International Journal of Image Processing and Vision Science

Volume 1 | Issue 3 Article 11

January 2013

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Recommended Citation

A, MANICKAVASAGAN.; THOMAS, GABRIEL; AL-YAHYAI, R.; and M, HEMA (2013) "BRIGHTNESS PRESERVING HISTOGRAM EQUALIZATION (BPHE) TECHNIQUE FOR CLASSIFICATION OF DATES," *International Journal of Image Processing and Vision Science*: Vol. 1 : Iss. 3 , Article 11.
DOI: 10.47893/IJIPVS.2013.1038
Available at: https://www.interscience.in/ijipvs/vol1/iss3/11

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BRIGHTNESS PRESERVING HISTOGRAM EQUALIZATION (BPHE) TECHNIQUE FOR CLASSIFICATION OF DATES

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ABSTRACT-Brightness preserving histogram equalization (BPHE) technique was used to enhance the features to discriminate three dates varieties (Khalas, Fard and Madina). Mean, entropy and kurtosis features were computed from the enhanced images and used in an Artificial Neural Network classifier. The classification efficiency of 4 sets of hidden neurons (5, 10, 20, and 30) was tested and the network with 5 neurons yielded the highest classification accuracy of 95.2%.

Key words: Computer vision, brightness preserving histogram equalization, dates variety

ACKNOWLEDGMENT

We thank The Research Council (TRC) of Sultanate of Oman for funding this study (Project No. RC/AGR/SWAE/11/01-Development of Computer Vision Technology for Quality Assessment of Dates in Oman).

INTRODUCTION

Date is an important agricultural commodity in Oman. Approximately 50% of the total cultivated land is under date palm vegetation. The production of dates in Oman has improved magnificently from 45,000 metric tonnes in 1970 to 255,891 metric tonnes in 2007 (FAO, 2007). In spite of achievements in production, date quality has been a major concern in Oman. Quality, composition and packaging have always been a problem for Omani dates to compete in the international market (Al-Marshudi, 2002). The average annual export is only 9000 metric tons which is 2.5 to 3.5% of production (FAO, 2007). Whereas in some other date producing countries, a major portion of the production is being exported. For example, 55.5% in Tunisia, 54.7% in Israel, 24.2% in Iran and 18.7% in Pakistan are exported from production (FAO, 2007).

In general, manual grading is followed in dates handling and processing facilities and analytical methods are used for specific quality determination. Visual inspection method (manual grading) of quality assessmenthas many constraints such as subjectivity (personal perception), influence of mental stress, influence of environment (lightings), efficiency of individuals at various times of the shift and so on. On the other hand, in analytical methods, sample collection, sample preparation, exclusive laboratories, time consumption, and chemical reagents requirement restrict the frequency of quality tests in the dates handling chain. Computer vision (CV) technology is a potential alternative technology for analytical and visual inspection method of quality assessment. In CV method, various cameras are used to take images of the products and characterize food qualities (internal and external). This method is being used for various quality measurements with acceptable accuracy in developed countries. Algorithm development and training of calibration models are the important components in determining the accuracy of the CV system. In Oman, the implementation of quality assessment program for dates at various stages of supply chain will add values in export and domestic markets. The objective of this study was to determine the classification of three date varieties using gray scale images and brightness preserving histogram equalization (BPHE) enhancement technique.

MATERIALS AND METHODS

Image Acquisition

Three date varieties namely Khalas, Fard and Madina were purchased from local shopping centers. Each variety was purchased at least from three different shopping centers and the varietal purity was confirmed by a "date variety expert" at Sultan Qaboos University. A conglomerate sample of 108 dates was taken for each variety (n=108 for each variety) and each date sample was imaged with a color camera (RGB) (Nikon, Japan) separately (total = 324 images). Then all images were converted into gray scale images in Matlab and used for analysis.

Image Analysis

A threshold operation was done in order to eliminate the background based on the maximization of the between-class variance using Otsu's method (Otsu, 1979). The mean gray value seemed to work for the class
Fard, since they looked darker than the other two classes. Figure 1shows the mean gray values for 108 images of each class and note how the values for class Fard do appear darker and dissimilar than the other two. Another feature that can be calculated to help the classification is entropy defined by Shannon (1948). Entropy will capture texture information and measure dispersion of these histograms. Entropy value indicates the possible usefulness of including it in a classifier for discriminating the Madina class (Fig. 1). The scatter plot shown in Figure 2 shows how these two features may not be enough since the clusters for each class overlap considerably.

Brightness Preserving Histogram Equalization

In this section the image enhancement technique which preserves the mean of the original image is presented. Even though, it was originally introduced as an image enhancement technique (Wang and Ye, 2005), it is used here as a way to enhance the classification features. Because the mean value of an image is associated with its brightness, this approach was named Brightness Preserving Histogram Equalization (BPHE). As the name indicates, the method relies on histogram modification and this section starts with a brief discussion on Histogram Equalization (HE), a common and popular contrast enhancement technique that will help on understanding and appreciating the technique. We included a brief discussion here but more detail can be found in Wang and Ye (2005).

It is well known that certain images can cause problems when using histogram equalization (Gonzalez and Woods, 2001). In particular if the histogram of an image shows a strong peak because the image is dominated by a larger area of a single gray level value. Regardless of the shape of the histogram in the original image, HE will yield an image with a final level of brightness that is close to 0.5.

Wang and Ye (2005) proposed a technique that yields an image with a similar brightness level as the original one. The idea is to find a specified histogram which mean or average level of brightness is equal to

the original one subject to the constraint that the entropy is maximum. Because the uniform distribution has maximum entropy, this condition offers excellent contrast.

The brightness of the images is preserved in BPHE images as in original images (dark as the original but with enhanced contrast). There are also no terrible over or under enhancement effects. When BPHE is applied to the original images of date samples, rather than expecting nice images we are looking for more contrast but preserving the level of darkness of the original ones.From the final type of exponential histograms obtained using BPHE, one can expect changes in the normalized moment values obtained when using the original and modified images (Fig. 3). Figure 4 shows the kurtosis values for the original set of images and the contrast enhanced ones corroborating these changes. As indicated before, these changes happen without modifying the original values for the mean.

RESULTS AND DISCUSSION

Evaluation of Features Obtained from Images Enhanced by BPHE

In order to validate the use of image enhancement technique, a feature selection approach was used in order to compare the features extracted with and without the contrast enhancement. Three features were used to make the training of the neural network classifier fast given the enhanced quality of the features. Then, for the feature evaluation, a selection scheme with a backward sequential search starting with a full feature set and sequentially removing features was considered to be a practical solution. We decided to use a new feature selection scheme that is based on fuzzy entropy measures with a similarity classifier as presented in Luukka (2011).

The mean, Shanon's entropy, kurtosis and skewness were evaluated together with the values of kurtosis and skewness computed from the contrast enhanced images. Feature selection by the method proposed by Luukka using both fuzzy entropy metrics resulted on favoring the use of kurtosis over the skewness values

regardless of the type of image used, either original ones or the ones enhanced by BPHE. The kurtosis values selected were the ones using BPHE. This gives us justification for the use of these features in the neural network implemented and described in the following section.

Neural Network and Classification

A two layer neural network was used with hyperbolic tangent sigmoid transfer functions using Matlab as the software platform for development. The training

algorithm used was the scaled conjugate gradient. The features to be used were the ones suggested by Lukkka's feature selection approach: mean and Shannon's entropy values using the original images, and the Kurtosis values from the BPHE enhanced images. To confirm the use of the BPHE method, neural networks were trained 30 times (n=30) with different numbers of hidden neurons. The initial weights are calculated randomly by Matlab and these averages would give an idea of the better performance of the enhanced kurtosis feature. Because only three features are used, the expectation was that the network would not need many neurons. Table 1 shows mean squared error and analysis time obtained while testing the features extracted from original and BPHE enhancement. Because of the small numbers of neurons used, the training time was very short for all of them with a tendency to be faster for the proposed method, this at the expense of taking an extra 0.03 seconds to do BPHE. The highest classification accuracy of 95.2% was obtained while using 5 neurons in the prposed approach.

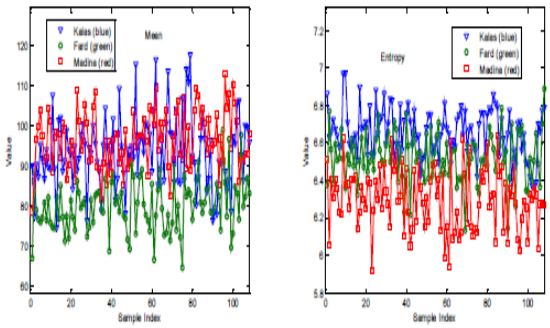

Figure 1. Average gray values and entropy values of date varieties

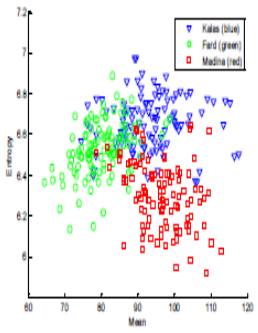

Figure 2 Scatter plot of mean and entropy values

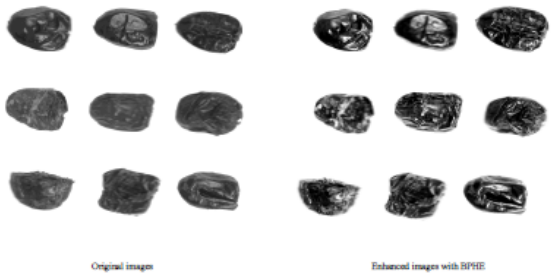

Figure 3. Images of date varieties (first t row Fard, second row Madina, third row Khalas) after and before enhancement with BPHE

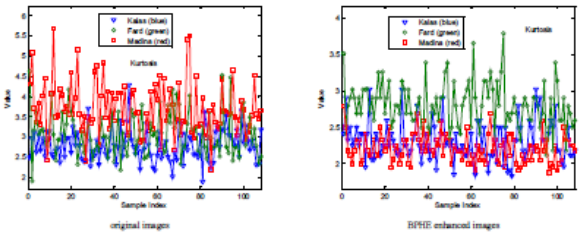

Figure 4. Kurtosis of date varieties before and after BPHE enhancement

Table 1. Mean squared error during neural network classifications with features from original and BPHE enhanced images while using different number of hidden neurons

	Nn* = 5		Nn = 10		Nn = 20		Nn = 30	
	BPHE	Original	BPHE	Original	BPHE	Original	BPHE	Original
MSE %	11.52	13.00	11.78	13.48	12.17	13.17	13.81	14.46
Time seconds	0.8698	0.9344	1.0417	0.9792	0.9365	1.055	0.9537	0.9849

*Nn = number of neurons

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