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Original Article

Application of Image Processing Techniques for Quality Control of Mushroom

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ABSTRACT

Background: Mushroom is one of the sources for protein supply, and it has taken into consideration among most countries in the world due to its rich medicinal features. Nowadays, due to the mechanization of traditional methods and quality control of products, it is possible to evaluate the quality of mushrooms with the help of image processing techniques.
Methods: In this study, image processing systems were used to determine the appearance quality of mushrooms. Using the properties of color, area, weight, and volume obtained from data mining techniques, artificial neural networks and fuzzy logic system mushroom quality was evaluated.
Results: A total of 250 images in three categories of defective, moderate were assessed. The correct detection rate by the image processing system was 95.6%.
Conclusion: The results of this study showed the optimum performance of image processing systems for assessing the quality of mushrooms. The superiority of image processing systems compared to traditional method can be observed in the quality of increased efficiency and high accuracy, as well as the reduction of costs and destructive effects in the production and packaging of food products.
Keywords: Image processing, Data mining, Mushroom quality, Neural network, Fuzzy logic
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Introduction

One of the most important agricultural products in food industry is mushroom that can grow in a variety of climatic environments. This particular agricultural product has been given special attention with increasing the world population and the demand for high-protein foods with reasonable prices and high quality Currently, one of the major problems in the food industry is the lack of accurate diagnosis of food quality. Quality assessment of food products rely on previous experiences and objective observations that may accompanied by human error. Traditionally, inspections are carried out by workers. The high cost of labor, the low speed, impact of environmental conditions, and not consistency among workers, has led to the necessity for modern systems to be applied in quality assessment of food products (1). In fact, Products grading in terms of shape, size and healthy condition increase the additional value of the product and allow customers to choose a product that meets their needs (2). The image processing is one of the branches of computer science, which is more often referred to as digital image processing. Image processing includes two fundamental part of computer vision and image enhancement that improves images in a variety of ways such as increasing contrast for improved image quality, applying

blurry filters, and ensuring that they are displayed correctly in printers or desktop (3, 4). Computer vision is a relatively new method of research that dates back to the 1960s, and recently have been developed for grading product quality (5). The machine vision has been extensively used for detecting physical properties and visual appearance of images in various fields such as food industry, pharmacy, technical faults diagnostics, automobile vehicles and the conduct of robots (6, 7).

One of the most basic and important stages in post-harvest operations is grading agricultural products in terms of quality and quantity. Previous studies have applied image processing technique for quality control of food and agriculture products including walnut (8), potato (9), date (10, 11), sweet tamarind (12), rice (13) and fruit and vegetable (14). Since there are limited studies using image processing technique for assessing mushroom products, the purpose of this study was to evaluate the quality of mushrooms using an image processing system.

Methods

Study sample

In this study, 250 images of mushroom without contamination were prepared in three categories of defective, moderate and healthy. Their images were digitized by an 8-megapixel digital camera webcam. The mushrooms were placed on a flat surface, with a normal and direct lighting exposure. Before taking photos, the mushroom were dried for moisture to prevent reflection of light. In order to prevent the reflection of light and the correct processing of the images, a non-gloss black cloth was used for the dark background and the photograph was taken vertically on the surface of the mushroom. After taking the photos, they were transferred to the computer to be stored there and analyzed by system. Figure 1 illustrates the image taken from four mushroom sample. Figure 2. Shows the study algorithm to determine the quality of the mushroom.

Figure 1. Initial images of the mushroom

Pre-processing

In order to obtain an improved image, the photos went under pre-processing stage. To preprocess the image, noise reduction filter was used to reduce noise, and obtaining smoother clearer image. In this step, as the image was taken from the external environment, image noise was deleted with the RGB system. LAB color space was used to remove shadows and other objects, the reasons for using the LAB color space is the fact that, these are closer to human vision and able to perceived by individuals.

Measurement

The quality of mushrooms were evaluated using four characteristics of color, area, weight and volume.

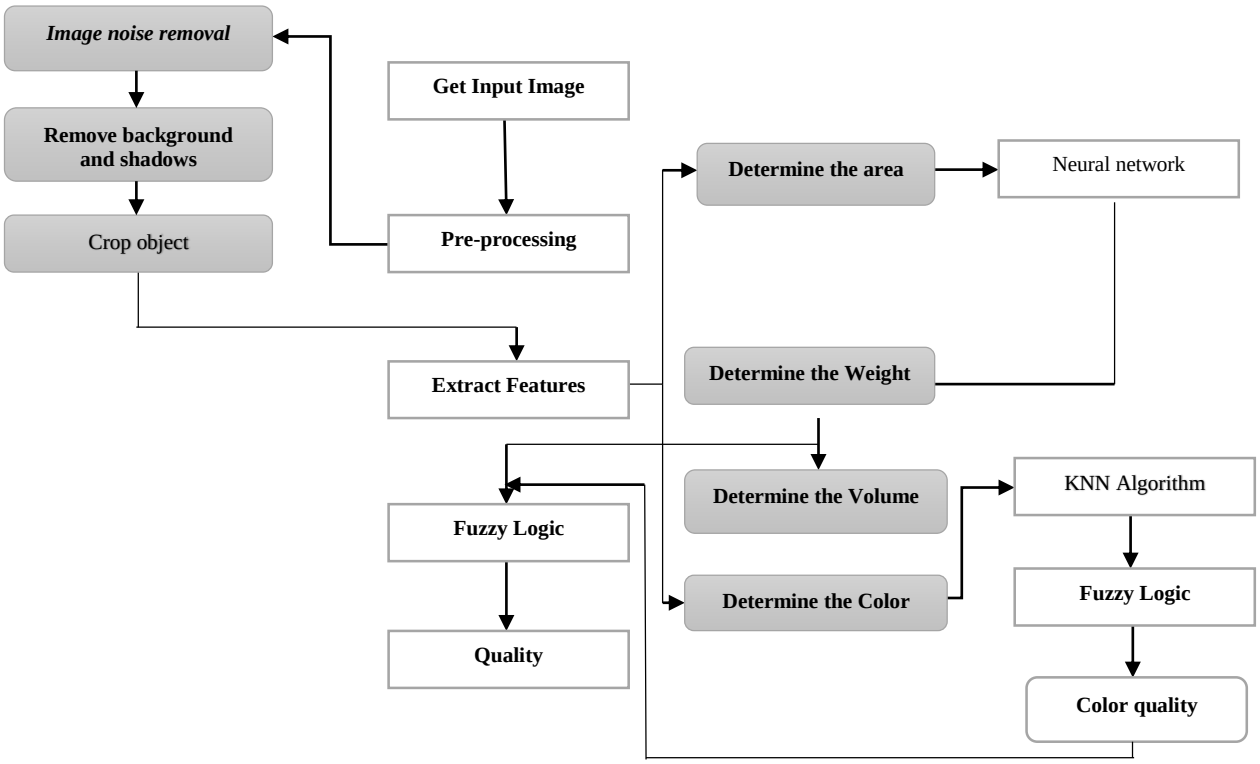
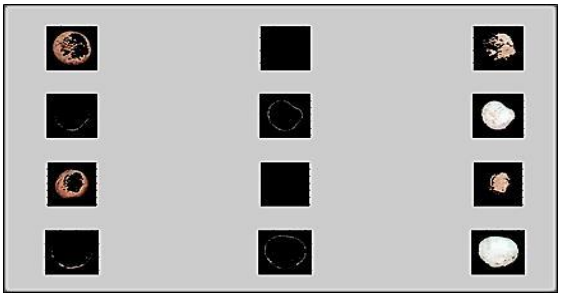


Figure 2. Study algorithm

Color

To extract the color appearance as an important parameters in determining the quality of all food products, the image color was divided into three equal colors spectra using k-nearest neighbor algorithm. Figure 3 shows three color spectrum and Figure 4 shows the binary equivalent.

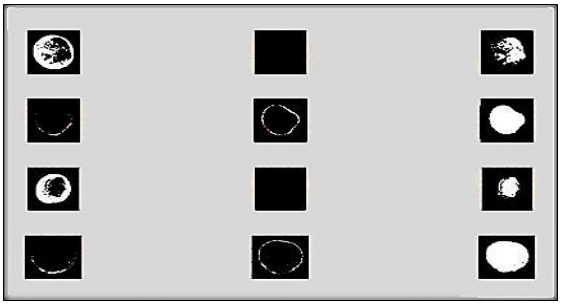


Defective Moderate Healthy

Figure 3. Three color spectrums of mushroom images

Area

To calculate area, the images of each colorful mushroom were cut and then were made binary by applying k-nearest neighbor algorithm. The area of each mushroom was estimated separately. Each of these areas was given a numeric value, so that the damaged areas were given less numeric value than the healthy areas.



Defective Moderate Healthy

Figure 4. Binary equivalent of mushroom images

Weight and volume:

One of the important characteristics in determining the quality of food products are their weight. The weight was estimated using neural network. In order to train the neural network, Bayesian algorithm was used. The number of hidden layers were considered as ten to increase the accuracy.

The volume was measured using the formula $\rho = m / v$. Where V represent the volume, m represents the weight of mushroom obtained by the neural network and the density (denoted as ρ) as a constant number of 0.95 was estimated based on the results of experiments performed on a number of mushrooms as.

Fuzzy logic

Quantitative data obtained from area, color, volume and weight properties were used as inputs of fuzzy logic. In this study Mamdani conditional fuzzy logic were used. The first fuzzy logic in this research has two inputs including the area of each colorful image and the value of that area. The resulting output is the initial color quality of the input image that based on the fuzzy system with 25 conditional rules were classified into 5 category of (very good, good, medium, bad, very bad). Then, the color quality and weight of the mushroom were considered as input of second fuzzy logic. The output was ultimately divided into defective, moderate, and healthy mushroom based on the fuzzy system with 9 conditional rules.

Software

Image pre-processing and fuzzy logic were performed using MATLAB 2014 software on Windows 8 operating system (hardware specifications of 12GB Memory-DDR3, Ghraphic-GeForce-GTX750Ti CPU, Intel® core ™ i5-2400 © 3.10GHZ (4CPUs).

Results

The results obtained from the image processing system were compared with an expert. Table 1 demonstrates the number of correct and incorrect results implemented by the software. The accurate identification rate were calculated based on the ratio of the correct answers to the total images for three categories of healthy, defective and moderate mushroom. The total accurate identification rate was 95.6%.

Discussion

The results of current study, using image processing system, showed high accurate identification rate for mushroom quality assessment. The results of this study compared with the previous research revealed higher accuracy for quality control. In this study, four characteristics were used to evaluate the quality of mushroom. Previous study carried out by Mohammad Kazemi et al. used two attributes for 45 mangoes and the obtained results showed an accuracy of 76.4% (15). Mozaffari et al. used two characteristics for the evaluation of 125 images of dates and the results showed an accuracy of 75.6% (16). Rahmani et al., used three features to evaluate 211 dates and the results presented an accuracy rate of 89.89% (17). It can be concluded that accuracy rate could be improved by increasing the number of products' attributes used for image processing system.

One of the limitations of the present study is the implementation of imaging in normal conditions and lack of utilization of an isolated environment without mushroom contamination, which can affect the quality of imaging by introducing shadows in the images. For this purpose, pre-processing was used to improve the images.

Table 1. Descriptive Results and Identification Rates

Grades class	Total number of images	Correct identification	Incorrect identification	Accurate identification rate (%)
Healthy	104	100	4	96.15
Defective	99	95	4	99.95
Moderate	47	44	3	93.61
Total	250	239	11	95.6

The present study was carried in the laboratory of standardized institutions. The time required for laboratory testing by human is much higher than vision machine. High accuracy, low error rate, high speed rate of implementation and low cost are among optimum characteristics that can be considered for substitution of traditional method by image processing system.

Conclusion

This work proposed image processing systems as an optimal method with high accuracy rate, high implementation speed, and low cost for evaluating the quality of the mushroom.

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Ethical consideration

The study protocol has been scientifically approved by school of Engineering of Deylaman Institute for High Education, Lahijan, Iran.

Conflicts of interests

Authors declared no conflict of interest.

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