Back Propagation Neural Network (BPNN) to Detect Surface Crack on Dates Using RGB Images

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***Abstract*—Surface crack is a type of defect which depreciates dates quality. An automated system to detect and sort cracked dates is needed in the factories in order to ensure quality. The objective of this study was to determine the efficiency of a computer vision system with RGB color camera to classify dates based on surface cracks using Back Propagation Neural Network (BPNN). A total of 315 samples were imaged using a digital color camera. Each image was processed in MATLAB software and converted to HSV plane. The binary image of the segmented sample was used to extract features for the determination of surface cracks. Back propagation neural network (BPNN) was implemented to obtain the classification accuracies of the developed algorithm. The neural network classified dates into three classes (no-crack dates, low-crack dates and high-crack dates) with 77% accuracy. The accuracy was improved to 90% while classifying into two classes (without-crack dates and with-crack dates). The developed algorithm may be modified further and used to detect cracks on other dried fruits and vegetables.**

***Index Terms*—BPNN, color imaging, dates, surface defect**

I. Introduction

The annual production of dates in Oman is around 276,400 metric tons which represents 4% of the total world production [1]. Although production in Oman is high, annual export is less than 10,000 tons [2]. This lower export may be due to the poor quality of the processed and packaged dates [3]. Date quality is determined mainly based on color, size and absence of defects or damages [4]. In the "CODEX Standards for Grades of dates" 30 points are awarded for the absence of defects, which contributes significantly to the overall quality score [5]. Crack is a type of surface defect which appears in the cuticle and epidermal cells. These cracks may be transverse, longitudinal or irregular and their abundance and shape differ in various varieties of dates [6]. Cracks are attributed to the old world date mite *Oligonychus afrasiaticus* [7], [8] or to wet weather [6]. Palevsky (2004) noted the seriousness of cracks caused by mites by mentioning that "not even birds feed on these cracked and desiccated dates" [9].

In date processing industries, date cracks are usually detected and removed by manual inspection which is a highly subjective method, and the accuracy is determined by various factors such as lighting condition, experience and skill level and mental stress of the graders. As such, there is a necessity to develop an effective method to detect cracked dates during handling, processing and packing. Computer vision technique is becoming popular for the assessment of many surface and internal quality attributes of agricultural and food products. In this method, the image of the object is acquired by a camera and analyzed by a computer and other devices in order to obtain useful information. The computer vision technique can improve the production speed, efficiency, and accuracy, and reduce the production cost [10].

A neural network is a computer model that is used to classify the objects using different features extracted from the images. They interact with each other via weighted connections. There is an input layer where data are entered in the neural network, and an output layer that holds the results of the network. In between the two layers, there are number of interconnected elements, known as neurons in the hidden layers where the complicated associations between patterns are computed [11].

The objective of this study was to determine the efficiency of a computer vision system with RGB color camera to classify dates based on surface cracks using Back Propagation Neural Network (BPNN).

Al-Yahyai and Manickavasagan explained various influencing factors and assessment methods for the quality of dates [12]. Artificial neural network models have been used to classify dates based on variety or hardness [13], [14]. Al-Rahbi *et al.* used linear discriminant analyses (LDA) to classify dates based on surface cracks. However the classification system should be selected based on data set using trial and error methods [15].

II. Materials and Methods

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A. Sample Collection

Three grades of dates (high crack, low crack and no crack) were collected from two dates' factories in Sultanate of Oman. The grade was decided based on the percentage of cracks over the total area of the date fruit. Samples with approximately 30% cracks or less were classified as low crack dates and samples with above 30% cracks where classified as high crack dates. The graded samples were confirmed by an expert on date quality. A total of 315 samples (105 samples /grade) were used for imaging and data analysis.

B. Image Acquisition

Images were captured using a digital color camera (model: EOS 550D, Canon INC., Japan) with a resolution of 5184×3456 pixels. The camera was adjusted to be in autofocus mode with focal ratio of 5:6. The camera was located at 15cm above the sample platform. A cardboard box was used to cover the whole setup to avoid interference from other light sources [16]. A white sheet was used as the background to the sample to increase the contrast and assist in the segmentation process during image analysis. The camera was connected to the USB port of a computer which contained remote shooting software. The sample was manually oriented so that the side with the highest cracked region was facing the camera. An illumination system which composed of two fluorescent lights (36W, model: Dulux L, OSRAM, Italy) was used to illuminate the sample. The schematic diagram of the image acquisition system is shown in Fig. 1.

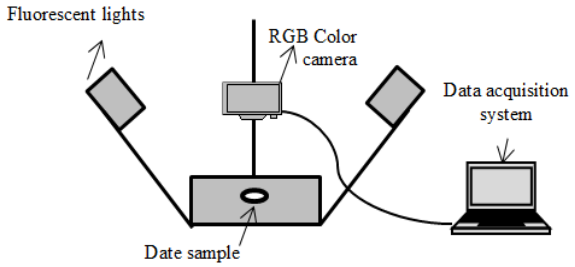

Figure 1. The schematic diagram of the image acquisition system

C. Image Analysis and Feature Extraction

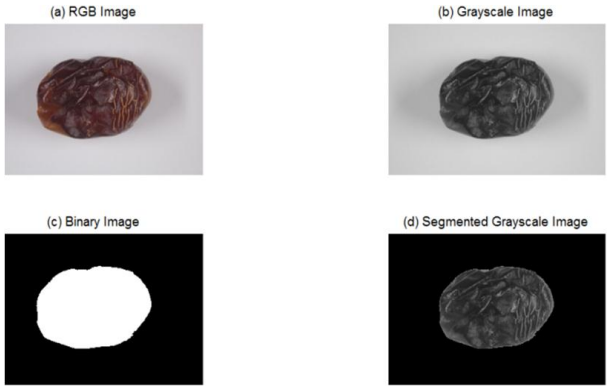

Figure 2. Segmentation steps applied to the images of date samples [15]

The acquired images were analyzed using Matlab software (version 7.6.0.324, Mathwork INC., USA). The object was segmented from the background using Otsu threshold method (Fig. 2).

Seven features were extracted from each date image based on color and four features based on cracks' area. The color based features and their descriptions are shown in Table I.

TABLE I. FEATURES EXTRACTED FROM THE SEGMENTED OBJECTS [17]

Feature	Description
Gray-Intensity	The mean intensity of gray scale image
Red-Intensity	The mean intensity of red component
Green-Intensity	The mean intensity of green component
Blue-Intensity	The mean intensity of blue component
Hue-Intensity	The mean intensity of hue component (dominant wavelength on the color)
Saturation-Intensity	The mean intensity of saturation component (color purity)
Value-Intensity	The mean intensity of value component (color brightness)

Apart from color features, crack area and percentage of crack area were calculated using 2 different methods:

Threshold method: in each grade, five random images were selected and the Value-Intensity for the crack region was determined and used to threshold the cracks on the surface of the dates (Fig. 3).

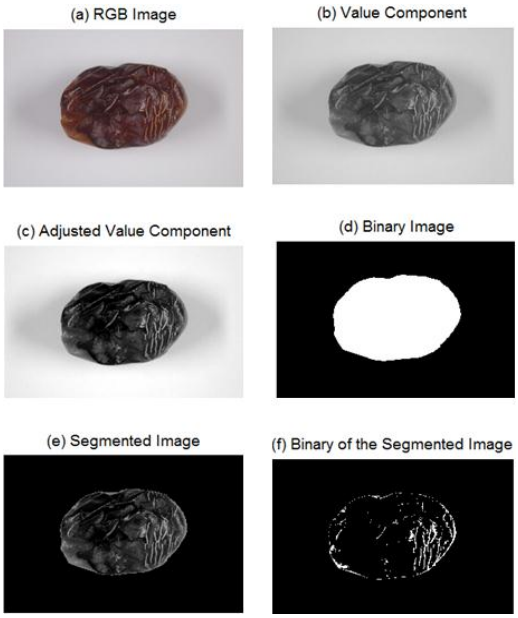

Figure 3. Calculating cracks area using threshold method [15]

HSV mask method: similar to threshold method, the range of range of Hue-Intensity, Saturation-Intensity and Value-Intensity for the crack regions were determined and used to detect crack area on the surface of the dates (Fig. 4).

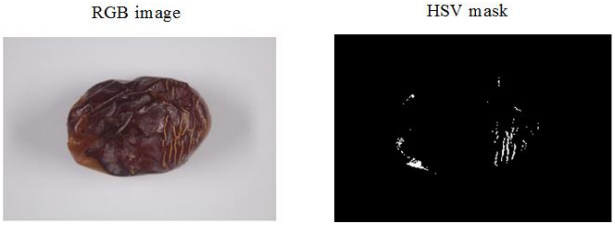

Figure 4. Calculating cracks area using HSV mask method [15]

In both methods, the percentage crack area was calculated as: Percentage crack area = (number of pixels occupied by cracks/total number of pixels occupied by the date sample) × 100.

D. Classification Models

Back propagation neural network (BPNN) was used to determine the classification accuracies of two different classification approaches in MATLAB (version 7.6.0.324, Mathwork INC., USA):

- Three classes model (high-crack, low-crack and no-crack)
- Two classes model (with-crack and without-crack)

III. Results and Discussion

A. Three Classes Model

The confusion matrix obtained by BPNN is shown in Table II. The classification accuracy was 83.8%, 57.1% and 89.5% for high-crack, low-crack and no-crack, respectively. The overall classification accuracy was 76.8%.

TABLE II. The Classification Accuracy (%) of BPNN in Three Classes Model

From	To			
	high-crack	*low-crack*	*no-crack*	*Total*
high-crack	**88**	16	1	105
low-crack	28	**60**	17	105
no-crack	0	11	**94**	105

In three classes model, around 27% of misclassification occurred from low-crack to high-crack dates.

B. Two Classes Model

In this approach, the images of high-crack and low-crack dates were mixed together and treated as dates *with-crack.* The cracked dates were discriminated against dates *without-crack*. The confusion matrix of BPNN of the two classes' model is shown in Table III. The system correctly classified 91.9% of with-crack class and 86.7% of without-crack dates. The overall classification accuracy was 90.2%.

TABLE III. The Classification Accuracy (%) of BPNN in Two Classes Model

From	To		
	with-crack	*without-crack*	*Total*
with-crack	**193**	17	210
without-crack	14	**91**	105

Al-Ohali achieved 55 to 80% classification accuracy using BPNN while sorting dates based on defects, flabbiness, size, shape and intensity [18].

IV. Conclusion

The developed algorithm with RGB camera was able to classify the cracked dates with more than 90%. It is recommended to evaluate the accuracy of Near Infrared (NIR) imaging in the classification of dates based on surface cracks.

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