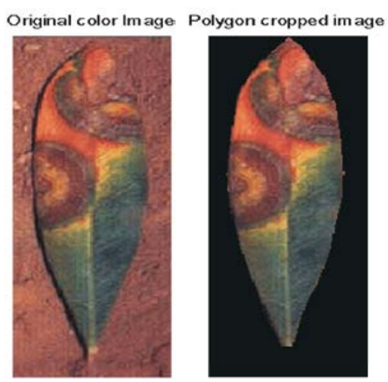

Fig. 4: Color filtered and polygon cropped images

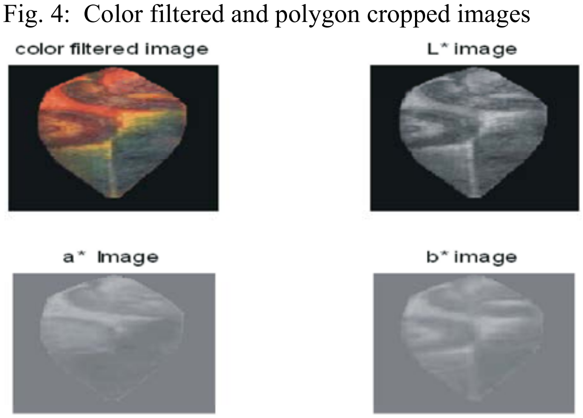

Fig. 5: Color transformation into L*a*b*

space consists of a luminosity layer 'L*', chromaticity-layer 'a*' indicating where color falls along the red-green axis and chromaticity-layer 'b*' indicating where the color falls along the blue-yellow axis. All of the color information is in the 'a*' and 'b*' layers. RGB filtered image is converted into CIE XYZ using following Equation [14].

$$X = 0.4124 * R + 0.3576 * G + 0.1805 * B$$
$$Y = 0.2126 * R + 0.7152 * G + 0.0722 * B$$
$$Z = 0.0193 * R + 0.1192 * G + 0.9505 * B$$

XYZ converted into L*a*b model using following formulas [15].

$$L = 0.2126 * R + 0.7152 * G + 0.0722 * B$$
$$A = 1.4749 * (0.2213 * R - 0.3390 * G + 0.1177 * B) + 128$$
$$B = 0.6245 * (0.1949 * R + 0.6057 * G - 0.8006 * B) + 128$$

RGB color transformation into L*a*b* implemented and the result as shown in Figure 5.

The second step in classification pre processing was fuzzy c-means clustering for reshaped a* and b* color information in which an (ab) dataset is grouped into n clusters with every data point n the dataset belonging to every cluster to a certain degree. In proposed work a 3 clusters was chosen to avoid local minima, Figure 6. Fuzzy c-means clustering algorithm works by assigning membership to each data point corresponding to each cluster center on the basis of distance between the cluster and the data point.

FCM mathematically represented as follow:

$$J = \sum_{i=1}^{C} \sum_{j=1}^{n} \left(u_{ij}\right)^{m} D\left(x_j, v_i\right) \text{ where}$$

u_{ij} represent the membership degree of j_{th} object in the i_{th} cluster, v_i represent the i_{th} cluster cnter, D represents a distance metric that measures the similarity between an

Fig. 6: FCM clustering with respect of 3 groups

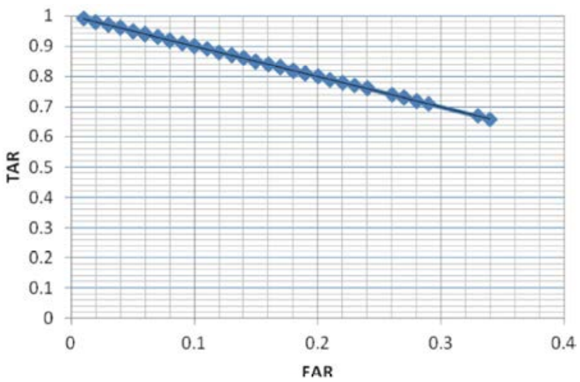

Fig. 7: FCM TAR-FAR representation

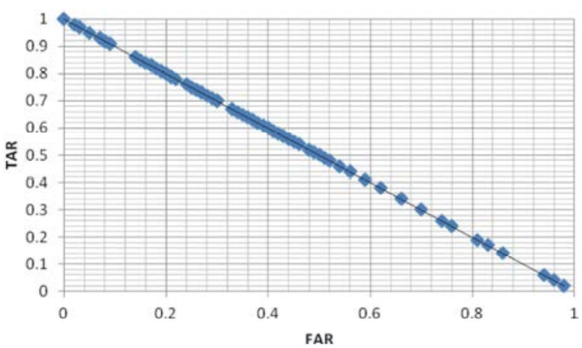

Fig. 8: KMC TAR-FAR representation

Table 1: Subjective detection scale

Scale degree	Olive leaf spot QTY	Severity Percentage
0	0	0%
1	1-2	33%
2	3-5	66%
3	>5	100%

object and a cluster center. Applying FCM to search for homogenous regions in a segmented ROI based on color, as well for severity determination. It used identified color area to be calculated with reference to defined normal color.

Experimental Results: The various experiment carried out on different olive leaves to define infected leaves and these results compared with subjective experimentation results as well with results of K-mean clustering algorithm. Algorithms were implemented in MATLAB environment Version 7.0.0.1(R14). To define the mean opinion score (MOS) of subjective analysis a 100 olive leaf images passed to 6 expert observers, Expert observers were considered to be observers with significant experience in the fields of imaging perception and image processing. They were used judgment scale Table 1, to decide the infection degree of leaves.

Results of 6 scores of observers were averaged for each image to be reference for both algorithms FCM and K-mean clustering (KMC) for comparison reason. Both algorithms compared from point of views of speed and true – false accept rate (TAR, FAR) and it is found that the average speed for FCM, KMC were 6.96 second, 4.23 second respectively. An accuracy values were calculated according true acceptance rate (TAR) and false acceptance rate (FAR). The accuracy test shows that FCM TAR was 86%, FAR was 14% while KMC TAR was 66% while FAR 34% which show that FCM is a high accuracy algorithm. Results of complete tests were shown in receiver operating characteristic curve constructed by moving the threshold from the highest similarity score (TAR) down to the lowest one FAR, Figures 7, 8.

CONCLUSION

In this paper, FCM and KMC for disease detected were investigated. Evaluation results of FCM algorithm with polygon auto-cropping segmentation shows encouraging accuracy prospects. A further contribution of this paper is an automated polygon cropping stage in plant disease detection systems and image clustering classification to avoid image features calculation.

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